Advanced Design
System 2019 Update 1.0

Nonlinear Devices

KEYSIGHT
TECHNOLOGIES

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Notices

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Contents

Devices and Models, BJT

Devices and Models, BJT

Bin Model

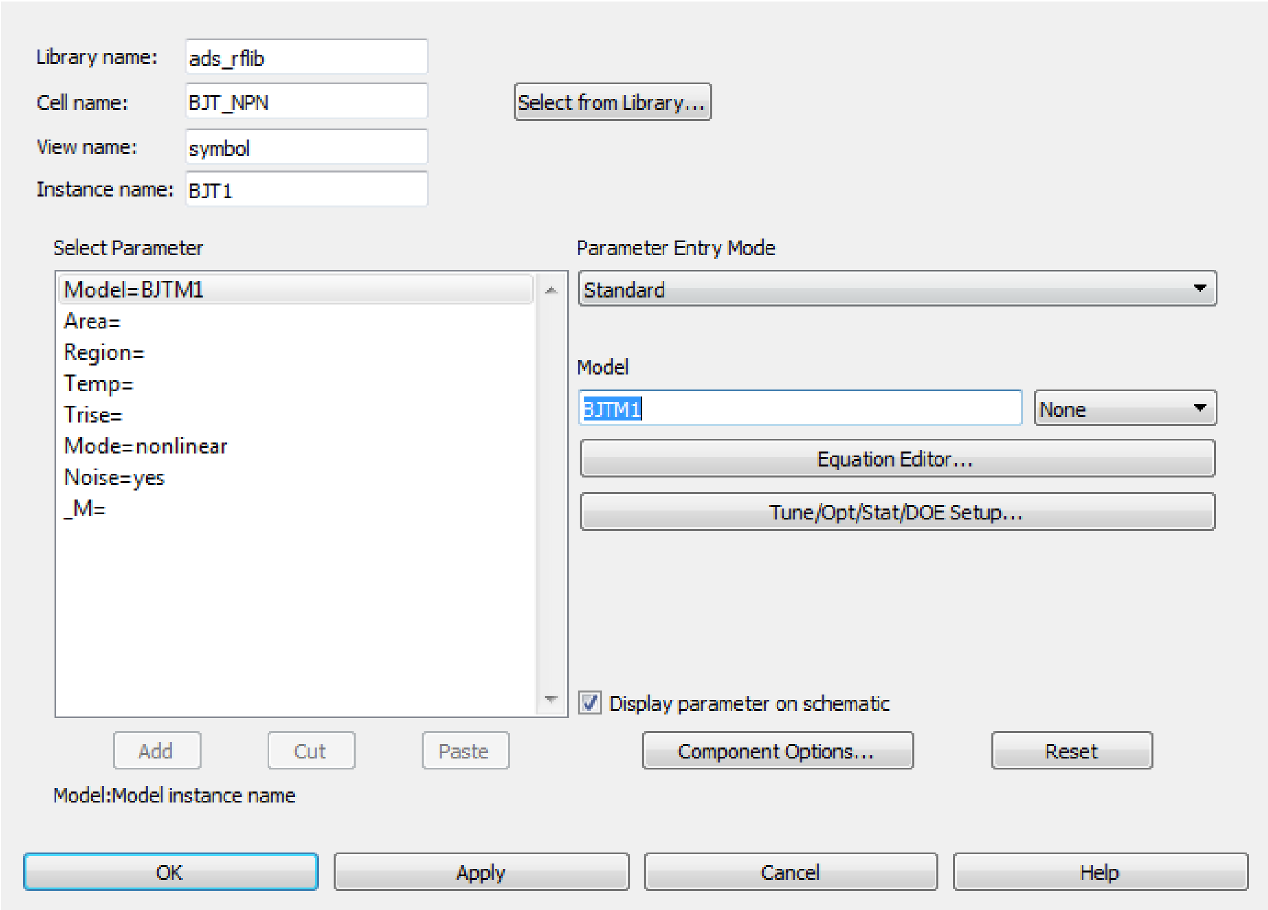
The BinModel in the BJT library allows you to sweep a parameter (usually a geometry, such as gate length), then enable the simulator to automatically select between different model cards. This alleviates the problem that one scalable model typically doesn't work for all sizes of a device.

For information on the use of the binning feature, refer to BinModel (For Automatic Model Selection).

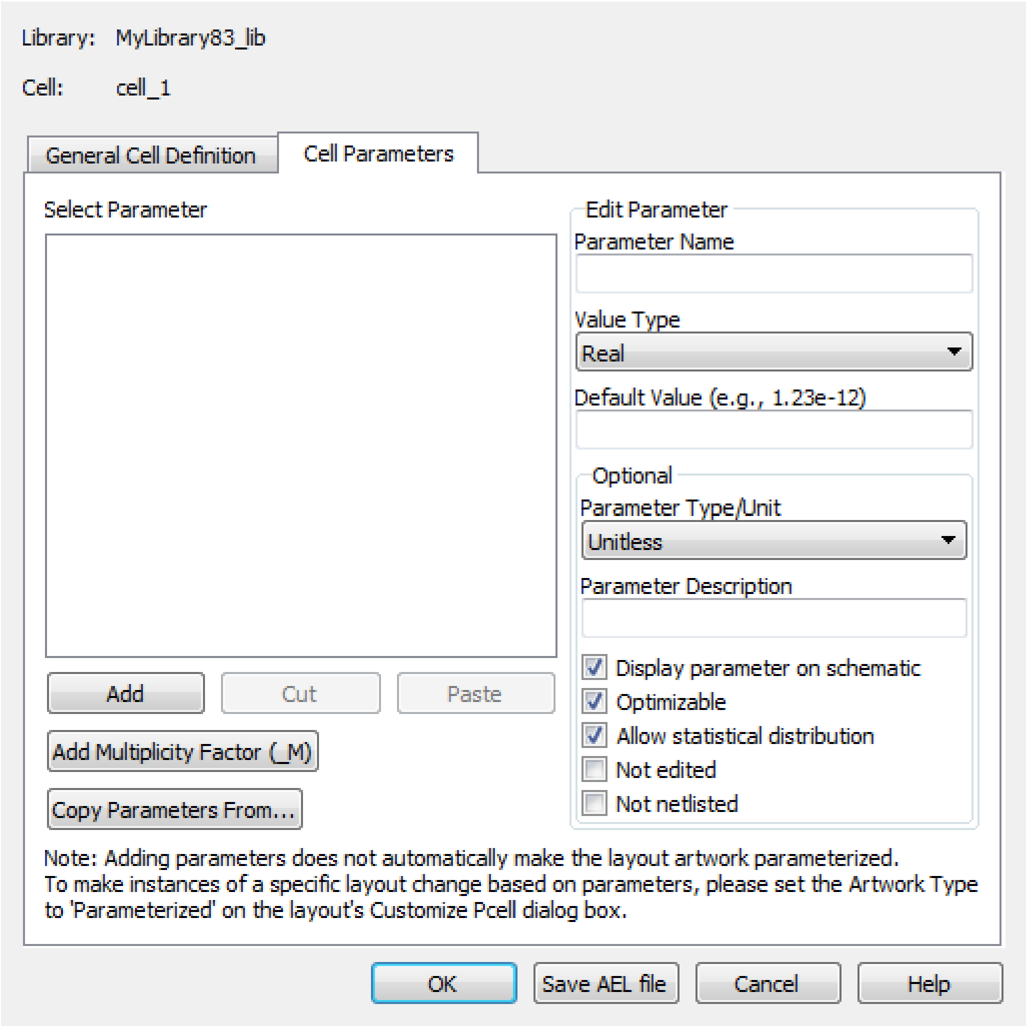
Multiplicity Parameter _M

The multiplicity feature provides a way to scale components or entire sub-circuits containing many components and sub-circuits. Given a component with a multiplicity value *M*, the simulator treats this component as if there were *M* such components all connected in parallel. Sub-circuits within sub-circuits will be appropriately scaled.

The _M parameter is available at the component level as shown here. (For components that do not explicitly have a Multiplicity parameter, the same functionality can be achieved by placing the component in a sub-circuit and using the sub-circuit's Multiplicity parameter, as described next.)



For sub-circuits, the parameter is enabled by selecting **File** > **Design Parameters** from the Schematic window. In the dialog box, select the **Parameters** tab. To add the Multiplicity parameter, choose **Add Multiplicity Factor_M**.



Netlist Syntax

Models for the ADS circuit simulator have the following syntax:

> *model modelname modeltype [param=value]**

where `model` is a keyword, `modelname` is the user-defined name for the model and `modeltype` is one of the predefined model types (e.g., Diode, BJT, MOSFET). After these three required fields comes zero or more `param=value` pairs. `param` is a model keyword and value is its user-assigned value. There is no required order for the `param=value` pairs. Model keywords that are not specified take on their default values. Refer to documentation for each model type to see the list of model parameters, their meanings and default values.

The model statement must be on a single line. Use the backslash "\"as a line continuation character. The instance and model parameter names are case sensitive; most, (not all) model parameters have their first character capitalized and the rest are lower case. Scale factors (e.g.,

$p=10^{-12}$, $n=10^{-9}$, $u=10^{-6}$, $m=10^{-3}$, $k=10^{+3}$, $M=10^{+6}$) can be used with numbers for numeric values. For more information about the circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

A netlist translator is available for translating models and subcircuits from Pspice, Hspice, and Spectre syntax to the form used by the ADS Circuit Simulator. Refer to Netlist Translator for SPICE for more information.

Parameter Aliases

For compatibility with other simulators, some models accept two or more different keywords for the same parameter. For example, the Diode model accepts both model keywords Is and Js for the saturation current. In the documentation, the parameter Name column lists the aliases in parentheses after the main parameter name. The main parameter name is the one that appears in the ADS dialog box for the model.

Tnom

All nonlinear device models have a parameter that specifies the temperature at which the model parameters were extracted. Normally called Tnom, some models may use Tref, Tr, or Tmeas. The default value for Tnom is specified on the Options item in the Tnom field. If Options.Tnom is not specified it defaults to 25°C. This is true for all nonlinear devices.

It is strongly suggested that the user explicitly set Tnom in each model and not depend on its default value. First, this provides a self-documenting model; other users of the device will not have to guess at what Tnom should be. Second, different users of the same model would get different results for the same circuit if they simulate with different values of Options.Tnom.

Temp and Trise

The ADS circuit simulation allows the user to directly specify the temperature of each individual device instance. This is done with the device instance parameter Temp which is the device temperature in degrees Celsius. If it is not specified, it defaults to the ambient temperature set with Options.Temp, which defaults to 25°C.

For compatibility with other simulators, many of the nonlinear devices allow the user to specify Trise for each device instance, which specifies actual device temperature as an increase from ambient. It defaults to zero. The Trise instance value is used only if the Temp instance value is not specified. If the user does not specify Trise on the instance, a default value for Trise can also be specified in the model. It defaults to zero. The following shows the logic of how the instance temperature is calculated if it is not explicitly specified.

```
if Instance.Temp is not specified
  if instance.Trise is not specified
    Instance.Temp = Options.Temp + Model.Trise
  else
    Instance.Temp = Options.Temp + Instance.Trise
```

ADSHBT_NPN (ADS Heterojunction Bipolar Transistor, NPN)

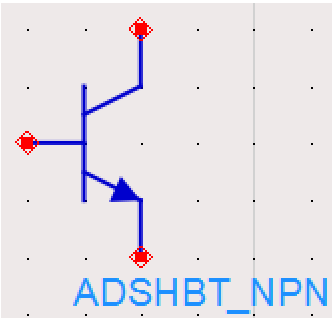
ADSHBT_NPN (ADS Heterojunction Bipolar Transistor, NPN)

ADS Heterojunction NPN Bipolar Transistor.

NOTE The AgilentHBT is now the ADSHBT. Existing netlists that reference the AgilentHBT will continue to work without modification.

Symbols

ADS Heterojunction Bipolar Transistor, NPN (ADSHBT_NPN)



Parameters

Name	Description	Units	Default
Model	Model instance name	None	HBTM1
Area	Scaling factor for resistances, currents, and capacitances	None	1.0
Temp	Device operating temperature	°C	25
Trise	Temperature rise over ambient	°C	0
Mode	Simulation mode: nonlinear or linear (refer to note 3)	None	Nonlinear
Noise	Noise generation option: yes, no	None	yes
SelfTmod	Self-Heating Model, 0=Off, 1=On	None	0

Name	Description	Units	Default
_M	Number of devices in parallel	None	1

- The Area factor scales the device capacitances, currents, and resistances. The parasitic capacitances (*Cpbe*, *Cpbc*, *Cpce*) and inductances, (*Lpb*, *Lpc*, *Lpe*) are not scaled by this factor. In addition, Rth1, Cth1, Rth2, and Cth2 are not scaled with the Area factor. For more information on area scaling dependence, refer to the section Area Scaling Equations of the ADSHBT_Model component documentation.
- The Temp parameter specifies the physical (operating) temperature of the device; if different from the temperature at which the model parameters are extracted (specified by Tnom in the model), certain model parameters are scaled such that the device is simulated at its operating temperature. For more information on the temperature scaling relationships, refer to the section Temperature Scaling Equations of the ADSHBT_Model component documentation.
- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with *Mode=linear* are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- DC operating point parameters that can be sent to the dataset are listed in the following table.

DC Operating Point Parameters

Name	Description	Units
Ic †	Total current flowing into the collector terminal	amperes
Ib †	Total current flowing into the base terminal	amperes
Ie †	Total current flowing into the emitter terminal	amperes
Power †	Total power dissipation	watts
Temp †	Intrinsic device /(junction/) temperature	celsius
Vbe †	Voltage across the base and emitter terminals	volts
Vbc †	Voltage across the base and collector terminals	volts
Vce †	Voltage across the collector and emitter terminals	volts

Name	Description	Units
BetaDC †	$\frac{\mathrm{Ic}}{\mathrm{Ib}}$: DC current gain	
Gm_ext †	$\frac{\mathrm{Gm\_int}}{1+\mathrm{Gm\_int}\times\left(\mathrm{Re}+\frac{\mathrm{Re+Rbi+Rbx}}{\mathrm{BetaDC}}\right)}$:Estimated extrinsic transconductance in CE-configuration	siemens
Gm_int †	$\left.\frac{\partial I_{CE}}{\partial I_{BEi}}\right\|_{V_{cei}}$: Intrinsic transconductance	siemens
Ft_ext †	$\frac{1}{2\pi\times(\mathrm{Tau\_ext})}$: Estimated extrinsic fT	hertz
Fmax †	$\sqrt{\frac{f_{t\_ext}}{8\pi\|RCeff\|}}$ where $RCeff = Rbi\cdot\|Cbci\| + Rbx\cdot\|Cbci+Cbcx\|$ $+(2\pi f_{t\_ext}\cdot(Rci+Rcx)\cdot\|Cbci+Cbcx\|)\cdot\left(Re+\frac{1}{gm\_int}\right)\cdot(\|Cbci+Cbcx\|)$ This estimate of Fmax /(from unilateral gain/) based on Vaidyanathan and Pulfrey	hertz
Tau_ss †	$\frac{\mathrm{Cm}}{\mathrm{Gm\_int}}$: Small-signal delay. This modifies the overall intrinsic transconductance to gm = Gm_int × exp/(- <i>j</i> ω × Tau_ss/)	seconds
Rpi †	$\frac{1}{\mathrm{Gbei}+\mathrm{Gbex}}$: Total base-emitter resistance for hybrid-π model	ohms
Rmu †	$\frac{1}{\mathrm{Gbci}+\mathrm{Gbcx}}$: Total base-collector resistance for hybrid-π model	ohms

Name	Description	Units
Ro †	$\dfrac{1}{\left.\dfrac{\partial I_{CE}}{\partial V_{CEi}}\right\|_{V_{BEi}}}$: Output resistance	ohms
Re †	Area and temperature scaled emitter resistance	ohms
Rbi †	Area and temperature scaled intrinsic base resistance	ohms
Rbx †	Area and temperature scaled extrinsic base resistance	ohms
Rci †	Area and temperature scaled intrinsic collector resistance	ohms
Rcx †	Area and temperature scaled extrinsic collector resistance	ohms
Cpi †	Cbei + Cbex: Total base-emitter capacitance for hybrid-π model	farads
Cmu †	Cbci + Cbcx: Total base-collector capacitance for hybrid-π model	farads
Co †	$\left.\dfrac{\partial Q_{CC}}{\partial V_{CEi}}\right\|_{V_{BEi}} + \left(\left.\dfrac{\partial Q_{BB}}{\partial V_{CEi}}\right\|_{V_{BEi}}\right)$: Collector-emitter \/(output/) capacitance	farads
Gbei	$\dfrac{dI_{BEi}}{dV_{BEi}}$: Intrinsic base-emitter conductance	siemens
Gbci	$\dfrac{dI_{BCi}}{dV_{BCi}}$: Intrinsic base-collector conductance	siemens
Gbex	$\dfrac{dI_{BEx}}{dV_{BEx}}$: Extrinsic base-emitter conductance	siemens

Name	Description	Units
Gbcx	$\frac{dI_{BCx}}{dV_{BCx}}$: Extrinsic base-collector conductance	siemens
Cbei	$\left.\frac{\partial Q_{BB}}{\partial V_{BEi}}\right\|_{V_{CEi}} + \left(\left.\frac{\partial Q_{BB}}{\partial V_{CEi}}\right\|_{V_{BEi}}\right)$: Total intrinsic base-emitter capacitance /(diffusion + depletion/)	farads
Cbci	$-\left.\frac{\partial Q_{BB}}{\partial V_{CEi}}\right\|_{V_{BEi}}$: Total intrinsic base-collector capacitance /(diffusion + depletion/)	farads
Cbex	$\frac{dQ_{BEx}}{dV_{BEx}}$: Extrinsic base-emitter depletion capacitance	farads
Cbcx	$\frac{dQ_{BCx}}{dV_{BCx}}$: Extrinsic base-collector depletion capacitance	farads
Cbei_depl	$\frac{dQ_{BEid}}{dV_{BEi}}$: Intrinsic base-emitter depletion capacitance	farads
Cbci_depl	$\frac{dQ_{BCid}}{dV_{BCi}}$: Intrinsic base-collector depletion capacitance	farads
Cm	$-\left.\frac{\partial Q_{CC}}{\partial V_{BEi}}\right\|_{V_{CEi}} + \left(\left.\frac{\partial Q_{BB}}{\partial V_{CEi}}\right\|_{V_{BEi}}\right)$: Transcapacitance which is used to calculate the small-signal delay Tau_ss	farads
Vbei	Voltage across the intrinsic base and intrinsic emitter	volts

Name	Description	Units
Vbci	Voltage across the intrinsic base and intrinsic collector	volts
Vcei	Voltage across the intrinsic collector and intrinsic emitter	volts
BetaAC	Gm_int × Rpi: gm_int/gBE	
Tau_int	$TFB\ (@\ Temp) + \left.\frac{\partial Q_{tC}}{\partial I_{cfq}}\right\|_{Vbci} + \left(\left.\frac{\partial Q_{krk}}{\partial I_{cfq}}\right\|_{Vbci}\right)$ Intrinsic delay in forward active mode	seconds
Tau_ext	/(/(Tau_int + /(Re + Rci + Rcx/) × /(Cbci_depl + Cbcx_depl/) + /(Cbci_depl + Cbcx + Cbei_depl + Cbex/) /) / Gm_int. Estimated extrinsic /(total/) emitter-collector delay in forward-active mode.	seconds
Ft_int	$\frac{1}{2\pi \times (\ \mathrm{Tau\_int})}$: Estimated intrinsic fT	hertz
Teff	Effective \/(limited/) device temperature used in model equations. Approximately within [-200,500].	celsius
Rth1	Temperature scaled thermal resistance #1	Kelvin/watt
Cth1	Thermal capacitance #1	sec watt/Kelvin
Rth2	Temperature scaled thermal resistance #2	Kelvin/watt
Cth2	Thermal capacitance #2	sec watt/Kelvin
Gmdc_int	$\frac{DI_{CE}}{DV_{BEi}}$ Intrinsic DC transconductance. Includes modulation of temperature with bias. Gmdc_int=Gm_int+Gth Dthi	siemens

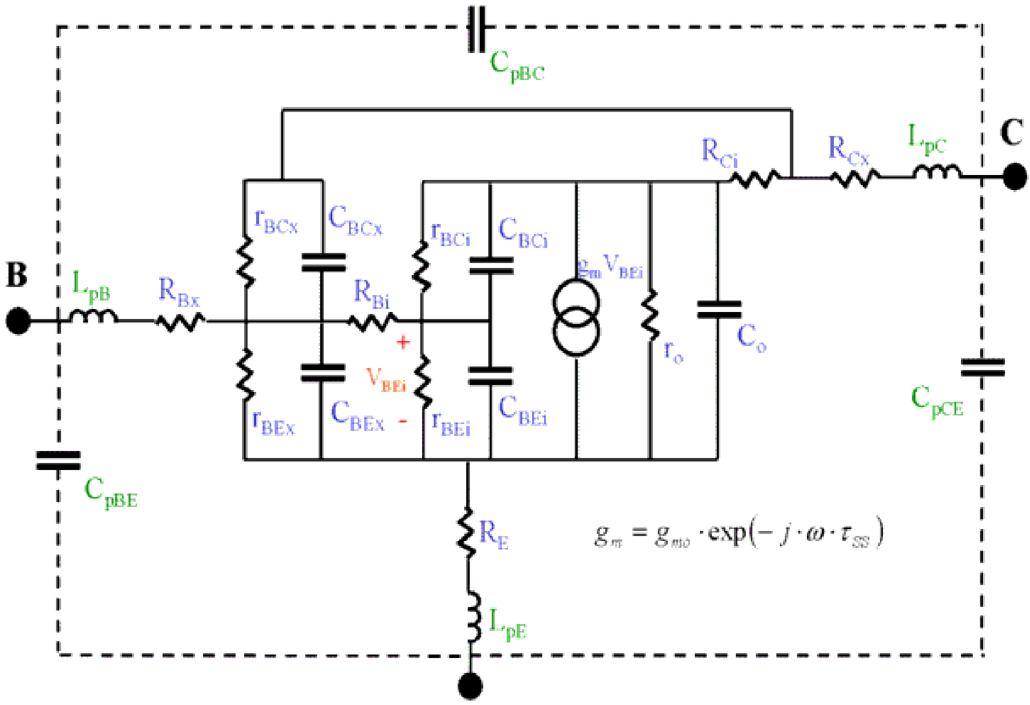
Name	Description	Units
Gmdc_ext	$\frac{DI_{CE}}{DV_{BEx}}$ Extrinsic DC transconductance. Includes modulation of temperature with bias. Gmdc_ext=Gm_ext+Gth Dthx	siemens
Godc_int	$\frac{DI_{CE}}{DV_{CEx}}$ Intrinsic DC output conductance. Includes modulation of temperature with bias.	siemens
Gth	$\left.\frac{\partial I_{CE}}{\partial T}\right\|_{V_{BE},\,V_{CE}}$ Rate of change in intrinsic collector current with temperature	amp/Kelvin
Dthi	$\left.\frac{\partial T}{\partial V_{BEi}}\right\|_{V_{CEi}}$ Rate of change in temperature with intrinsic base-emitter voltage	Kelvin/volt
Dthx	$\left.\frac{\partial T}{\partial V_{BEx}}\right\|_{V_{CEx}}$ Rate of change in temperature with extrinsic base-emitter voltage	Kelvin/volt
Ibb	Total intrinsic base current.[‡]	ampere
Icc	Total intrinsic collector current.[‡]	ampere
Qbb	Total intrinsic base charge.[‡]	coulombs
Qcc	Total intrinsic collector charge.[‡]	coulombs

[†] Parameters are displayed under "Brief Device Operating Point".

[‡] From 2-Port Network of the Large-Signal Intrinsic Model in ADSHBT Model (ADS Heterojunction Bipolar Transistor Model).

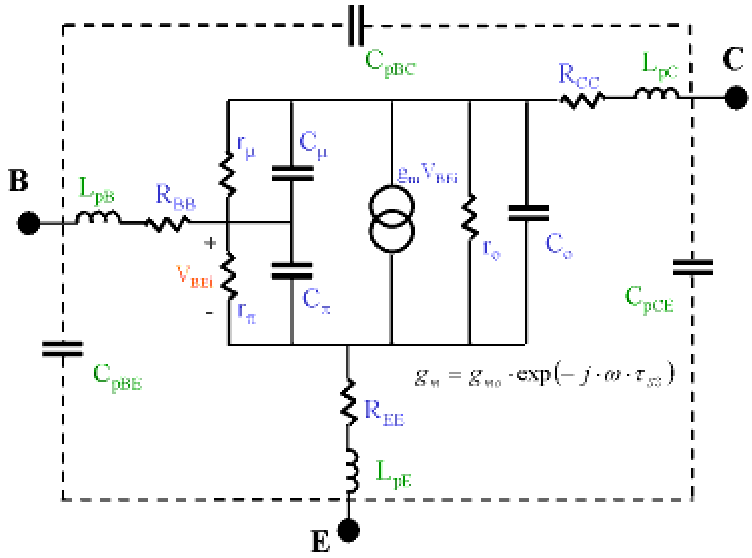
- The operating point parameter calculations do not account for the parasitic capacitances (*Cpbe*, *Cpbc*, *Cpce*) and inductances (*Lpb*, *Lpc*, *Lpe*).
  The DC operating point results can be used to construct an accurate small-signal representation of the

large-signal topology.



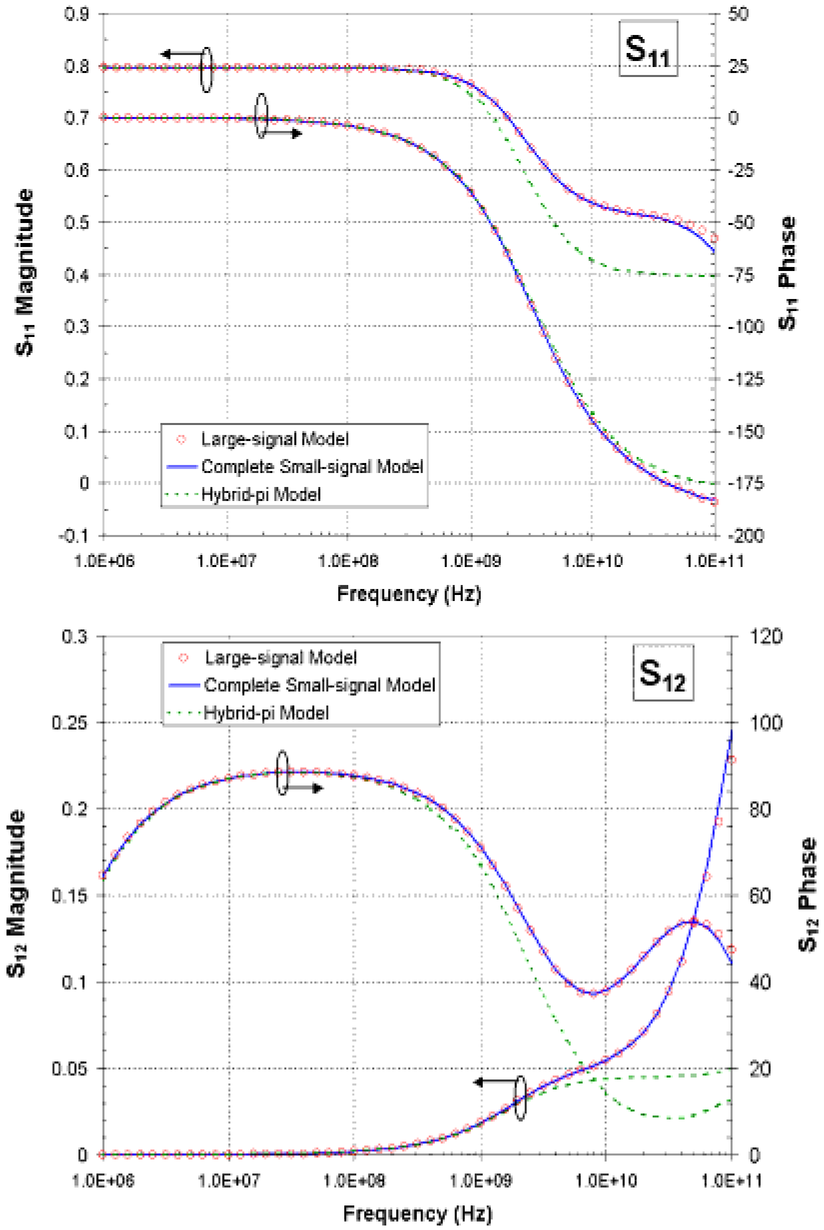
- The circuit elements of the small-signal model correspond to the DC operating point parameters as follows:
  R_E = Re
  R_{Bi} = Rbi
  R_{Bx} = Rbx
  R_{Ci} = Rci
  R_{Cx} = Rcx
  r_{BEx} = 1/Gbex
  r_{BCx} = 1/Gbcx
  C_{BEx} = Cbex
  C_{BCx} = Cbcx
  r_{BEi} = 1/Gbei
  r_{BCi} = 1/Gbci
  C_{BEi} = Cbei
  C_{BCi} = Cbci
  g_{mo} = Gm_int
  τ_{SS} = Tau_ss
  r_o = Ro
  C_o = Co

- The DC operating point parameters can be also used to construct a standard hybrid-π model.

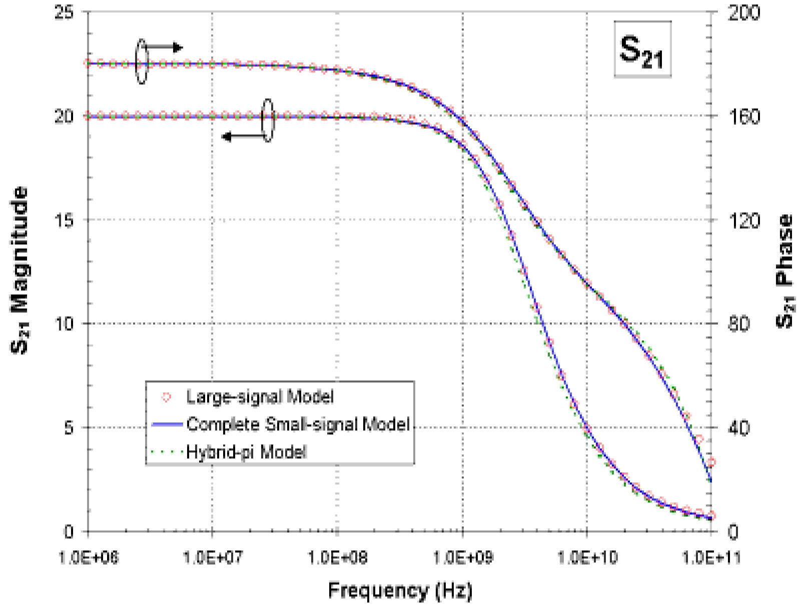


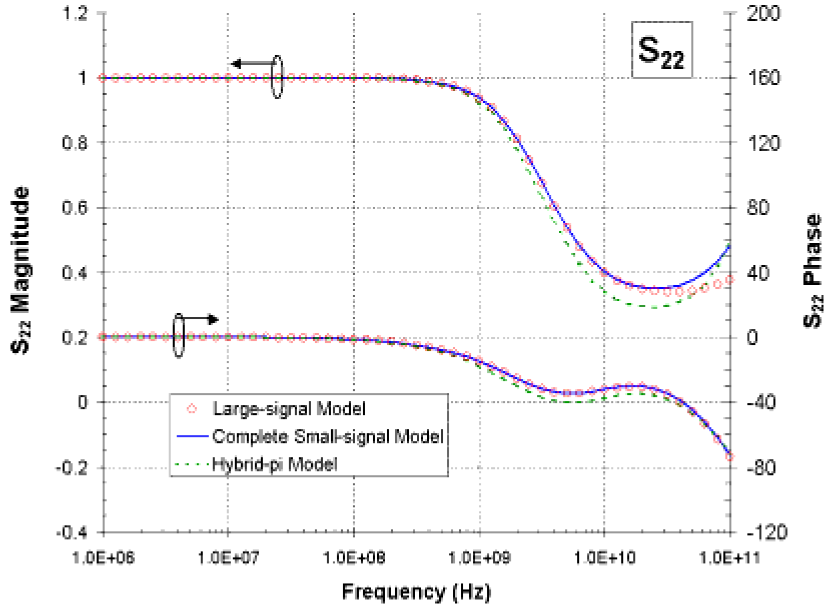
R_{EE} = Re
R_{BB} = Rbi + Rbx
R_{CC} = Rci + Rcx
$r\pi$ = Rpi
$r\mu$ = Rmu
$C\pi$ = Cpi
$C\mu$ = Cmu
g_{mo} = Gm_int
τ_{SS} = Tau_ss
r_o = Ro
C_o = Co

- The following 2 illustrations show the accuracy of the two small-signal models. Note the limited accuracy of the hybrid-π model topology at high frequencies.



(Default parameters of ADSHBT_Model: VBE=1.39V and VCE=3V)





(Default parameters of ADSHBT_Model: VBE=1.39V and VCE=3V)

- This device has no default artwork associated with it.

ADSHBT_NPN_Th (ADS Heterojunction Bipolar Transistor Thermal Terminal, NPN)

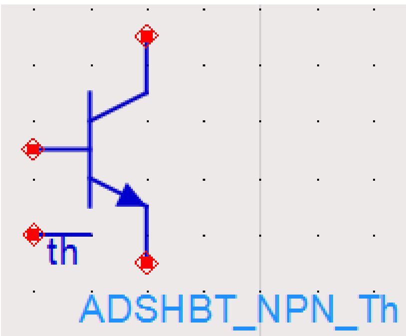
ADSHBT_NPN_Th (ADS Heterojunction Bipolar Transistor Thermal Terminal, NPN)

ADS Heterogeneous Bipolar Transistor with a thermal terminal.

NOTE The AgilentHBT is now the ADSHBT. Existing netlists that reference the AgilentHBT will continue to work without modification.

Symbols

ADS Heterojunction Bipolar Transistor Thermal Terminal, NPN (ADSHBT_NPN_Th)



Parameters

Name	Description	Units	Default
Model	Model instance name	None	HBTM1
Area	Scaling factor for resistances, currents, and capacitances	None	1.0
Temp	Device operating temperature	°C	25
Trise	Temperature rise over ambient	°C	0
Mode	Simulation mode: nonlinear or linear (refer to note 3)	None	Nonlinear
Noise	Noise generation option: yes, no	None	yes

Name	Description	Units	Default
SelfTmod	Self-Heating Model, 0=Off, 1=On	None	0
_M	Number of devices in parallel	None	1

- The Area factor scales the device capacitances, currents, and resistances. The parasitic capacitances (*Cpbe*, *Cpbc*, *Cpce*) and inductances, (*Lpb*, *Lpc*, *Lpe*) are not scaled by this factor. In addition, Rth1, Cth1, Rth2, and Cth2 are not scaled with the Area factor. For more information on area scaling dependence, refer to the section Area Scaling Equations of the ADSHBT_Model component documentation.
- The Temp parameter specifies the physical (operating) temperature of the device; if different from the temperature at which the model parameters are extracted (specified by Tnom in the model), certain model parameters are scaled such that the device is simulated at its operating temperature. For more information on the temperature scaling relationships, refer to the section Temperature Scaling Equations of the ADSHBT_Model component documentation.
- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with *Mode=linear* are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- DC operating point parameters that can be sent to the dataset are listed in the following table.

DC Operating Point Parameters

Name	Description	Units
Ic †	Total current flowing into the collector terminal	amperes
Ib †	Total current flowing into the base terminal	amperes
Ie †	Total current flowing into the emitter terminal	amperes
Power †	Total power dissipation	watts
Temp †	Intrinsic device /(junction/) temperature	celsius
Vbe †	Voltage across the base and emitter terminals	volts
Vbc †	Voltage across the base and collector terminals	volts
Vce †	Voltage across the collector and emitter terminals	volts

Name	Description	Units
BetaDC †	$\frac{\mathrm{Ic}}{\mathrm{Ib}}$: DC current gain	
Gm_ext †	$\frac{\mathrm{Gm\_int}}{1+\mathrm{Gm\_int}\times\left(\mathrm{Re}+\frac{\mathrm{Re+Rbi+Rbx}}{\mathrm{BetaDC}}\right)}$:Estimated extrinsic transconductance in CE-configuration	siemens
Gm_int †	$\left.\frac{\partial I_{CE}}{\partial I_{BEi}}\right\|_{V_{cei}}$: Intrinsic transconductance	siemens
Ft_ext †	$\frac{1}{2\pi\times(\mathrm{Tau\_ext})}$: Estimated extrinsic fT	hertz
Fmax †	$\sqrt{\frac{f_{t\_ext}}{8\pi\|RCeff\|}}$ where $RCeff = Rbi\cdot\|Cbci\| + Rbx\cdot\|Cbci+Cbcx\|$ $+(2\pi f_{t\_ext}\cdot(Rci+Rcx)\cdot\|Cbci+Cbcx\|)\cdot\left(Re+\frac{1}{gm\_int}\right)\cdot(\|Cbci+Cbcx\|)$ This estimate of Fmax /(from unilateral gain/) based on Vaidyanathan and Pulfrey	hertz
Tau_ss †	$\frac{\mathrm{Cm}}{\mathrm{Gm\_int}}$: Small-signal delay. This modifies the overall intrinsic transconductance to gm = Gm_int × exp/(- <i>j</i> ω × Tau_ss/)	seconds
Rpi †	$\frac{1}{\mathrm{Gbei}+\mathrm{Gbex}}$: Total base-emitter resistance for hybrid-π model	ohms
Rmu †	$\frac{1}{\mathrm{Gbci}+\mathrm{Gbcx}}$: Total base-collector resistance for hybrid-π model	ohms

Name	Description	Units
Ro †	$\frac{1}{\left.\frac{\partial I_{CE}}{\partial V_{CEi}}\right\|_{V_{BEi}}}$: Output resistance	ohms
Re †	Area and temperature scaled emitter resistance	ohms
Rbi †	Area and temperature scaled intrinsic base resistance	ohms
Rbx †	Area and temperature scaled extrinsic base resistance	ohms
Rci †	Area and temperature scaled intrinsic collector resistance	ohms
Rcx †	Area and temperature scaled extrinsic collector resistance	ohms
Cpi †	Cbei + Cbex: Total base-emitter capacitance for hybrid-π model	farads
Cmu †	Cbci + Cbcx: Total base-collector capacitance for hybrid-π model	farads
Co †	$\left.\frac{\partial Q_{CC}}{\partial V_{CEi}}\right\|_{V_{BEi}} + \left(\left.\frac{\partial Q_{BB}}{\partial V_{CEi}}\right\|_{V_{BEi}}\right)$: Collector-emitter \/(output/) capacitance	farads
Gbei	$\frac{dI_{BEi}}{dV_{BEi}}$: Intrinsic base-emitter conductance	siemens
Gbci	$\frac{dI_{BCi}}{dV_{BCi}}$: Intrinsic base-collector conductance	siemens
Gbex	$\frac{dI_{BEx}}{dV_{BEx}}$: Extrinsic base-emitter conductance	siemens

Name	Description	Units
Gbcx	$\frac{dI_{BCx}}{dV_{BCx}}$: Extrinsic base-collector conductance	siemens
Cbei	$\left.\frac{\partial Q_{BB}}{\partial V_{BEi}}\right\|_{V_{CEi}} + \left(\left.\frac{\partial Q_{BB}}{\partial V_{CEi}}\right\|_{V_{BEi}}\right)$: Total intrinsic base-emitter capacitance /(diffusion + depletion/)	farads
Cbci	$-\left.\frac{\partial Q_{BB}}{\partial V_{CEi}}\right\|_{V_{BEi}}$: Total intrinsic base-collector capacitance /(diffusion + depletion/)	farads
Cbex	$\frac{dQ_{BEx}}{dV_{BEx}}$: Extrinsic base-emitter depletion capacitance	farads
Cbcx	$\frac{dQ_{BCx}}{dV_{BCx}}$: Extrinsic base-collector depletion capacitance	farads
Cbei_depl	$\frac{dQ_{BEid}}{dV_{BEi}}$: Intrinsic base-emitter depletion capacitance	farads
Cbci_depl	$\frac{dQ_{BCid}}{dV_{BCi}}$: Intrinsic base-collector depletion capacitance	farads
Cm	$-\left.\frac{\partial Q_{CC}}{\partial V_{BEi}}\right\|_{V_{CEi}} + \left(\left.\frac{\partial Q_{BB}}{\partial V_{CEi}}\right\|_{V_{BEi}}\right)$: Transcapacitance which is used to calculate the small-signal delay Tau_ss	farads
Vbei	Voltage across the intrinsic base and intrinsic emitter	volts

Name	Description	Units
Vbci	Voltage across the intrinsic base and intrinsic collector	volts
Vcei	Voltage across the intrinsic collector and intrinsic emitter	volts
BetaAC	Gm_int × Rpi: gm_int/gBE	
Tau_int	$TFB\ (@\ Temp) + \left.\frac{\partial Q_{tC}}{\partial I_{cfq}}\right\vert_{Vbci} + \left(\left.\frac{\partial Q_{krk}}{\partial I_{cfq}}\right\vert_{Vbci}\right)$ Intrinsic delay in forward active mode	seconds
Tau_ext	/(/(Tau_int + /(Re + Rci + Rcx/) × /(Cbci_depl + Cbcx_depl/) + /(Cbci_depl + Cbcx + Cbei_depl + Cbex/) /) / Gm_int. Estimated extrinsic /(total/) emitter-collector delay in forward-active mode.	seconds
Ft_int	$\frac{1}{2\pi \times (\ \mathrm{Tau\_int})}$: Estimated intrinsic fT	hertz
Teff	Effective \/(limited/) device temperature used in model equations. Approximately within [-200,500].	celsius
Rth1	Temperature scaled thermal resistance #1	Kelvin/watt
Cth1	Thermal capacitance #1	sec watt/Kelvin
Rth2	Temperature scaled thermal resistance #2	Kelvin/watt
Cth2	Thermal capacitance #2	sec watt/Kelvin
Gmdc_int	$\frac{DI_{CE}}{DV_{BEi}}$ Intrinsic DC transconductance. Includes modulation of temperature with bias. Gmdc_int=Gm_int+Gth Dthi	siemens

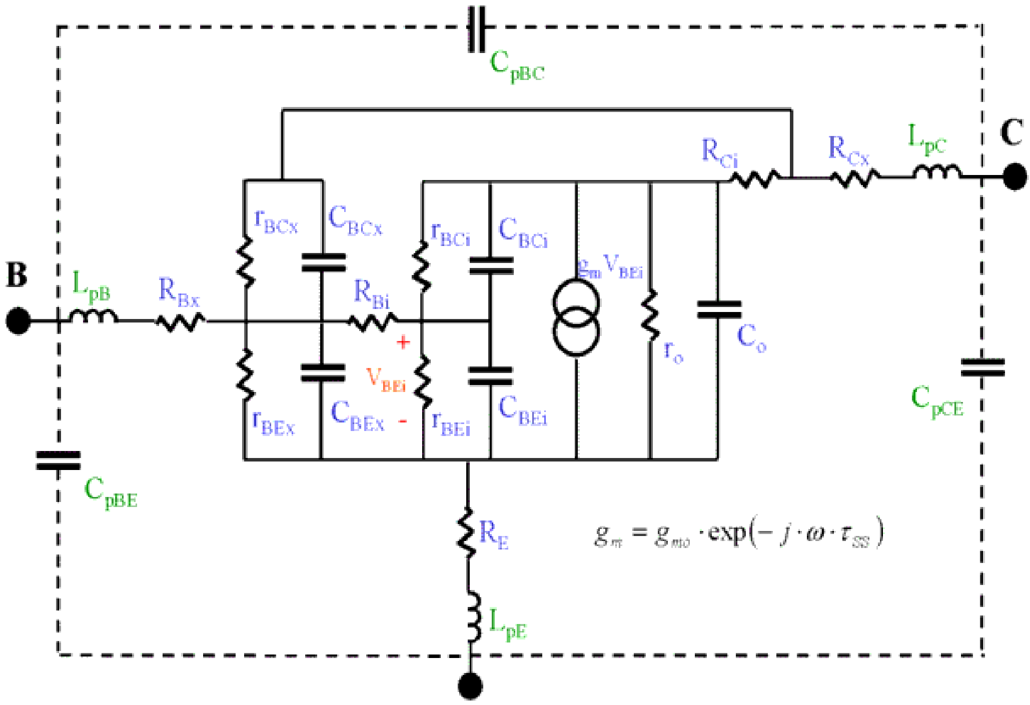
Name	Description	Units
Gmdc_ext	$\frac{DI_{CE}}{DV_{BEx}}$ Extrinsic DC transconductance. Includes modulation of temperature with bias. Gmdc_ext=Gm_ext+Gth Dthx	siemens
Godc_int	$\frac{DI_{CE}}{DV_{CEx}}$ Intrinsic DC output conductance. Includes modulation of temperature with bias.	siemens
Gth	$\left.\frac{\partial I_{CE}}{\partial T}\right\|_{V_{BE},\,V_{CE}}$ Rate of change in intrinsic collector current with temperature	amp/Kelvin
Dthi	$\left.\frac{\partial T}{\partial V_{BEi}}\right\|_{V_{CEi}}$ Rate of change in temperature with intrinsic base-emitter voltage	Kelvin/volt
Dthx	$\left.\frac{\partial T}{\partial V_{BEx}}\right\|_{V_{CEx}}$ Rate of change in temperature with extrinsic base-emitter voltage	Kelvin/volt
Ibb	Total intrinsic base current.[‡]	ampere
Icc	Total intrinsic collector current.[‡]	ampere
Qbb	Total intrinsic base charge.[‡]	coulombs
Qcc	Total intrinsic collector charge.[‡]	coulombs

[†] Parameters are displayed under "Brief Device Operating Point".

[‡] From 2-Port Network of the Large-Signal Intrinsic Model in ADSHBT Model (ADS Heterojunction Bipolar Transistor Model) .

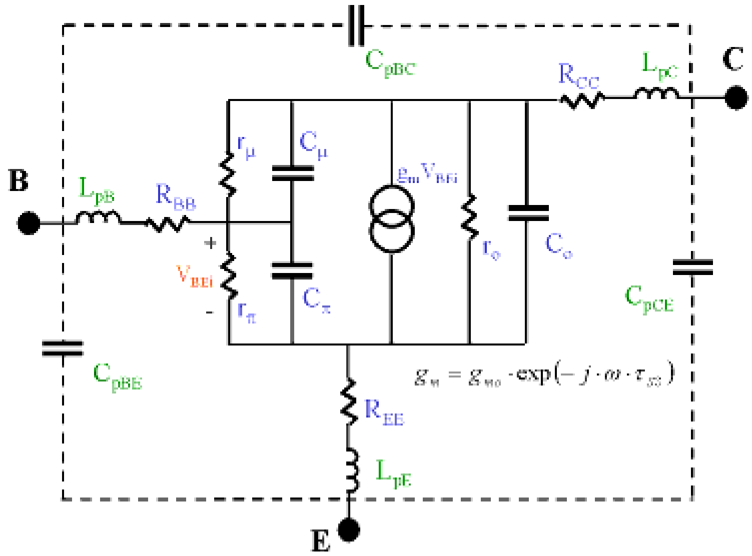
- The operating point parameter calculations do not account for the parasitic capacitances (*Cpbe*, *Cpbc*, *Cpce*) and inductances (*Lpb*, *Lpc*, *Lpe*).
  The DC operating point results can be used to construct an accurate small-signal representation of the

large-signal topology.



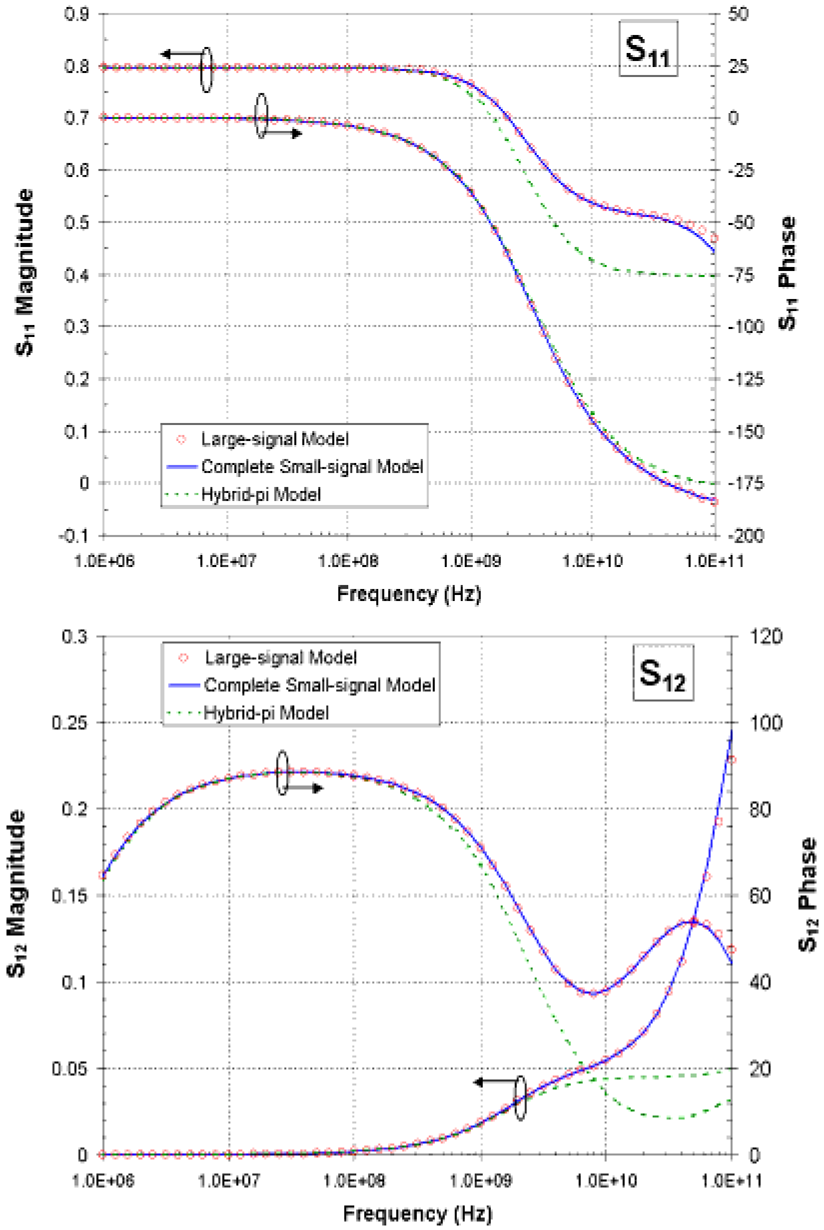
- The circuit elements of the small-signal model correspond to the DC operating point parameters as follows:
  R_E = Re
  R_{Bi} = Rbi
  R_{Bx} = Rbx
  R_{Ci} = Rci
  R_{Cx} = Rcx
  r_{BEx} = 1/Gbex
  r_{BCx} = 1/Gbcx
  C_{BEx} = Cbex
  C_{BCx} = Cbcx
  r_{BEi} = 1/Gbei
  r_{BCi} = 1/Gbci
  C_{BEi} = Cbei
  C_{BCi} = Cbci
  g_{mo} = Gm_int
  τ_{SS} = Tau_ss
  r_o = Ro
  C_o = Co

- The DC operating point parameters can be also used to construct a standard hybrid-π model.

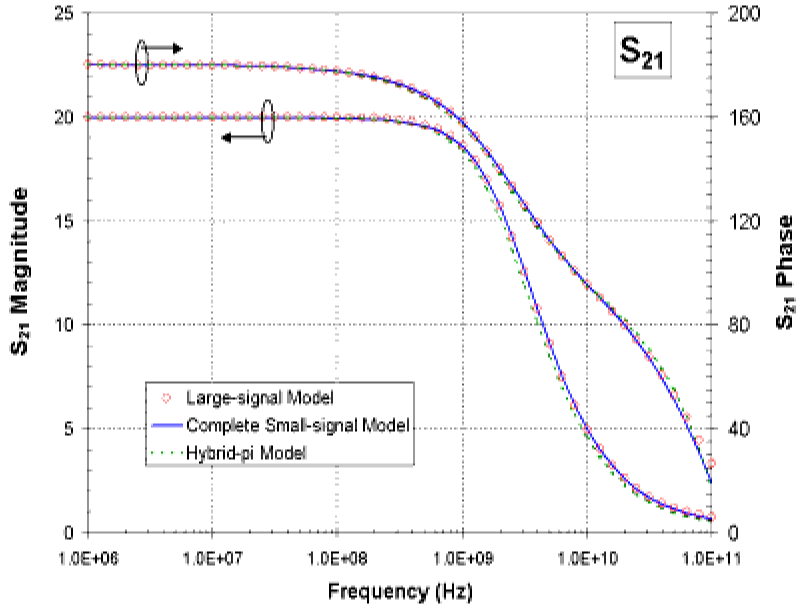


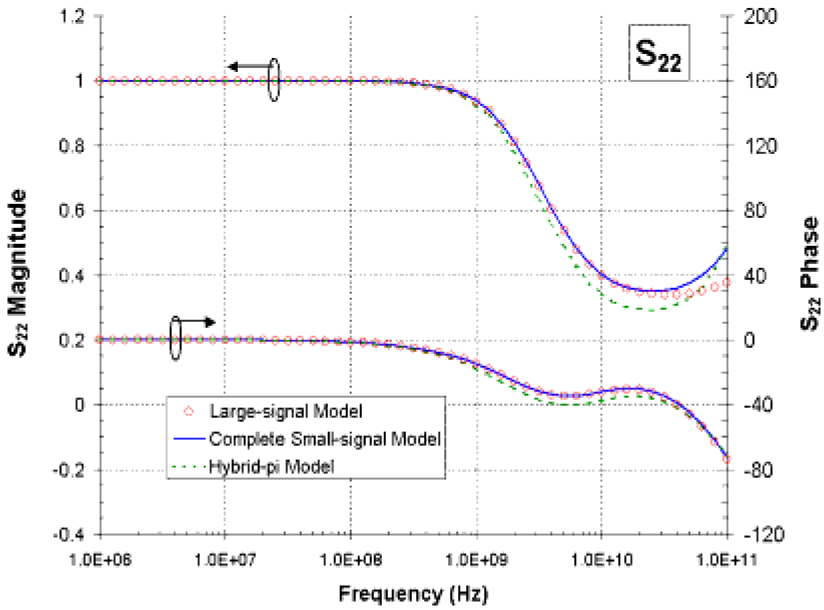
R_{EE} = Re
R_{BB} = Rbi + Rbx
R_{CC} = Rci + Rcx
$r\pi$ = Rpi
$r\mu$ = Rmu
$C\pi$ = Cpi
$C\mu$ = Cmu
g_{mo} = Gm_int
τ_{SS} = Tau_ss
r_o = Ro
C_o = Co

- The following 2 illustrations show the accuracy of the two small-signal models. Note the limited accuracy of the hybrid-π model topology at high frequencies.



(Default parameters of ADSHBT_Model: VBE=1.39V and VCE=3V)





(Default parameters of ADSHBT_Model: VBE=1.39V and VCE=3V)

- This device has no default artwork associated with it.

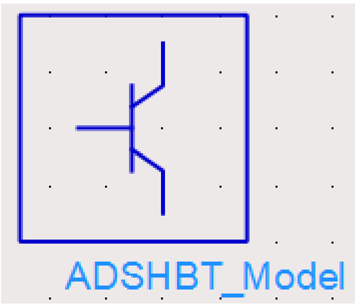
ADSHBT Model (ADS Heterojunction Bipolar Transistor Model)

ADSHBT_Model (ADS Heterojunction Bipolar Transistor Model)

This model supplies values for ADSHBT_NPN and ADSHBT_NPN_Th devices. ADSHBT model is based on the general concepts from the UCSD HBT model, (in which the charge model is originally based on [2]), and the Gummel-Poon BJT model [3]. The charge model contains a flexible collector transit time formulation that empirically accounts for the electric field dependent electron drift velocity in GaAs and InP collectors (based on the work from [4]). This enables accurate fits of ft vs. bias over a wide range of bias points, which improves linearity predictions [5]. The depletion and high-current charges are leveraged from HICUM [6,7] (http://www.iee.et.tu-dresden.de/iee/eb/comp_mod.html).

NOTE The AgilentHBT is now the ADSHBT. Existing netlists that reference the AgilentHBT will continue to work without modification.

Symbol



Parameters

Model parameters must be specified in SI units

Name	Description and Comments	Units	Default
Tnom	Nominal temperature (temperature at which the room temperature parameters are extracted)	°C	25
Re	Emitter resistance	Ohm	2.0
Rci	Intrinsic collector resistance	Ohm	1.0
Rcx	Extrinsic collector resistance	Ohm	5.0
Rbi	Intrinsic base resistance	Ohm	15.0

Name	Description and Comments	Units	Default
Rbx	Extrinsic base resistance	Ohm	5.0
Is	Collector-Emitter current: Forward collector saturation current	A	1.0e-25
Nf	Collector-Emitter current: Forward collector current ideality factor	None	1.0
Isr	Collector-Emitter current: Reverse emitter saturation current	A	1.00e-15
Nr	Collector-Emitter current: Reverse emitter current ideality factor	None	2.0
Ish	Base-Emitter current: Ideal base-emitter current	A	1.0e-27
Nh	Base-Emitter current: Ideal base-emitter current ideality factor	None	1.0
Ise	Base-Emitter current: Non-ideal base-emitter current	A	1.0e-18
Ne	Base-Emitter current: Non-ideal base-emitter current ideality factor	None	2.0
Isrh	Base-Collector current: Ideal base-collector saturation current	A	1.0e-15
Nrh	Base-Collector current: Ideal base-collector current ideality factor	None	2.0
Isc	Base-Collector current: Non-ideal base-collector saturation current	A	1.0e-13
Nc	Base-Collector current: Non-ideal base-collector current ideality factor	None	2.0
Abel	Base-Emitter current: Portion of base-emitter current allocated to extrinsic region	None	0.0
Vaf	Forward Early voltage	V	500
Var	Reverse Early voltage	V	1000
Isa	Base-emitter heterojunction saturation current (BE barrier effects)	A	1.0e+10
Na	Base-emitter heterojunction ideality factor	None	1.0
Isb	Base-collector heterojunction saturation current (BC barrier effects)	A	1.0e+10
Nb	Base-collector heterojunction ideality factor	None	1.0
Ikdc1	I-V knee effect: Slope of q3 function	A	1.0
Ikdc2Inv †	I-V knee effect: Transition width of Ic	A^{-1}	infinity †
Ikdc3	I-V knee effect: I-V knee effect critical current	A	1.0
VkdcInv	I-V knee effect: Transition width of Vcb	V^{-1}	0.1

Name	Description and Comments	Units	Default
Nkdc	I-V knee effect: Maximum value of q3	None	3.0
Gkdc	I-V knee effect: Exponent of q3 factor in base current	None	0.0
Ik	High injection roll-off current	A	1.0
Cje	Base-emitter capacitance: zero-bias capacitance	F	4.0e-14
Vje	Base-emitter capacitance: built-in voltage	V	1.3
Mje	Base-emitter capacitance: grading factor	None	0.3
Cemax	Base-emitter capacitance: maximum value in forward bias	F	1.0e-13
Vpte	Base-emitter capacitance: punch-through voltage	V	1.0
Mjer	Base-emitter capacitance: grading factor beyond punchthrough	None	0.05
Abex	Base-emitter capacitance: ratio between extrinsic and total base-emitter regions	None	0.0
Cjc	Base-collector capacitance: zero-bias capacitance	F	5.0e-14
Vjc	Base-collector capacitance: built-in voltage	V	1.1
Mjc	Base-collector capacitance: grading factor	None	0.3
Ccmax	Base-collector capacitance: maximum value in forward bias	F	9.0e-14
Vptc	Base-collector capacitance: punch-through voltage	V	3.0
Mjcr	Base-collector capacitance: grading factor beyond punch-through	None	0.03
Abcx	Base-collector capacitance: Ratio between extrinsic and total base-collector regions	None	0.75
Tfb	Base delay: Intrinsic base transit time	sec	1.0e-12
Fextb	Base delay: Fraction of base delay charge allocated to B-C junction	None	0.2
Tfc0	Collector delay: Low current transit time	sec	2.0e-12
Tcmin	Collector delay: High current transit time	sec	5.0e-13
Itc	Collector delay: Midpoint in Ice between Tfc0 and Tcmin	A	0.006
Itc2	Collector delay: Width in Ic between Tfc0 and Tcmin	A	0.008
Vtc0Inv	Collector delay: Rate of change of Tfc0 with Vcb	V^{-1}	0.3

Name	Description and Comments	Units	Default
Vtr0	Collector delay: Transition width in Vcb to Vmx0	V	2.0
Vmx0	Collector delay: Maximum Vcb for Tfc0	V	2.0
VtcminInv	Collector delay: Rate of change of Tcmin with Vcb	V^{-1}	0.5
Vtrmin	Collector delay: Transition width in Vcb to Vmxmin	V	1.0
Vmxmin	Collector delay: Maximum Vbc for Tcmin	V	1.0
VtcInv	Collector delay: Rate of change of Itc with Vcb	V^{-1}	0.1
Vtc2Inv	Collector delay: Rate of change of Itc2 with Vcb	V^{-1}	0.1
Fextc	Collector delay: Fraction of collector delay charge allocated to B-C junction	None	0.8
Tkrk	Kirk effect delay: Kirk effect delay time	sec	1.00e-12
Ikrk	Kirk effect delay: Critical current for Kirk effect	A	0.025
Ikrktr	Kirk effect delay: Transition width to Ikirk=0	A	1.00e-06
Vkrk	Kirk effect delay: Rate of change of Ikrk with Vcb	V	3.0
Vkrk2Inv	Kirk effect delay: Rate of change of Tkrk with Vcb	V^{-1}	0.2
Gkrk	Kirk effect delay: Exponent of Kirk effect delay	None	4.0
Vktr	Kirk effect delay: Transition width in Vcb to Vkmx	V	1.0
Vkmx	Kirk effect delay: Maximum Vcb	V	1.0
Fexke	Fraction of Kirk effect charge allocated to the B-C junction	None	0.2
Tr	Reverse transit time	sec	1.0e-09
Cpce	Parasitic / fringing collector-emitter capacitance	F	1.0e-15
Cpbe	Parasitic / fringing base-emitter capacitance	F	1.0e-15
Cpbc	Parasitic / fringing base-collector capacitance	F	1.0e-15
Lpb	Parasitic base inductance	H	0.0
Lpc	Parasitic collector inductance	H	0.0
Lpe	Parasitic emitter inductance	H	0.0

Name	Description and Comments	Units	Default
Xrb	Temperature exponent for Rbi and Rbx	None	0.0
Xrc	Temperature exponent for Rci and Rcx	None	0.0
Xre	Temperature exponent for Re	None	0.0
Tvje	Rate of change in temperature of Vje	V/K	0.0
Tvpe	Rate of change in temperature of Vpte	V/K	0.0
Tvjc	Rate of change in temperature of Vjc	V/K	0.0
Tvpc	Rate of change in temperature of Vptc	V/K	0.0
Tnf	Rate of change in temperature of Nf	K^{-1}	0.0
Tnr	Rate of change in temperature of Nr	K^{-1}	0.0
Ege	Effective emitter band gap parameter	V	1.55
Xtis	Temperature exponent for Is	None	3.0
Xtih	Temperature exponent for Ish	None	4.0
Xtie	Temperature exponent for Ise	None	3.0
Egc	Effective collector bandgap parameter	V	1.5
Xtir	Temperature exponent for Isr	None	3.0
Xtic	Temperature exponent for Isc	None	3.0
Xtirh	Temperature exponent for Isrh	None	4.0
Xtik3	Temperature exponent for Ikdc3	None	0.0
Eaa	Temperature dependence of Isa	V	0.0
Eab	Temperature dependence of Isb	V	0.0
Xtfb	Temperature exponent for Tfb	None	0.0
Xtcmin	Temperature exponent for Tcmin	None	0.0
Xtfc0	Temperature exponent for Tfc0	None	0.0
Xitc	Temperature exponent for Itc	None	0.0

Name	Description and Comments	Units	Default
Xitc2	Temperature exponent for Itc2	None	0.0
Xtkrk	Temperature exponent for Tkrk	None	0.0
Xikrk	Temperature exponent for Ikrk	None	0.0
Xvkrk	Temperature exponent for Vkrk	None	0.0
Rth1	Thermal resistance #1	K/W	1000.0
Cth1	Thermal capacitance #1	J/K	5e-10
Xth1	Temperature exponent for Rth1	None	0.0
Rth2	Thermal resistance #2	K/W	0.0
Cth2	Thermal capacitance #2	J/K	0.0
Xth2	Temperature exponent for Rth2	None	0.0
Kf	Flicker (1/f) noise coefficient	None	0.0
Af	Flicker (1/f) noise exponent	None	1.0
Ffe	Flicker (1/f) noise frequency exponent	None	1.0
Kb	Burst (popcorn) noise exponent	None	0.0
Ab	Burst (popcorn) noise corner frequency	None	1.0
Fb	Burst noise corner frequency	Hz	1
Imax	Explosion current	A	10
wBvbe	Base-emitter reverse voltage (warning)	V	0.0
wBvbc	Base-collector reverse voltage (warning)	V	0.0
wVbcfwd	Base-collector forward bias (warning)	V	0.0
wIbmax	Maximum base current (warning)	A	0.0
wIcmax	Maximum collector current (warning)	A	0.0
wPmax	Maximum power dissipation (warning)	W	0.0
Version	Model version/revision (1.0 = ADS2003C, 2.0 = ADS2004A)	None	2.0
AllParams	Data Access Component (DAC) Based Parameters	None	None

Name	Description and Comments	Units	Default
† A value of 0.0 is interpreted as infinity.			

- The ideal base-emitter current has its distinct saturation current (Ish) and ideality factor (Nh), similar to HICUM and VBIC [8,9] (http://www.designers-guide.org/VBIC/references.html). Therefore, the parameter *Bf* in the Gummel-Poon and UCSD HBT models is not used. This is required for a III-V HBT model because the mechanism of base current is not necessarily proportional to the collector current (due to the presence of a heterojunction between the base and emitter). The current gain (Beta) at a bias point can be viewed from the DC operating point information under Simulate > Detailed Device Operating Point.
- Dynamic self-heating is implemented (Version 2) and can be activated (de-activated) by setting the device instance parameter *SelfTmod=1* (*SelfTmod=0*). For more information, refer to Self-Heating Model. Static temperature scaling of parameters with operating temperature (*Temp* in the device instance) applies to both cases.
- Heterojunction effects on DC current (from the UCSD HBT model) is taken into account by ISA and NA (through VBEi dependent Ica) in the base-emitter junction and ISB and NB (through VBCi dependent Icb) in the base-collector junction. Ica typically models the barrier effects that occur at the base-emitter heterojunction, which modifies the relationship between the collector current and VBEi. Icb typically models the influence of the barrier for electrons at the base-collector junction (which is present at zero bias and is gradually removed with reverse-bias of the base-collector junction).
- The *soft-knee* observed in the common-emitter ICE vs. VCE curve in single heterojunction bipolar transistors at high currents and low voltages [10] can be taken into account by the parameters of q3mod. For the *soft-knee* observed in double heterojunction bipolar transistors, for example the *Tiwari effect* [11] (which is separate from the base-collector blocking accounted by ISB and NB), q3mod can also be used. *Gkdc* can be used to empirically fit the increase in base current. If a *soft-knee* is not apparent, q3mod can be turned off by setting *Ikdc2Inv=0*
- '*Inverse*' parameters for several of the model parameters are used to enable flexibility. For example, the parameter Vkrk2Inv is used in the manner:

  $$TKRK \times (1 - V_{BCi} \times VKRK2Inv)$$

  If the standard way of normalizing VBCi were used with a parameter called Vkrk2 (which does not exist in this model), it would look like:

  $$TKRK \times \left(1 - \frac{V_{BCi}}{VKRK2}\right)$$

  Although the latter method is more intuitive because the parameter *VKRK2* is in the familiar units of voltage, it is numerically inconvenient because a divide-by-zero occurs when *VKRK2* is set to 0, which prevents parameter sweeps crossing 0. Therefore, by defining an `inverse' parameter, this numerical problem is circumvented. Another advantage of using `inverse' parameters is that setting that particular parameter to 0 can turn off its effect. Otherwise, parameters must be set to a high value to turn off the effect (e.g., Forward early voltage, *Vaf*). The only inconvenience for using `inverse' parameters is that the units of these parameters are the reciprocal of the units of the variable that it is modifying, which may be difficult to conceptualize.
- Resistances (Re, Rci, Rcx, Rbi, Rbx). When set to 0, the nodes connected by resistors collapse to a single node. When set to a value greater than 0, the effective resistance (after temperature and area scaling) is limited to be greater than or equal to MinExtR, which can be specified in the General Simulation Options. When Re, Rci, Rcx, Rbi or Rbx is initially set to 0 and then swept to non-zero values, the circuit response will not change due to the node collapsing described above.
- Zero bias junction capacitances (Cje and Cjc). When set to 0, the depletion charge is set to 0. Note that Ccmax and Cemax must be >0.

- Junction capacitance built-in voltages (Vjc and Vje). When temperature scaled values go below 1e-6, these parameters are set to 1e-6.
- Imax specifies the P-N junction explosion current. Imax can be specified in the device model or in the General Simulation Options; the device model value takes precedence over the Options value.
- For the Version parameter, the default setting is 2. Setting *Version=1* selects the first ADSHBT model release (without dynamic self-heating) in ADS2003C, for backwards compatibility. Note however, there have been a few minor bug fixes to the *Version=1* model, so it is possible that simulation results will not always be exactly identical with the ADS2003C release. If the Version parameter is within the range [1,2], and set to any value other than 1.0 or 2.0, then it will default to 2.0 with a warning. Outside of this range, an error is returned. Note that the dynamic self-heating option is available only in *Version=2*. The following is a brief list of enhancements for *Version=2*.
    - Dynamic self-heating (self-consistent electro-thermal interaction) effects on currents, capacitances, delays, and resistances.
    - Temperature scaling of *NF*, *NR*, *VPTE*, *VPTC*, *VKRK*
    - Parameters *NKDC* and *GKDC* can be real values
    - Parasitic inductances included at the electrical terminals
- Use *AllParams* with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those via *AllParams*.

Netlist Syntax

Model

```
model model_name ADSHBT list_of_parameters
```

model_name is the user defined name for the particular ADSHBT model which can be used in multiple instances. *list_of_parameters* is the list of the model parameters and values.

Example:

```
model hbt1 ADSHBT Re=2 Rci=1 Rcx=5 Rbi=
```

Model name hbt1 is an ADSHBT model with the corresponding listed parameters. hbt1 can be used in multiple instances with its area and temperature scaled independently for each instance.

Device

When the device specified by model_name is called, the syntax below is used:

```
model_name:deviceID Cnode Bnode Enode list_of_parameters
```

deviceID is the unique identification given to the particular instance with the corresponding listed parameters.

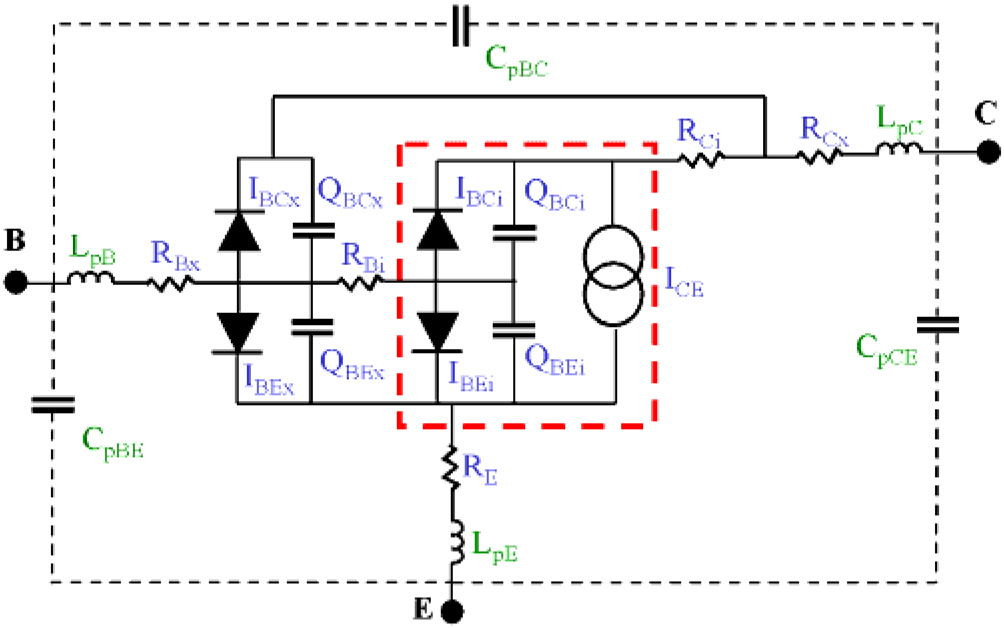
Example:

```
hbt1:q1 2 1 0 Area=1 Temp=25
```

Component q1 is defined by hbt1, which is an ADSHBT model. The collector node is at node 2, the base node is at node 1, and the emitter node is at node 0. The area factor is set to 1 and the device (operating) temperature is at 25°C.

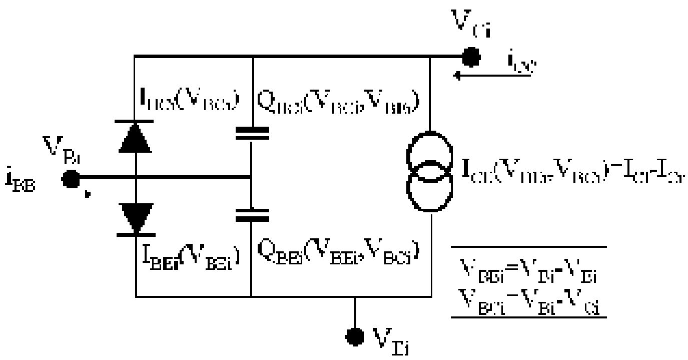
Large- and Small-signal Model Topologies Overview

The large-signal topology of the ADSHBT model is given in Figure 1 . The intrinsic model (bounded by the dashed box) is shown in more detail in Figure 2 . The thermal equivalent circuit is given in Figure 8 .



> *Figure 1.*

*



> *Figure 2.*

*

The intrinsic model can be expressed in general as a 2-port network as shown in the following figure.

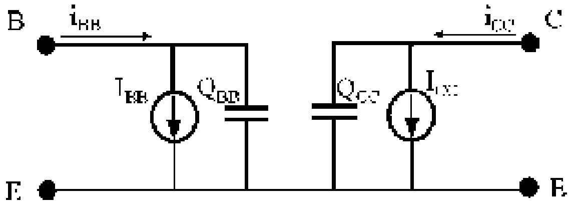


Figure 3. "2-Port Network of the Large-Signal Intrinsic Model"
*

In Figure 3, shown above:

$$I_{BB} = I_{BEi} + I_{BCi}$$

$$Q_{BB} = Q_{BEi} + Q_{BCi}$$

$$i_{BB} = I_{BB} + \frac{dQ_{BB}}{dt}$$

$$I_{CC} = I_{CE} - I_{BCi}$$

$$Q_{CC} = -Q_{BCi}$$

$$i_{CC} = I_{CC} + \frac{dQ_{CC}}{dt}$$

This 2-port circuit representation of the intrinsic device facilitates the calculation of the intrinsic elements of the small-signal model. This is because the intrinsic Y-parameters can be expressed using the 2- port circuit elements as follows:

$$[Y_{int}] = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} = \begin{bmatrix} \left(\left.\frac{\partial I_{BB}}{\partial V_{BEi}}\right|_{V_{CEi}}\right) + j\omega\left(\left.\frac{\partial Q_{BB}}{\partial V_{BEi}}\right|_{V_{CEi}}\right) & \left(\left.\frac{\partial I_{BB}}{\partial V_{CEi}}\right|_{V_{BEi}}\right) + j\omega\left(\left.\frac{\partial Q_{BB}}{\partial V_{CEi}}\right|_{V_{BEi}}\right) \\ \left(\left.\frac{\partial I_{CC}}{\partial V_{BEi}}\right|_{V_{CEi}}\right) + j\omega\left(\left.\frac{\partial Q_{CC}}{\partial V_{BEi}}\right|_{V_{CEi}}\right) & \left(\left.\frac{\partial I_{CC}}{\partial V_{CEi}}\right|_{V_{BEi}}\right) + j\omega\left(\left.\frac{\partial Q_{CC}}{\partial V_{CEi}}\right|_{V_{BEi}}\right) \end{bmatrix}$$

Small-signal parameters such as the total intrinsic base-emitter and base-collector capacitances (depletion + diffusion) can be extracted directly from the intrinsic Y-parameters, as well as the transconductance (g_m) and the transcapacitance (C_m), which can then be used to calculate the small-signal time delay (SS).

The small-signal equivalent circuit approximates the time delay with a modification to the transconductance (g_m). It is represented as the circuit shown in Figure 4.

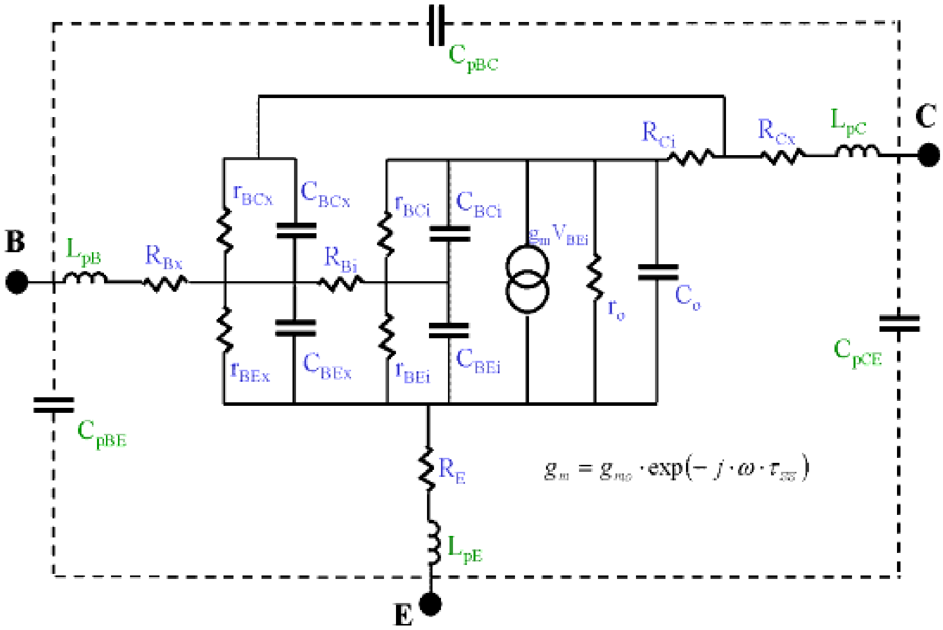


Figure 4.

*

In Figure 4:

$$r_{BCi} = \left(\frac{dI_{BCi}}{dV_{BCi}}\right)^{-1}$$

$$r_{BEi} = \left(\frac{dI_{BEi}}{dV_{BEi}}\right)^{-1}$$

$$C_{BCi} = -\frac{\partial Q_{BB}}{\partial V_{CEi}}\bigg|_{V_{BEi}}$$

$$C_{BEi} = \frac{\partial Q_{BB}}{\partial V_{BEi}}\bigg|_{V_{CEi}} + \frac{\partial Q_{BB}}{\partial V_{CEi}}\bigg|_{V_{BEi}}$$

$$r_{BCx} = \left(\frac{dI_{BCx}}{dV_{BCx}}\right)^{-1}$$

$$r_{BEx} = \left(\frac{dI_{BEx}}{dV_{BEx}}\right)^{-1}$$

$$C_{BCx} = \frac{dQ_{BCx}}{dV_{BCx}}$$

$$C_{BEx} = \frac{dQ_{BEx}}{dV_{BEx}}$$

$$g_{mo} = \left.\frac{\partial I_{CE}}{\partial V_{BEi}}\right|_{V_{CEi}}$$

$$r_o = \left(\left.\frac{\partial I_{CE}}{\partial V_{CEi}}\right|_{V_{BEi}}\right)^{-1}$$

$$C_o = \left.\frac{\partial Q_{CC}}{\partial V_{CEi}}\right|_{V_{BEi}} + \left.\frac{\partial Q_{BB}}{\partial V_{CEi}}\right|_{V_{BEi}}$$

$$C_m = -\left.\frac{\partial Q_{CC}}{\partial V_{BEi}}\right|_{V_{CEi}} + \left.\frac{\partial Q_{BB}}{\partial V_{CEi}}\right|_{V_{BEi}}$$

$$\tau_{SS} = \frac{C_m}{g_{mo}}$$

Collector-Emitter Current Equations

The collector-emitter current (i.e., main collector current) is composed of the forward and reverse currents (Icf and Icr). The formulation for the modification factor DD is based on the UCSD HBT model. q1 and q2 (contained in qb) are originally from the Gummel-Poon model where they model the Early and high-current roll-off effects, respectively. Ica and Icb model the heterojunction effects on the collector current for the base-emitter and base-collector junctions, respectively. q3mod is a function that empirically models the drop in current gain at high currents and low collector voltages that results in a softening of the knee behavior of a common-emitter I-V plot. In the following equations, T represents Tdev, defined in terms of the ambient or dynamical temperature, as described in Self-Heating Model.

$$I_{CE} = I_{cf} - I_{cr}$$

$$I_{cf} = \frac{IS \times \left(\exp\left(\frac{qV_{BEi}}{NF \times k \times T}\right) - 1\right)}{DD \times q3mod}$$ (total forward collector current)

$$I_{cr} = \frac{ISR \times \left(\exp\left(\frac{qV_{BCi}}{NR \times k \times T}\right) - 1\right)}{DD}$$ (total reverse emitter current)

$$DD = qb + Ica + Icb$$

$$qb = \frac{q1 \times (1 + \sqrt{1 + 4 \times q2})}{2}$$

$$q1 = \frac{1}{1 - \frac{V_{BEi}}{VAR} + \frac{V_{BCi}}{VAF}}$$ (Early effect)

(A limiting function is used in the model implementation to prevent divide-by-zero error when the denominator is equal to zero)

$$q2 = \frac{IS \exp\left(\frac{qV_{BEi}}{NF \times k \times T}\right)}{IK}$$ (high current Beta roll-off)

(The numerator is slightly modified from the diode equation by removing the -1 term)

$$Ica = \frac{IS}{ISA} \exp\left(\frac{qV_{BEi}}{NA \times k \times T}\right)$$ (BE heterojunction effect)

$$Icb = \frac{IS}{ISB} \exp\left(\frac{qV_{BCi}}{NB \times k \times T}\right)$$ (BC heterojunction effect)

$$q3mod = \frac{NKDC \times q3}{(NKDC - 1) + q3}$$ (*Soft-knee* effect)

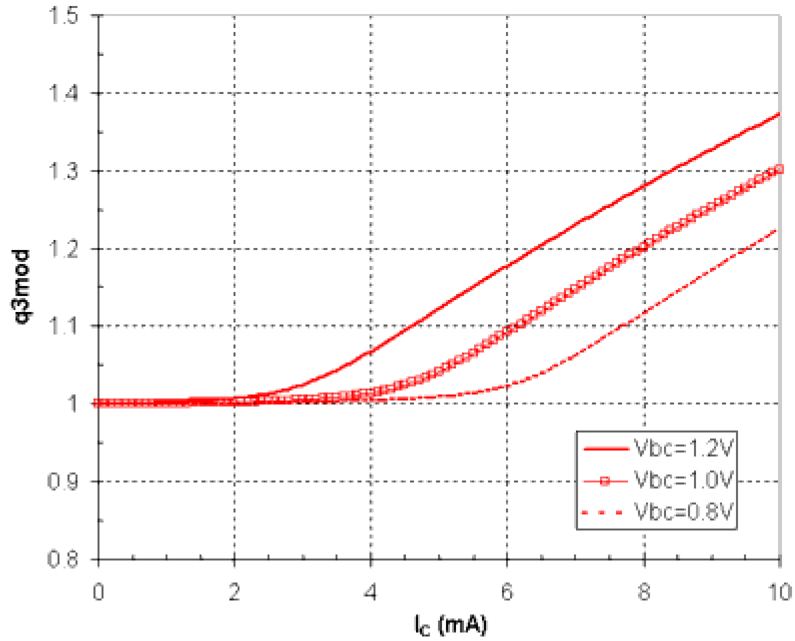
$$q3 = trans2\left(IS\left(\exp\left(\frac{qV_{BEi}}{NF \times k \times T}\right) - 1\right)\right) - trans2(0) + 1$$

$$trans2(I) = \frac{IKDC2Inv(\sqrt{(I - Icrit1)2 + IKDC^2} + I - Icrit1 - IKDC1)}{2}$$

$$Icrit1 = IKDC3(1 - (V_{BCi} - VJC) \times VKDCInv)$$

Explanation of q3mod

Because q3mod divides the forward collector current (I_{cf}), it remains a value of 1 when its effect is not present. Figure 5 shows the behavior of *q3mod* versus the collector current at various V_{BCi} values.



> **Figure 5. q3mod Behavior versus Collector Current (Ikdc1=0.001; Ikdc2Inv=100; kdc3=0.00; VkdcInv=5.26; Nkdc=3; Vjc=1.4)*

*

Ikdc1 defines the 'width' in current of the transition region, *Ikdc2Inv* defines the 'slope', and *Ikdc3* defines the 'turn-on' current of q3mod. *VkdcInv* defines the voltage dependence of the 'turn-on' current and *Nkdc* sets the limit to the value of *q3mod*. It should be noted that the parameter *Vjc* is used in the equation for *q3mod*. Because *Vjc* is primarily used to define the base-collector depletion charge (or capacitance), the base-collector capacitance should be extracted first before the parameters of *q3mod* are extracted.

Base-Emitter Current Equations

In the following equations, T represents Tdev, defined in terms of the ambient or dynamical temperature, as described in Self-Heating Model.

$$I_{BEi} = (1 - ABEL) \times \left((q3mod)^{GKDC} \times ISH\left(\exp\left(\frac{qV_{BEi}}{NH \times k \times T} \right) - 1 \right) + ISE\left(\exp\left(\frac{qV_{BEi}}{NE \times k \times T} \right) - 1 \right) \right)$$

$$I_{BEx} = (ABEL) \times \left((q3mod)^{GKDC} \times ISH\left(\exp\left(\frac{qV_{BEx}}{NH \times k \times T} \right) - 1 \right) + ISE\left(\exp\left(\frac{qV_{BEx}}{NE \times k \times T} \right) - 1 \right) \right)$$

q3mod is in the I_{BE} equations to empirically model any increase in base current due to the *soft-knee* effect, which occurs at high collector currents and low collector voltages. If this feature is not needed, set *Gkdc=0* (default).

Abel is used as a partitioning factor of the total base-emitter current to separate extrinsic and intrinsic components.

Base-Collector Current Equations

In the following equations, T represents Tdev, defined in terms of the ambient or dynamical temperature, as described in Self-Heating Model.

$$I_{BCi} = (1 - ABCX) \times \left(ISRH\left(\exp\left(\frac{qV_{BCi}}{NRH \times k \times T}\right) - 1\right) + ISC\left(\exp\left(\frac{qV_{BCi}}{NC \times k \times T}\right) - 1\right)\right)$$

$$I_{BCx} = ABCX \times \left(ISRH\left(\exp\left(\frac{qV_{BCx}}{NRH \times k \times T}\right) - 1\right) + ISC\left(\exp\left(\frac{qV_{BCx}}{NC \times k \times T}\right) - 1\right)\right)$$

Abcx is used as a partitioning factor for the total base-collector current to separate the extrinsic and intrinsic components. It is also the same parameter that is used to partition the intrinsic and extrinsic base-collector depletion charges.

Depletion Capacitance/Charge

The depletion charge functions for both the base-emitter and base-collector junctions are based on the formulation from HICUM (version 2.1). This formulation and its derivatives are fully continuous for all regions of bias, and therefore appropriate for a large-signal model for CAD. The original documentation which can be found at: "http://www.iee.et.tu-dresden.de/iee/eb/comp_mod.html" describes this function in more detail.

Modifications made for the ADSHBT_Model from the original HICUM formulation are:

- Specification of a maximum capacitance (i.e., *Ccmax*, *Cemax* in the ADSHBT_Model), rather than the ratio of the maximum to zero bias capacitance (e.g., Aljei in HICUM).
- Specification of grading factors Mjcr and Mjer in the punchthrough, or fully-depleted, region (which are fixed values in HICUM).
- Computationally efficient transition functions between the three regions of biases (i.e., vjxm and vjxr). Because the same depletion charge functions are used for the base-emitter and base-collector charges, the following equations apply to both junctions. The variable x is used to denote either base-collector (*C*) or base-emitter (*E*).

$$Q_{xd}(V_x) = Q_{jxf} + Q_{jxm} + Q_{jxr} - Q_{jxcorr}$$

- The depletion capacitance can be derived in a straightforward manner (in concept) by taking the derivative of the total depletion charge (Qxd) with respect to Vx , given by the expression:

$$C_{xd}(V_x) = \frac{dQ_{xd}}{dV_x} = \frac{dQ_{jxf}}{dV_x} + \frac{dQ_{jxm}}{dV_x} + \frac{dQ_{jxr}}{dV_x} - \frac{dQ_{jxcorr}}{dV_x}$$

The derivatives of each of the four terms are provided:

$$\frac{dQ_{jxf}}{dV_x} = CxMAX\left(1-\frac{d(v_{jxr})}{dV_x}\right)$$ (forward-bias case)

$$\frac{dQ_{jxm}}{dV_x} = CJx\left(1-\frac{v_{jxm}}{VJx}\right)^{-MJx}\times\frac{d(v_{jxm})}{dV_x}$$ (partially-depleted case)

$$\frac{dQ_{jxr}}{dV_x} = C_{jx0r}\left(1-\frac{v_{jxr}}{VJx}\right)^{-MJxR}\times\frac{d(v_{jxr})}{dV_x}$$ (fully-depleted case)

$$\frac{dQ_{jxcorr}}{dV_x} = C_{jx0r}\left(1-\frac{v_{jxm}}{VJx}\right)^{-MJxR}\times\frac{d(v_{jxm})}{dV_x}$$ (correction term)

where:

$$v_{jxm} = \frac{1}{2}(v_{jxr}-V_{jPxi}+\sqrt{(V_{jPxi}+v_{jxr})^2+V_r^2})$$

$$V_r = 0.1V_{jPxi}+4\left(\frac{k\times Temp}{q}\right)$$

$$V_{jPxi} = VPTx-VJx$$

$$v_{jxr} = -0.5\left(-V_x-V_{fxi}+\sqrt{(V_{fxi}-V_x)^2+\left(\frac{k\times Temp}{q}\right)^2}\right)$$

$$V_{fxi} = VJx\left[1-\left(\frac{CxMAX}{CJx}\right)^{-(1/MJx)}\right]$$

$$C_{jx0r} = CJx\left(\frac{VJx}{VPTx}\right)^{MJx-MJx.}$$

$$\frac{d(v_{jxr})}{dV_x} = \frac{1}{2}\left(1-\frac{V_x-V_{fxi}}{\sqrt{(V_x-V_{fxi})^2+\left(\frac{k\times Temp}{q}\right)^2}}\right)$$

$$\frac{d(v_{jxm})}{dV_x} = \frac{d(v_{jxr})}{dV_x}\times\frac{1}{2}\left(1+\frac{V_{jPxi}+v_{jxr}}{\sqrt{(V_{jPxi}-v_{jxr})^2+V_r^2}}\right)$$

- *Vx* is the junction voltage (e.g., VBEi or VBCi).
- *Vpte* and *Vptc* are the punchthrough voltages for the base-emitter and base-collector junctions, respectively.

- *Cemax* and *Ccmax* are the maximum depletion capacitances when forward biased for the base-emitter and base-collector junctions, respectively.
- *Mjer* and *Mjcr* are parameters that describe the slope of the punchthrough region for the base-emitter and base-collector junctions, respectively.

The total base-emitter depletion charge is denoted Q_{BEd} and the corresponding capacitance is denoted C_{BEd}. Likewise, the total base-collector depletion capacitance is denoted Q_{BCd} and its corresponding capacitance is denoted as C_{BCd}.

An example plot of the analytical equation for the base-collector capacitance (C_{BC}) versus V_{BCi} is shown in Figure 6, with some of the notable parameters.

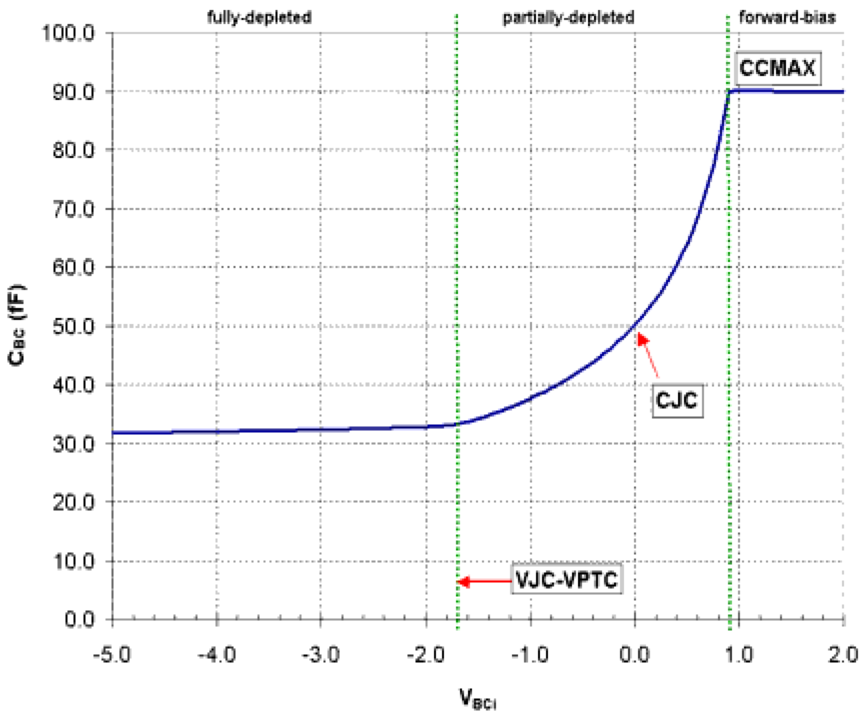


Figure 6.

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Delay Charge Equations

The delay (or *diffusion*) charge equations account for the intrinsic delay of the device. They are grouped into three separate components: base delay charge (QtB), Kirk effect charge (Qkrk), and collector delay charge (QtC). They are expressed in terms of the bias dependence of the forward collector current (Icfq) and the intrinsic base-collector voltage (VBCi). Icfq is a slightly modified version of the DC forward collector current (Icf), which is used to improve computational robustness by avoiding negative values for any bias voltage.

The base transit time (*Tfb*) is assumed to be constant due to the highly doped metallurgical base region of III-V HBTs. The increase in transit time at high currents is accounted for by Qkrk. The general form of Qkrk is leveraged from the HICUM model with some modifications. Note that Qkrk should generally account for any increase in transit time at high currents; for example, the f_t roll-off in DHBTs (which is not necessarily due to Kirk effect (or base pushout).

The collector delay charge, QtC, is a flexible function that empirically models the field-dependent electron drift velocity in the collector depletion region (modified from [4] for computational robustness). Because the depletion charge function of the base-collector junction does not contain a current dependence, QtC (in addition to Qkrk at very high currents) should be used to fit the current dependence of the intrinsic base-collector capacitance (CBCi). The *capacitance cancellation* (described in [13]) is taken into account by QtC because of its dependence with VBCi.

The delay due to the three *diffusion* charges can be expressed by taking the derivatives with respect to the forward current Icfq. Expressions for the delays and a graphical representation of them (see Figure 7) are given:

$$\tau_B = \frac{dQ_{tB}}{dI_{cfq}} = TFB$$ (base transit time)

$$\tau_{KE} = \left.\frac{\partial Q_{krk}}{\partial I_{cfq}}\right|_{V_{BCi}} = TKRK(1 - V_{BCi} \times VKRK2Inv)\left(\frac{I_{cfq}}{Ikirk2}\right)^{gKRK}$$ (Kirk effect delay)

$$Ikirk2 = IKRK \times \left(1 - \frac{V_{BCiKE}}{VKRK}\right)$$

Note that *IKRKtr* is used in the implementation of Ikirk2 to define the *transition width* in current to a 0 value. By default, *IKRKtr* is set to 1e-6; it is recommended to not change this parameter.

$$V_{BCiKE} = trans3(V_{BCi}, VKTR, VKMX)$$

$$trans3(x, x_{ir}, x_{max}) = \frac{\sqrt{(x + x_{max})^2 + x_{tr}^2} + x - x_{max}}{2}$$

$$\tau_C = \left.\frac{\partial Q_{IC}}{\partial I_{cfq}}\right|_{V_{BCi}} = 0.5$$

$$\Bigg((TFC0(1 - VTC0Inv \times trans3(V_{BCi}, VTR0, VMX0)))$$

$$+ 2 \times TCMIN(1 - VTCMINInv \times trans3(V_{BCi}, VTRMIN, VMXMIN))$$

$$- \frac{(TFC0(1 - VTC0Inv \times trans3(V_{BCi}, VTR0, VMX0)) \times (I_{cfq} - ITC(1 - V_{BCi} \times VTCInv)))}{\sqrt{(ITC(1 - V_{BCI} \times VTCInv) - I_{cfq})^2 + (ITC2(1 - V_{BCI} \times VTC2Inv))^2}}\Bigg)$$

(collector transit time)

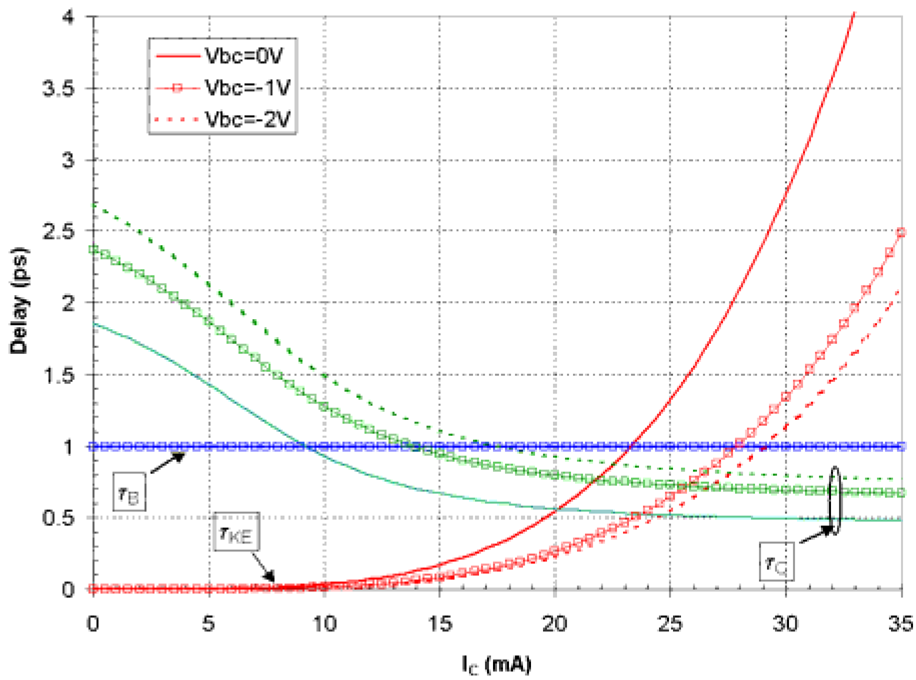

Figure 7.

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A very simple reverse delay charge is implemented by a constant reverse transit time parameter *TR*. The charge associated with this delay is equal to:

$$Q_{tR} = TR \times I_{crq}$$

Total Charge Formulation

Implementations of the base-emitter depletion charge (QBEd) and the base-collector depletion charge (QBCd) are straightforward because they solely reside between the base-emitter and base-collector junctions, respectively. Partitioning between the intrinsic and extrinsic portion of the device is accomplished by the parameters *Abex* and *Abcx*. Therefore, the intrinsic depletion charges are defined as:

$$Q_{BEid} = (1 - ABEX) \times Q_{BEd}(V_{BEi})$$

$$Q_{BCid} = (1 - ABCX) \times Q_{BCd}(V_{BCi})$$

and in turn, the extrinsic depletion charges are defined as:

$$Q_{BEx} = Q_{BExd} = (ABEX) \times Q_{BEd}(V_{BEx})$$

$$Q_{BCx} = Q_{BCxd} = (ABCX) \times Q_{BCd}(V_{BCx})$$

The delay charges (Qtb, Qtc, and Qkrk) reside only in the intrinsic region of the device (because they physically represent the time it takes for electrons to traverse the intrinsic base region and the intrinsic portion of the collector depletion region). These delay charges can be independently partitioned between the base-emitter and base-collector junctions by the partitioning factors *Fextb*, *Fextc*, and *Fexke*. These partitioning factors play an important role in defining the phase characteristics of the device at high frequencies [1,12].

The total intrinsic base-emitter and base-collector charges are defined as:

$$Q_{BEi} = Q_{BEid} + (1 - FEXTB)Q_{tB} + (1 - FEXTC)Q_{tC} + (1 - FEXKE)Q_{krk}$$

$$Q_{BCi} = Q_{BCid} + FEXTB \times Q_{tB} + FEXTC \times Q_{tC} + FEXKE \times Q_{krk} + Q_{tR}$$

The total charge at the intrinsic base (Q_{BB}) and collector (Q_{CC}) branches (as illustrated in Figure 3) are defined as:

$$Q_{BB} = Q_{BEi} + Q_{BCi} = Q_{BEid} + Q_{BCid} + Q_{tB} + Q_{tC} + Q_{krk} + Q_{tR}$$

$$Q_{CC} = -Q_{BCi} = -Q_{BCid} - FEXTB \times Q_{tB} - FEXTC \times Q_{tC} - FEXKE \times Q_{krk} - Q_{tR}$$

Noise Model

Thermal noises generated by resistors *Rbi*, *Rbx*, *Rci*, *Rcx*, and *Re* are represented by the spectral densities:

$$\frac{\langle i_{Rbi}{}^2 \rangle}{\Delta f} = \frac{4 \times k \times T}{RBI}$$

$$\frac{\langle i_{Rci}{}^2 \rangle}{\Delta f} = \frac{4 \times k \times T}{RCI}$$

$$\frac{\langle i_{Re}{}^2 \rangle}{\Delta f} = \frac{4 \times k \times T}{RE}$$

$$\frac{\langle {i_{RBx}}^2 \rangle}{\Delta f} = \frac{4 \times k \times T}{RBX}$$

$$\frac{\langle {i_{Rcx}}^2 \rangle}{\Delta f} = \frac{4 \times k \times T}{RCX}$$

The DC collector current generates shot noise represented by the spectral density:

$$\frac{\langle {i_c}^2 \rangle}{\Delta f} = 2qI_C$$

The DC base current generates shot noise represented by the spectral density:

$$\frac{\langle {i_b}^2 \rangle}{\Delta f} = 2qI_B$$

The DC base-emitter currents (IBEi and IBEx) generate flicker (1/f) noise (parameters Kf, Af, Ffe), and burst noise (parameters *Kb*, *Ab*, *Fb*) which are represented by the spectral densities:

$$\frac{\langle {i_{bei}}^2 \rangle}{\Delta f} = (KF)\frac{{I_{BEi}}^{AF}}{f^{FFE}} + (Kb)\frac{{I_{BEi}}^{AB}}{1 + \left(\frac{f}{FB}\right)^2}$$

$$\frac{\langle {i_{bex}}^2 \rangle}{\Delta f} = (KF)\frac{{I_{BEx}}^{AF}}{f^{FFE}} + (Kb)\frac{{I_{BEx}}^{AB}}{1 + \left(\frac{f}{FB}\right)^2}$$

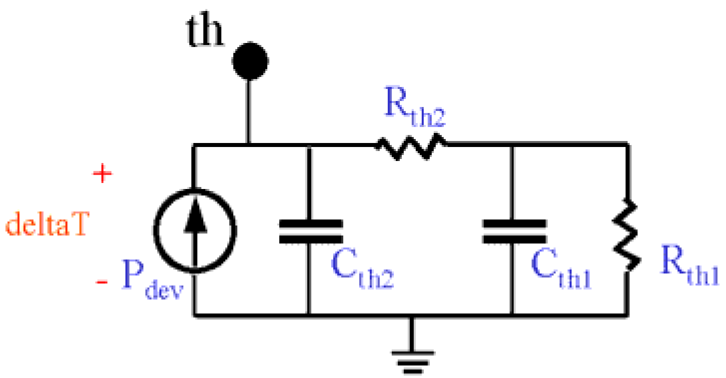
Self-Heating Model

In an isothermal model (e.g., Version 1), the electrical constitutive relations, such as the collector forward current function, and their associated parameter values, such as IS (for details, refer to Collector-Emitter Current Equations), depend on temperature only through the static value specified by Temp (defined at the device instance, ADSHBT_NPN (ADS Heterojunction Bipolar Transistor, NPN) and ADSHBT_NPN_Th (ADS Heterojunction Bipolar Transistor Thermal Terminal, NPN)).

In a real device, temperature is constantly changing in time. This is due to the interplay between electrical energy conversion into heat, as a function of signal (level and frequency, waveform, and load), and the diffusion and other mechanisms of heat transfer, including thermal coupling to other heat sources or sinks. This changing of temperature with time, in turn, changes the electrical behavior of the device, which modifies the generation of heat etc., all in a self-consistent way.

In order to model these important effects, the self-heating (dynamic electro-thermal) model (Version 2) treats temperature as a dynamical variable, on the same footing as the time-dependent voltages and currents of the electrical part of the model. To select the self-heating model, set SelfTmod=1 at the device instance. The default is SelfTmod=0. That is, self-heating is not invoked as the default. Specifically, the self-heating switch behaves in the following way:

```
If SelfTmod=0 Then
Tdev=Temp
(self-heating is OFF. The ambient temperature, Temp, is used)
ElseIf SelfTmod=1 Then
Tdev=Temp+deltaT
(self-heating is ON. All temperature dependent equations use dynamic
temperature)
ElseIf SelfTmod >0 and <1 Then
Tdev=Temp+deltaT
(if not set to 0 or 1, the model turns self-heating is ON in the range (0,1))
Else
Error returned (out of range)
EndIf
```



> *Figure 8.

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The electrical constitutive relations depend on the dynamical variable Tdev = Temp + deltaT(t), when SelfTmod=1, rather than just Temp, when SelfTmod=0. deltaT(t) represents the time-dependent temperature rise above ambient temperature. It is computed by a thermal evolution equation, which relates the total dissipated electrical power to the generation of heat, which then causes a time-dependent temperature rise based on thermal resistance and thermal capacitance. The thermal evolution equation is modeled by a thermal equivalent circuit, shown in 1148735. The circuit is in general a two-pole approximation to the diffusion equation, which governs the propagation of heat. A minimum of two poles has been shown to be needed in many practical cases for III-V devices [14].

The current source element of the thermal equivalent circuit is set equal to the total dissipated power in the device model, including contributions from the intrinsic and extrinsic active device, and all parasitic resistors. The thermal node voltage represents the time-dependent deltaT(t). A voltage probe attached to the thermal node will return the value of deltaT(t). A (dc) voltage source added between the thermal node and ground will fix the value of deltaT. If the thermal node voltage is shorted to ground, the self-heating model is de-activated, which is equivalent to setting SelfTmod=0.

The electrical constitutive relations and their associated electrical parameters are evaluated at the temperature LimitT(Temp + deltaT(t)). The LimitT function limits the time-dependent temperature to a range [-200, 500] in degrees centigrade. This limiting function prevents the device model from thermally running away to infinity, and hence not-converging. If the device instance senses a temperature at the limits, a warning will be returned indicating that the device being modeled is potentially thermally unstable at the operating conditions being simulated. It should be noted that the model is not necessarily accurate over such a wide temperature range. Typically, the model is extracted from measurements over a temperature range approximately from 20 to 100 degrees centigrade, but is typically accurate over a wider range (e.g., -50 to 0 degrees centigrade).

The temperature limiting function may cause a very slight (e.g., 10-3) fractional modification to the value Temp + deltaT(t). Therefore the temperature value used to evaluate the electrical constitutive equations and parameters is not exactly equal the value Temp + deltaT(t). The actual value of the limited temperature is reported by the DC Operating Point parameter Teff, in DC Operating Point Parameters.

By default, the general two-pole thermal equivalent circuit is reduced to a single pole thermal equivalent circuit. That is, by default, *Cth2* and *Rth2* are zero. *Cth2* and *Cth1* can be set equal to zero, even if *Rth2* and *Rth1* are non-zero. *Rth1* can be set to zero, but this completely de-activates the self-heating model and is equivalent to setting SelfTmod=0.

Under some conditions, it may be desirable to use a more complicated thermal network for the device than provided by the two-pole thermal equivalent circuit. This can be done by setting *Rth2=0*, *Cth2=0* (making sure the second pole is removed), setting *Cth1=0*, and setting Rth1 to a very large resistance (e.g., 1e9) (to make it irrelevant once a substitute thermal network is added). Then users can attach their own thermal network from the thermal terminal (fourth device terminal) to ground and/or to any other thermal terminals of other device instances.

It is important to note that the thermal resistance parameters, *Rth1* and *Rth2*, themselves are functions of the time-dependent temperature variable Tdev = Temp + deltaT(t). The temperature dependence of thermal resistance is an important property of III-V HBTs, and the modeling of it enables improved model fits.

Temperature Scaling Equations

The temperature scaling equations allow simulations at various operating temperatures, specified by Temp (defined at the device instance). The change in temperature from the operating temperature can also be specified by the parameter Trise. Tnom is defined as the nominal temperature at which the room temperature parameters are extracted. The device temperature Tdev is defined in the section Self-Heating Model.

$$rTemp = \frac{ZeroCKelvin + Tdev}{ZeroCKelvin + Tnom} \qquad ZeroCKelvin = 273.15$$

$$RBI_{Temp} = RBI \times (rTemp)^{XRB}$$

$$RBX_{Temp} = RBX \times (rTemp)^{XRB}$$

$$RCI_{Temp} = RCI \times (rTemp)^{XRC}$$

$$RCX_{Temp} = RCX \times (rTemp)^{XRC}$$

$$RE_{Temp} = RE \times (rTemp)^{XRE}$$

$$VJE_{Temp} = VJE - TVJE \times (Tdev - Tnom)$$

$$VJC_{Temp} = VJC - TVJC \times (Tdev - Tnom)$$

$$VPTE_{Temp} = (VPTE - TVPE)(Tdev - Tnom)$$

$$VPTC_{Temp} = (VPTC - TVPC)(Tdev - Tnom)$$

$$CJE_{Temp} = CJE \times \left(\frac{VJE}{VJE_{Temp}}\right)^{MJE}$$

$$CJC_{Temp} = CJC \times \left(\frac{VJC}{VJC_{Temp}}\right)^{MJC}$$

$$NF_{Temp} = NF + TNF \cdot (Tdev - Tnom)$$

$$NR_{Temp} = NR + TNR \cdot (Tdev - Tnom)$$

$$IS_{Temp} = IS \times (rTemp)^{(XTIS/NF)} \exp\left((1 - rTemp)\frac{(-EGE)}{NF \times k \times Tdev}\right)$$

$$ISH_{temp} = ISH \times (rTemp)^{(XTIH/NH)} \exp\left((1 - rTemp)\frac{(-EGE)}{NH \times k \times Tdev}\right)$$

$$ISE_{Temp} = ISE \times (rTemp)^{(XTIE/NE)} \exp\left((1 - rTemp)\frac{(-EGE)}{NE \times k \times Tdev}\right)$$

$$ISR_{Temp} = ISR \times (rTemp)^{(XTIR/NR)} \exp\left((1 - rTemp)\frac{(-EGC)}{NR \times k \times Tdev}\right)$$

$$ISC_{Temp} = ISC \times (rTemp)^{(XTIC/NC)} \exp\left((1 - rTemp)\frac{(-EGC)}{NC \times k \times Tdev}\right)$$

$$ISRH_{Temp} = ISRH \times (rTemp)^{(XTIRH/NRH)} \exp\left((1 - rTemp)\frac{(-EGC)}{NRH \times k \times Tdev}\right)$$

$$ISA_{Temp} = ISA \times (rTemp)^{(XTIS/NF)} \exp\left((1 - rTemp)\frac{(-EGE)}{NF \times k \times Tdev} + \frac{EAA}{k \times Tdev}\right)$$

$$ISB_{Temp} = ISB \times (rTemp)^{(XTIS/NF)} \exp\left((1 - rTemp)\frac{(-EGE)}{NF \times k \times Tdev} + \frac{EAB}{k \times Tdev}\right)$$

$$IKDC3_{Temp} = IKDC3 \times (rTemp)^{XTIK3}$$

$$TFB_{Temp} = TFB \times (rTemp)^{XTFB}$$

$$TCMIN_{Temp} = TCMIN \times (rTemp)^{XTCMIN}$$

$$TFC0_{Temp} = TFC0 \times (rTemp)^{XTFC0}$$

$$ITC_{Temp} = ITC \times (rTemp)^{XITC}$$

$$ITC2_{Temp} = ITC2 \times (rTemp)^{XITC2}$$

$$TKRK_{Temp} = TKRK \times (rTemp)^{XTKRK}$$

$$IKRK_{Temp} = IKRK \times (rTemp)^{XIKRK}$$

$$VKRK_{Temp} = VKRK \times (rTemp)^{XVKRK}$$

$$RTH1_{Temp} = RTH1 \times (rTemp)^{XTH1}$$

$$RTH2_{Temp} = RTH2 \times (rTemp)^{XTH2}$$

Area Scaling Equations

The Area factor (specified in the device instance) scales the device resistances, currents, and capacitances. In general, the currents and capacitances are multiplied, and the resistances are divided by the area factor.

$$RBI_{Area} = \frac{RBI}{Area}$$

$$RBX_{Area} = \frac{RBX}{Area}$$

$$RCI_{Area} = \frac{RCI}{Area}$$

$$RCX_{Area} = \frac{RCX}{Area}$$

$$RE_{Area} = \frac{RE}{Area}$$

$$CJE_{Area} = CJE \times Area$$

$$CEMAX_{Area} = CEMAX \times Area$$

$$CJC_{Area} = CJC \times Area$$

$$CCMAX_{Area} = CCMAX \times Area$$

$$IS_{Area} = IS \times Area$$

$$ISR_{Area} = ISR \times Area$$

$$ISH_{Area} = ISH \times Area$$

$$ISRH_{Area} = ISRH \times Area$$

$$ISE_{Area} = ISE \times Area$$

$$ISC_{Area} = ISC \times Area$$

$$IKDC1_{Area} = IKDC1 \times Area$$

$$IKDC2Inv_{Area} = \frac{IKDC2Inv}{Area}$$

$$IKDC3_{Area} = IKDC3 \times Area$$

$$ITC_{Area} = ITC \times Area$$

$$ITC2_{Area} = ITC2 \times Area$$

$$IKRK_{Area} = IKRK \times Area$$

$$ISA_{Area} = ISA \times Area$$

$$ISB_{Area} = ISB \times Area$$

NOTE There are several parameters that are not scaled with the Area factor. These parameters are Rth1, Cth1, Rth2, Cth2, Cpbe, Cpbc, Cpce, Lpb, Lpc, Lpe, and Ik.

Additional Information

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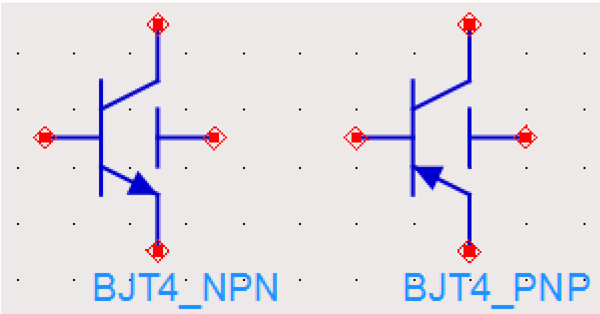
BJT4_NPN, BJT4_PNP (Bipolar Junction Transistors with Substrate Terminal, NPN, PNP)

BJT4_NPN, BJT4_PNP (Bipolar Junction Transistors w/Substrate Terminal, NPN, PNP)

Symbol



Parameters

Name	Description	Units	Default
Model	Model instance name	None	BJTM1
Area	Scaling Factor	None	1
Region	DC operating region: off=0, on=1, rev=2, sat=3	None	on
Temp	device operating temperature	°C	25
Trise	temperature rise over ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (refer to note 2)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes

Name	Description	Units	Default
_M	number of devices in parallel	None	1

- The Temp parameter specifies the physical (operating) temperature of the device; if different than the temperature at which the model parameters are valid or extracted (specified by Tnom of the associated model) certain model parameters are scaled such that the device is simulated at its operating temperature. Refer to the model to see which parameter values are scaled.
- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The fourth terminal (substrate) is available for connection to an external circuit.
- DC Operating Point Information Model = BJT_Model or EE_BJT2_Model, DC Operating Point Information Model = STBJT_Model, and DC Operating Point Information Model = MEXTRAM_Model (503) list the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information Model = BJT_Model or EE_BJT2_Mode

Name	Description	Units
Ic	Collector current	amperes
Ib	Base current	amperes
Ie	Emitter current	amperes
Is	Substrate current	amperes
Power	DC power dissipation	watts
BetaDc	DC current gain	
Gm	Forward transconductance (dIce/dVbe)	siemens
Rpi	Input resistance 1/(dIbe/dVbe)	ohms
Rmu	Feedback resistance 1/(dIbe/dVbc)	ohms
Rx	Base resistance	ohms

Name	Description	Units
Ro	Output resistance 1/(dIbe/dVbc - dIce/dVbc)	ohms
Cpi	Base-emitter capacitance	farads
Cmu	Base-internal collector capacitance	farads
Cbx	Base-external collector capacitance	farads
Ccs	Substrate capacitance	farads
BetaAc	AC current gain	
Ft	Unity current gain frequency	hertz
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

DC Operating Point Information Model = STBJT_Model

Name	Description	Units
Ic	Collector current	amperes
Is	Substrate current	amperes
Ib	Base current	amperes
Ie	Emitter current	amperes
Power	DC power dissipation	watts
BetaDc	DC current gain	
BetaAc	AC current gain	

Name	Description	Units
fTreal	Unity current gain frequency, full formula	hertz
fTappr	Unity current gain frequency, approximate formula gm/(2*PI*C)	hertz
Gm	Forward transconductance (dIce/dVbe)	siemens
Rpi	Input resistance 1/(dIbe/dVbe)	ohms
Rmu	Reedback resistance 1/(dIbe/dVbc)	ohms
Rx	Base resistance	ohms
Ro	Output resistance 1/(dIbe/dVbc - dIce/dVbc)	ohms
Rcv	Collector resistance	ohms
Cpi	Base-emitter capacitance	farads
Cmu	Base-internal collector capacitance	farads
Cbx	Base-external collector capacitance	farads
Ccs	Internal collector-substrate capacitance	farads
Cbs	Internal base-substrate capacitance	farads
Cxs	External base-substrate capacitance	farads
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

DC Operating Point Information Model = MEXTRAM_Model (503)

Name	Description	Units
Ic	Collector current	amperes
Ib	Base current	amperes
Ie	Emitter current	amperes
Is	Substrate current	amperes
Power	DC power dissipated	watts
dIc2e1_dVb2e1	(dIc2e1/dVb2e1)	siemens
Gb2e1	(dIb2e1/dVb2e1)	siemens
Gb1b2	(dIb1b2/dVb1b2)	siemens
Gb1c1	(dIb1c1/dVb1c1)	siemens
Gbc1	(dIbc1/dVbc1)	siemens
Gb2c2	(dIb2c2/dVb2c2)	siemens
Cb2e1	(dIb2e1/dVb2e1)	siemens
Cb2c2	(dIb2c2/dVb2c2)	siemens
Gb1e1	(dIb1e1/dVb1e1)	siemens
Gc1s	(dIc1s/dVc1s)	siemens
dIc2e1_dVb2c2	(dIc2e1/dVb2c2)	siemens
dIc2e1_dVb2c1	(dIc2e1/dVb2c1)	siemens
dIc1c2_dVb2e1	(dIc1c2/dVb2e1)	siemens

Name	Description	Units
dIc1c2_dVb2c2	(dIc1c2/dVb2c2)	siemens
dIc1c2_dVb2c1	(dIc1c2/dVb2c1)	siemens
dIb2c2_dVb2e1	(dIb2c2/dVb2e1)	siemens
dIb2c2_dVb2c1	(dIb2c2/dVb2c1)	siemens
dIb1b2_dVb2e1	(dIb1b2/dVb2e1)	siemens
dIb1b2_dVb2c2	(dIb1b2/dVb2c2)	siemens
dIb1b2_dVb2c1	(dIb1b2/dVb2c1)	siemens
dIc1s_dVb1c1	(dIc1s/dVb1c1)	siemens
dIc1s_dVbc1	(dIc1s/dVbc1)	siemens
Cb1b2	(dQb1b2/dVb1b2)	farads
Cc1s	(dQc1s/dVc1s)	farads
Cb1c1	(dQb1c1/dVb1c1)	farads
Cbc1	(dQbc1/dVbc1)	farads
dQb2e1_dVb2c2	(dQb2e1/dVb2c2)	farads
dQb2e1_dVb2c1	(dQb2e1/dVb2c1)	farads
dQc2b2_dVb2e1	(dQc2b2/dVb2e1)	farads
dQb2c2_dVb2c1	(dQb2c2/dVb2c1)	farads
dQb1b2_dVb2e1	(dQb1b2/dVb2e1)	farads
dQb1e1_dVb2e1	(dQb1e1/dVb2e1)	farads

Name	Description	Units
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

- This device has no default artwork associated with it.

Additional Information

References

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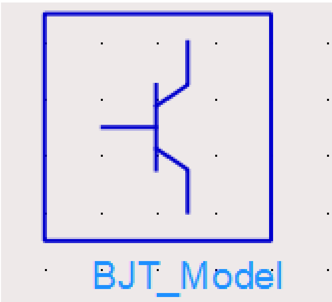
BJT Model (Bipolar Transistor Model)

BJT_Model (Bipolar Transistor Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NPN	Model type (NPN bipolar transistor): YES or NO	None	yes
PNP	Model type (PNP bipolar transistor): YES or NO	None	no
Is (Js)	Transport Saturation Current	A	1.0e-16
Bf	Ideal Maximum Forward Beta	None	100
Nf	Forward Current Emission Coefficient	None	1.0
Vaf (Vbf)	Forward Early Voltage	V	fixed at infinity [†]
Ikf (Jbf)	Corner for Forward Beta High Current Roll-off	A	fixed at infinity [†]
Ise (Jle)	base-emitter leakage saturation current	A	0.0
C2	forward leakage saturation current coefficient. If Ise is not given, Ise= C2 x Is	None	0.0
Ne (Nle)	base-emitter leakage emission coefficient	None	1.5
Br [††]	Ideal Maximum Reverse Beta	None	1.0 [††]

Nr	reverse current emission coefficient	None	1.0
Var (Vbr)	reverse early voltage	V	fixed at infinity †
Ikr (Jbr)	Corner for Reverse Beta High Current Roll-off	A	fixed at infinity †
Ke	base-emitter space charge integral multiplier	1/V	0.0
Kc	base-collector space charge integral multiplier	1/V	0.0
Isc (Jlc) ††, †††	base-collector leakage saturation current	A	0.0
C4	reverse leakage saturation current coefficient. If Isc is not given, Isc = C4 x Is.	None	0.0
Nc (Nlc)	base-collector leakage emission coefficient	None	2.0
Cbo †††	extrapolated 0-volt base-collector leakage current	A	0.0
Gbo †††	slope of Icbo vs. Vbc above Vbo	S	0.0
Vbo	slope of Icbo vs. Vbc at Vbc=0	V	0.0
Rb ††	zero-bias base resistance (Rb may be high-current dependent)	Ohm	fixed at 0
Irb (Jrb)	Current When Base Resistance Falls Halfway to Its Minimum Value	A	fixed at infinity †
Rbm	Minimum base resistance at high currents	Ohm	fixed at 0
Re ‡	emitter resistance	Ohm	fixed at 0
Rc ‡	collector resistance	Ohm	fixed at 0
Rcv ‡	variable collector resistance	Ohm	0.0
Rcm ‡	minimum collector resistance	Ohm	0.0
Dope	collector background doping concentration	cm^{-3}	1e15
Cex	current crowding exponent	None	1.0
Cco †††	current crowding normalization constant	A	1.0
Imax	explosion current beyond which diode junction current is linearized	A	1.0
Imelt	Explosion current; defaults to Imax (refer to note 3)	A	defaults to Imax
Cje ††, †††	base-emitter zero-bias depletion capacitance (Cje, Vje and Mje determine nonlinear depletion-layer capacitance for base-emitter junction)	F	0.0

Vje ††	base-emitter junction built-in potential (Cje, Vje and Mje determine nonlinear depletion-layer capacitance for base-emitter junction)	V	0.75
Mje	base-emitter junction exponential factor (Cje, Vje and Mje determine nonlinear depletion-layer capacitance for base-emitter junction)	None	fixed at 1/3
Cjc ††, †††	base-collector zero-bias depletion capacitance (Cjc, Vjc and Mjc determine nonlinear depletion-layer capacitance for base-collector junction)	F	0.0
Vjc ††	base-collector junction built-in potential (Cjc, Vjc and Mjc determine nonlinear depletion-layer capacitance for base-collector junction)	V	0.75
Mjc	base-collector junction exponential factor (Cjc, Vjc and Mjc determine nonlinear depletion-layer capacitance for base-collector junction)	None	fixed at 1/3
Xcjc (Cdis)	fraction of Cjc that goes to internal base pin	F	1.0
Cjs ††, †††	zero-bias collector substrate (ground) capacitance (Cjs, Mjs and Vjs determine nonlinear depletion-layer capacitance for C-S junction)	F	0.0
Vjs ††	substrate junction built-in potential (Cjs, Vjs, Mjs determine nonlinear depletion-layer capacitance for C-S junction)	V	0.75
Mjs	substrate junction exponential factor (Cjs, Vjs, Mjs determine nonlinear depletion-layer capacitance for C-S junction)	None	fixed at 0
Fc	forward-bias depletion capacitance coefficient	None	0.5
Xtf	coefficient of bias-dependence for Tf	None	0.0
Tf	ideal forward transit time (Tr and Tf, along with the depletion-layer capacitances model base charge storage effects; Tf may be bias-dependent)	sec	0.0
Vtf	voltage dependence of Tf on base-collector voltage	V	fixed at infinity‡
Itf (Jtf) †††	high-current effect on Tf	A	0.0
Ptf	excess phase at frequency = 1 / (Tf × 2π)	deg	0.0
Tr	ideal reverse transit time (Tr, Tf, and depletion-layer capacitances model base charge storage effects)	sec	0.0
Kf	flicker-noise coefficient	None	0.0
Af	flicker-noise exponent	None	1.0
Kb (Bnoisefc)	burst noise coefficient	None	0.0

Ab	burst noise exponent	None	1.0
Fb	burst noise corner frequency	Hz	1.0
Rbnoi	effective base noise resistance; defaults to Rb	Ohm	defaults to Rb
Iss ††, †††	collector-substrate P-N junction saturation current	A	0.0
Ns	collector-substrate P-N junction emission coefficient	None	1.0
Nk	high-current roll-off coefficient	None	0.5
Ffe	flicker noise frequency exponent	None	1.0
Lateral	lateral substrate geometry type: yes, no	None	no
RbModel	base resistance model: Spice=1, MDS=0	None	MDS
Approxqb	use the approximation for Qb vs early voltage: yes, no	None	yes
Tnom	nominal ambient temperature	°C	25
Trise	temperature rise over ambient	°C	0
Tlev	temperature equation selector (0/1/2/3)	None	0
Tlevc	temperature equation selector for capacitance (0/1/2/3)	None	0
Eg	energy gap for temperature effect on Is	eV	1.11
EgAlpha (Gap1)	energy gap temperature coefficient alpha	V/°C	7.04e-4
EgBeta (Gap2)	energy gap temperature coefficient beta	K	1108
Tbf1	Bf linear temperature coefficient	1/°C	0
Tbf2	Bf quadratic temperature coefficient	$1/(°C)^2$	0
Tbr1	Br linear temperature coefficient	1/°C	0
Tbr2	Br quadratic temperature coefficient	$1/(°C)^2$	0
Tcbc (Ctc)	Cbc linear temperature coefficient	1/°C	0
Tcbe (Cte)	Cbe linear temperature coefficient	1/°C	0
Tcbo	Cbo linear temperature coefficient	1/°C	0
Tccs (Cts)	Ccs linear temperature coefficient	1/°C	0
Tgbo	Gbo linear temperature coefficient	1/°C	0
Tikf1	Ikf linear temperature coefficient	1/°C	0
Tikf2	Ikf quadratic temperature coefficient	$1/(°C)^2$	0

Tikr1	Ikr linear temperature coefficient	1/°C	0
Tikr2	Ikr quadratic temperature coefficient	1/ (°C)^2	0
Tirb1	Irb linear temperature coefficient	1/°C	0
Tirb2	Irb quadratic temperature coefficient	1/ (°C)^2	0
Tis1	Is/Ibe/Ibc linear temperature coefficient	1/°C	0
Tis2	Is/Ibe/Ibc quadratic temperature coefficient	1/ (°C)^2	0
Tisc1	Isc linear temperature coefficient	1/°C	0
Tisc2	Isc quadratic temperature coefficient	1/ (°C)^2	0
Tise1	Ise linear temperature coefficient	1/°C	0
Tise2	Ise quadratic temperature coefficient	1/ (°C)^2	0
Tiss1	Iss linear temperature coefficient	1/°C	0
Tiss2	Iss quadratic temperature coefficient	1/ (°C)^2	0
Titf1	Itf linear temperature coefficient	1/°C	0
Titf2	Itf quadratic temperature coefficient	1/ (°C)^2	0
Tmjc1	Mjc linear temperature coefficient	1/°C	0
Tmjc2	Mjc quadratic temperature coefficient	1/ (°C)^2	0
Tmje1	Mje linear temperature coefficient	1/°C	0
Tmje2	Mje quadratic temperature coefficient	1/ (°C)^2	0
Tmjs1	Mjs linear temperature coefficient	1/°C	0
Tmjs2	Mjs quadratic temperature coefficient	1/ (°C)^2	0
Tnc1	Nc linear temperature coefficient	1/°C	0
Tnc2	Nc quadratic temperature coefficient	1/ (°C)^2	0
Tne1	Ne linear temperature coefficient	1/°C	0

Tne2	Ne quadratic temperature coefficient	1/ $(°C)^2$	0
Tnf1	Nf linear temperature coefficient	1/°C	0
Tnf2	Nf quadratic temperature coefficient	1/ $(°C)^2$	0
Tnr1	Nr linear temperature coefficient	1/°C	0
Tnr2	Nr quadratic temperature coefficient	1/ $(°C)^2$	0
Tns1	Ns linear temperature coefficient	1/°C	0
Tns2	Ns quadratic temperature coefficient	1/ $(°C)^2$	0
Trb1	Rb linear temperature coefficient	1/°C	0
Trb2	Rb quadratic temperature coefficient	1/ $(°C)^2$	0
Trc1	Rc linear temperature coefficient	1/°C	0
Trc2	Rc quadratic temperature coefficient	1/ $(°C)^2$	0
Tre1	Re linear temperature coefficient	1/°C	0
Tre2	Re quadratic temperature coefficient	1/ $(°C)^2$	0
Trm1	Rbm linear temperature coefficient	1/°C	0
Trm2	Rbm quadratic temperature coefficient	1/ $(°C)^2$	0
Ttf1	Tf linear temperature coefficient	1/°C	0
Ttf2	Tf quadratic temperature coefficient	1/ $(°C)^2$	0
Ttr1	Tr linear temperature coefficient	1/°C	0
Ttr2	Tr quadratic temperature coefficient	1/ $(°C)^2$	0
Tvaf1	Vaf linear temperature coefficient	1/°C	0
Tvaf2	Vaf quadratic temperature coefficient	1/ $(°C)^2$	0
Tvar1	Var linear temperature coefficient	1/°C	0
Tvar2	Var quadratic temperature coefficient	1/ $(°C)^2$	0

Tvjc	Vjc linear temperature coefficient	1/°C	0
Tvje	Vje linear temperature coefficient	1/°C	0
Tvjs	Vjs linear temperature coefficient	1/°C	0
Tvtf1	Vtf linear temperature coefficient	1/°C	0
Tvtf2	Vtf quadratic temperature coefficient	1/(°C)^2	0
Txtf1	Xtf linear temperature coefficient	1/°C	0
Txtf2	Xtf quadratic temperature coefficient	1/(°C)^2	0
Xtb (Tb)	temperature exponent for forward- and reverse-beta. Xtb partly defines dependence of base current on temp.	None	0.0
Xti (Pt)	temperature exponent for saturation current	None	3.0
wVsubfwd (Vsubfwd)	substrate junction forward bias (warning)	V	None
wBvsub (Bvsub)	substrate junction reverse breakdown voltage (warning)	V	None
wBvbe (Bvbe)	base-emitter reverse breakdown voltage (warning)	V	None
wBvbc (Bvbc)	base-collector reverse breakdown voltage (warning)	V	None
wVbcfwd (Vbcfwd)	base-collector forward bias (warning)	V	None
wIbmax	maximum base current (warning)	A	None
wIcmax	maximum collector current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None
† A value of 0.0 is interpreted as infinity. †† This parameter value varies with temperature based on model Tnom and device Temp. ††† This parameter value scales with Area. ‡ This parameter value scales with 1/Area.			

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model  modelname  BJT [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *BJT*. Use either parameter NPN=yes or PNP=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

```
model  Npn1  BJT  \
  NPN=yes Is=1.5e- Cjc=2.
```

- BJT_Model supplies values for BJT devices (BJT4 devices include a substrate terminal). Adapted from the integral charge control model of Gummel and Poon, it includes several effects at high bias levels. It reduces to the simpler Ebers-Moll model when certain parameters required for Gummel-Poon are not specified.
  The DC characteristics of a modified Gummel-Poon BJT are defined by:
  - Is, Bf, Ikf, Nf, Ise, and Ne, which determine forward-current gain characteristics.
  - Is, Br, Ikr, Nr, Isc, and Nc, which determine reverse-current gain characteristics
  - Vaf and Var, which determine output conductances for forward and reverse regions.
  - Is (saturation current). Eg and Xti partly determine temperature dependence of Is.
  - Xtb determines base current temperature dependence.
  - Rb, Rc, and Re are ohmic resistances. Rb is current dependent.
    The nonlinear depletion layer capacitances are determined by:
  - Cje, Vje, and Mje for the base-emitter junction.
  - Cjc, Vjc, and Mjc for the base-collector junction.
  - Cjs, Vjs, and Mjs for the collector-substrate junction (if vertical BJT), or for the base-substrate junction (if lateral BJT)
    The collector or base to substrate junction is modeled as a PN junction.
- Substrate Terminal
  Five model parameters control the substrate junction modeling: Cjs, Vjs and Mjs model the nonlinear substrate junction capacitance; Iss and Ns model the nonlinear substrate P-N junction current.
  When BJT4_NPN or BJT4_PNP devices are used, explicitly connect the substrate terminal as required.
  When 3-terminal BJT_NPN or BJT_PNP devices are used, the substrate terminal is implicitly grounded. This should not affect the simulation if the substrate model parameters Cjs and Iss are not specified, as they default to 0.
  The model Lateral parameter changes the connection of the substrate junction. At its default setting of no, the substrate junction models a vertical bipolar transistor with the substrate junction connected to

the collector. When Lateral=yes, a lateral bipolar transistor is modeled with the substrate junction connected to the base.

- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).

DC Equations

There are two components of base current associated with the bias on each junction. For the emitter junction, an ideal exponential voltage term *Ibei* arises due to recombination in the inactive base region and carrier injected into the emitter. A non-ideal exponential voltage term *Iben* predominates at low bias due to recombination in the emitter junction spaced charge region.

$$Ibei = Is\left(\exp\left(\frac{Vbe}{Nf \times V_T}\right) - 1\right)$$

$$Iben = Ise\left(\exp\left(\frac{Vbe}{Ne \times V_T}\right) - 1\right)$$

Similarly, emission and recombination near the collector junction result in similar terms.

$$Ibci = Is\left(\exp\left(\frac{Vbc}{Nr \times V_T}\right) - 1\right)$$

$$Ibcn = Isc\left(\exp\left(\frac{Vbc}{Nc \times V_T}\right) - 1\right)$$

Collector Leakage Current

If Vbo is specified, when Vbc < 0 the collector leakage current Icbo is modeled by

$$Icbo = (-Cbo + Gbo \times Vbc)\left[1 - \exp\left(\frac{Vbc}{Vbo}\right)\right]$$

Base Terminal Current (without substrate current)

$$Ib = \frac{Ibei}{Bf} + Iben + \frac{Ibci}{Br} + Ibcn$$

Collector Terminal Current (without substrate current)

$$Ic = \frac{Ibei - Ibci}{Qb} - \frac{Ibci}{Br} - Ibcn$$

Collector-Emitter Current

$$Ice = \frac{Ibei - Ibci}{Qb}$$

where the normalized base charge is Qb.

If Approxqb = yes

$$Qb = \frac{Q1}{2} \times \left(1 + \left(1 + 4\left(\frac{Ibei}{Ikf} + \frac{Ibci}{Ikr}\right)\right)^{Nk}\right)$$

where

$$Q1 = \frac{1}{1 - \dfrac{Vbc}{Vaf} - \dfrac{Vbe}{Var}}$$

if neither Ke nor Kc is specified

otherwise

$$Q1 = 1 + \int_0^{Vbe} f(Ke, Vje, Mje)dv + \int_0^{Vbc} f(Kc, Vjc, Mjc)dv$$

where *f*( ) is defined as:

$$f(K, V, M) = \begin{cases} K\left(1 - \dfrac{v}{V}\right)^{-M} & \text{if } v < Fc \times V \\ K\left(\dfrac{1 - Fc(1+M) + M\left(\dfrac{v}{V}\right)}{(1 - Fc)^{(1+M)}}\right) & \text{if } v \geq Fc \times V \end{cases}$$

If Approxqb = no

$$Qb = \frac{1 + \dfrac{Vbc}{Vaf} + \dfrac{Vbc}{Var}}{2} \times \left(1 + \left(1 + 4\left(\frac{Ibei}{Ikf} + \frac{Ibci}{Ikr}\right)\right)^{Nk}\right)$$

Substrate Current

Lateral = no (Vertical BJT)

$$Isc = Iss\left(\exp\left(\frac{Vsc}{Ns \times V_T}\right) - 1\right)$$

Lateral = yes (Lateral BJT)

$$Ibs = Iss\left(\exp\left(\frac{Vbs}{Ns \times V_T}\right) - 1\right)$$

Base Resistance

The base resistance *RBb* consists of two separate resistances. The contact and sheet resistance *Rbm* and the resistance of the internal (active) base register, *vbi,* which is a function of the base current.

If Rbm is zero or IB < 0, RBb = Rb

If *Ivb* is not specified

$$RBb = Rbm + \frac{Rb - Rbm}{Qb}$$

If *Ivb* is specified

RBb = Rbm + vbi

There are two equations for vbi; *RbModel* determines which equations to use.

If RbModel = Spice

$$vbi = 3(Rb - Rbm)\left(\frac{\tan(z) - z}{z\tan^2(z)}\right)$$

where

$$z = \frac{\sqrt{1 + \frac{144}{\pi^2} \times \frac{Ib}{Irb}} - 1}{\frac{24}{\pi^2}\sqrt{\frac{Ib}{Irb}}}$$

If RbModel = MDS

$$vbi = \frac{Rb - Rbm}{\sqrt{1 + 3\left(\frac{Ib}{Irb}\right)^{0.852}}}$$

Nonlinear Collector Resistance

If Rcv is specified

$$Rc = Rcv\left(\frac{1 + \left(\frac{Ic}{CCo}\right)^{Cex}}{1 + \left(\frac{ni}{Dope}\right)^{2}\exp\left(\frac{Vbc}{vt}\right)}\right) + Rcm$$

where
ni is intrinsic carrier concentration for _Si
vt_ is thermal voltage

Capacitance Equations

Capacitances in the small-signal model contain the junction depletion layer capacitance and the diffusion capacitance due to the minority charge storage in the base region.

Base-Emitter Depletion Capacitances

Vbe < Fc x Vje

$$Cbedep = Cje\left(1 - \frac{Vbe}{vje}\right)^{-Mje}$$

Vbe ≥ Fc x Vje

$$Cbedep = Cje\left(\frac{1 - Fc(1 + Mje) + Mje\left(\frac{Vbe}{Vje}\right)}{(1 - fc)^{(1 + Mje)}}\right)$$

Base-Emitter Diffusion Capacitance

$$Cbediff = \frac{d(Qbediff)}{d(Vbe)}$$

where the transit charge

$$Qbdiff = Tf\left(1 + xtf \times \exp\left(\frac{Vbc}{1.442695Vtf}\right)\left(\frac{Ibei}{Ibei + Itf}\right)^{2} \times \frac{Ibei}{Qb}\right)$$

Cbe = Cbedep + Cbediff

Base-Collector Depletion Capacitances

When Xcjc is not equal to one, the base-collector depletion capacitance is modeled as a distributed capacitance.
The internal base-internal collector depletion capacitance
Vbc < Fc x Vjc

$$Cbcdep = Xcjc \times Cjc\left(1 - \frac{Vbc}{Vjc}\right)^{-Mjc}$$

Vbc ≥ Fc x Vjc

$$Cbcdep = Xcjc \times Cje\left(\frac{1 - Fc(1 + Mjc) + Mjc\left(\frac{Vbc}{Vjc}\right)}{(1 - fc)^{(1 + Mjc)}}\right)$$

The external base-internal collector depletion capacitance
VBc < fc x Vjc

$$Cbcdep = (1 - Xcjc)Cjc\left(1 - \frac{Vbc}{Vjc}\right)^{-Mjc}$$

VBc ≥ Fc x Vjc

$$Cbcdep = (1 - Xcjc)Cjc\left(\frac{1 - Fc(1 + Mjc) + Mjc\left(\frac{Vbc}{Vjc}\right)}{(1 - fc)^{(1 + Mjc)}}\right)$$

CBc = CBcdep

Base-Collector Diffusion Capacitances

$$Cbcdiff = \frac{d(Qbcdiff)}{d(Vbc)}$$

where the transit charge
Qbcdiff = Tr × Ibci
Cbc = Cbcdep + Cbcdiff

Base-Collector Substrate Capacitance

Lateral = no (vertical BJT)
Vsc < 0

$$Csc = Cjs\left(1 - \frac{Vsc}{Vjs}\right)^{-Mjs}$$

Vsc ≥ 0

$$Csc = Cjs\left(1 + Mjs \times \frac{Vsc}{Vjs}\right)$$

Lateral = yes (Lateral BJT)
Vbs < 0

$$Cbs = Cjs\left(1 - \frac{Vbs}{Vjs}\right)^{-Mjs}$$

Vbs ≥ 0

$$Cbs = Cjs\left(1 + Mjs \times \frac{Vbs}{Vjs}\right)$$

Excess Phase

An additional phase shift at high frequencies is added to the transconductance model to account for the distributed phenomena in the transistor. The effective phase shift added to the *Ibei* item in the *Ic* equation is calculated as follows for *Ibei* (with excess phase):

$$Ibei = \frac{3\omega_0^{\;2}}{s^2 + 3\omega_0 s + 3\omega_0^{\;2}} \times Ibei$$

where

$$\omega_0 = \frac{1}{Ptf \times Tf \times \frac{\pi}{180}}$$

The current implementation in ADS applies the shifting factor to collector current IC.

Temperature Scaling

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device Temp parameter. (Temperatures in the following equations are in Kelvin.)
The energy bandgap E_G varies as:

$$E_G(T) = 1.16 - \frac{7.02 \times 10^{-4} T^2}{T + 1108}$$

Tlev = 0, 1, 3

$$E_G(T) = Eg - \frac{EgAlpha T^2}{T + EgBeta}$$

Tlev = 2
The intrinsic carrier concentration n_i for silicon varies as:

$$n_i(T) = 1.45 \times 10^{10}\left(\frac{T}{300.15}\right)^{3/2} \exp\left(\frac{E_G(300.15)}{2k300.15/q} - \frac{E_G(T)}{2k(T/q)}\right)$$

Saturation currents Is, Ise, Isc, and Iss scale as:

if Tlev=0

$$Ise^{NEW} = Ise\left(\frac{Temp}{Tnom}\right)^{-Xtb} \exp\left[\frac{Eg}{NekTnom/q} - \frac{Eg}{NekTemp/q} + \frac{Xti}{Ne}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Isc^{NEW} = Isc\left(\frac{Temp}{Tnom}\right)^{-Xtb} \exp\left[\frac{Eg}{NckTnom/q} - \frac{Eg}{NckTemp/q} + \frac{Xti}{Nc}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Iss^{NEW} = Iss\left(\frac{Temp}{Tnom}\right)^{-Xtb} \exp\left[\frac{Eg}{NskTnom/q} - \frac{Eg}{NskTemp/q} + \frac{Xti}{Ns}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Is^{NEW} = Is\exp\left[\frac{E_G}{kTnom/q} - \frac{E_G}{kTemp/q} + Xti\ln\left(\frac{Temp}{Tnom}\right)\right]$$

if Tlev=1

$$Ise^{NEW} = \frac{Ise}{1 + Xtb(Temp - Tnom)} \exp\left[\frac{Eg}{NekTnom/q} - \frac{Eg}{NekTemp/q} + \frac{Xti}{Ne}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Isc^{NEW} = \frac{Isc}{1 + Xtb(Temp - Tnom)} \exp\left[\frac{Eg}{NckTnom/q} - \frac{Eg}{NckTemp/q} + \frac{Xti}{Nc}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Iss^{NEW} = \frac{Iss}{1 + Xtb(Temp - Tnom)} \exp\left[\frac{Eg}{NskTnom/q} - \frac{Eg}{NskTemp/q} + \frac{Xti}{Ns}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Is^{NEW} = Is\exp\left[\frac{Eg}{kTnom/q} - \frac{Eg}{kTemp/q} + Xti\ln\left(\frac{Temp}{Tnom}\right)\right]$$

if Tlev=2

$$Ise^{NEW} = Ise\left(\frac{Temp}{Tnom}\right)^{-Xtb} \exp\left[\frac{E_G(Tnom)}{NekTnom/q} - \frac{E_G(Temp)}{NekTemp/q} + \frac{Xti}{Ne}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Isc^{NEW} = Isc\left(\frac{Temp}{Tnom}\right)^{-Xtb} \exp\left[\frac{E_G(Tnom)}{NckTnom/q} - \frac{E_G(Temp)}{NckTemp/q} + \frac{Xti}{Nc}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Iss^{NEW} = Iss\left(\frac{Temp}{Tnom}\right)^{-Xtb} \exp\left[\frac{E_G(Tnom)}{NskTnom/q} - \frac{E_G(Temp)}{NskTemp/q} + \frac{Xti}{Ns}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Is^{NEW} = Is\exp\left[\frac{E_G(Tnom)}{kTnom/q} - \frac{E_G(Temp)}{kTemp/q} + Xti\ln\left(\frac{Temp}{Tnom}\right)\right]$$

if Tlev=3

$$Ise^{NEW} = Ise^{(1 + Tise1(Temp-Tnom) + Tise2(Temp-Tnom)^2)}$$

$$Isc^{NEW} = Isc^{(1 + Tisc1(Temp-Tnom) + Tisc2(Temp-Tnom)^2)}$$

$$Iss^{NEW} = Iss^{(1 + Tiss1(Temp-Tnom) + Tiss2(Temp-Tnom)^2)}$$

$$Is^{NEW} = Is^{(1 + Tis1(Temp-Tnom) + Tis2(Temp-Tnom)^2)}$$

Series resistances Rc, Re, Rb, and Rbm scale as:

$$Rc^{NEW} = Rc[1 + Trc1(Temp-Tnom) + Trc2(Temp-Tnom)^2]$$

$$Re^{NEW} = Re[1 + Tre1(Temp-Tnom) + Tre2(Temp-Tnom)^2]$$

$$Rb^{NEW} = Rb[1 + Trb1(Temp-Tnom) + Trb2(Temp-Tnom)^2]$$

$$Rbm^{NEW} = Rbm[1 + Trm1(Temp-Tnom) + Trm2(Temp-Tnom)^2]$$

Emission coefficients Nc, Ne, Nf, Nr, and Ns scale as:

$$Nc^{NEW} = Nc[1 + Tnc1(Temp-Tnom) + Tnc2(Temp-Tnom)^2]$$

$$Ne^{NEW} = Ne[1 + Tne1(Temp-Tnom) + Tne2(Temp-Tnom)^2]$$

$$Nf^{NEW} = Nf[1 + Tnf1(Temp-Tnom) + Tnf2(Temp-Tnom)^2]$$

$$Nr^{NEW} = Nr[1 + Tnr1(Temp-Tnom) + Tnr2(Temp-Tnom)^2]$$

$$Ns^{NEW} = Ns[1 + Tns1(Temp-Tnom) + Tns2(Temp-Tnom)^2]$$

Transmit times Tf and Tr scale as:

$$Tf^{NEW} = Tf[1 + Ttf1(Temp-Tnom) + Ttf2(Temp-Tnom)^2]$$

$$Tr^{NEW} = Tr[1 + Ttr1(Temp-Tnom) + Ttr2(Temp-Tnom)^2]$$

High current effect on transit time Itf scales as:

$$Itf^{NEW} = Itf[1 + Titf1(Temp-Tnom) + Titf2(Temp-Tnom)^2]$$

Vbc dependence on transmit time Vtf scales as:

$$Vtf^{NEW} = Vtf[1 + Tvtf1(Temp-Tnom) + Tvtf2(Temp-Tnom)^2]$$

Bias dependence on transmit time Xtf scales as:

$$Xtf^{NEW} = Xtf[1 + Txtf1(Temp-Tnom) + Txtf2(Temp-Tnom)^2]$$

Early voltage Vaf and Var scale as:

$$Vaf^{NEW} = Vaf[1 + Tvaf1(Temp - Tnom) + Tvaf2(Temp - Tnom)^2]$$

$$Var^{NEW} = Var[1 + Tvar1(Temp - Tnom) + Tvar2(Temp - Tnom)^2]$$

Forward and reverse beta Bf and Br scale as:

if Tlev = 0

$$Bf^{NEW} = Bf\left(\frac{Temp}{Tnom}\right)^{Xtb}(1 + Tbf1(Temp - Tnom) + Tbf2(Temp - Tnom)^2)$$

$$Br^{NEW} = Br\left(\frac{Temp}{Tnom}\right)^{Xtb}(1 + Tbr1(Temp - Tnom) + Tbr2(Temp - Tnom)^2)$$

if Tlev = 1

$$Bf^{NEW} = Bf(1 + Xtb(Temp - Tnom))(1 + Tbf1(Temp - Tnom) + Tbf2(Temp - Tnom)^2)$$

$$Br^{NEW} = Br(1 + Xtb(Temp - Tnom))(1 + Tbr1(Temp - Tnom) + Tbr2(Temp - Tnom)^2)$$

if Tlev = 2

$$Bf^{NEW} = Bf\left(\frac{Temp}{Tnom}\right)^{Xtb}(1 + Tbf1(Temp - Tnom) + Tbf2(Temp - Tnom)^2)$$

$$Br^{NEW} = Br\left(\frac{Temp}{Tnom}\right)^{Xtb}(1 + Tbr1(Temp - Tnom) + Tbr2(Temp - Tnom)^2)$$

if Tlev = 3

$$Bf^{NEW} = Bf(1 + Tbf1(Temp - Tnom) + Tbf2(Temp - Tnom)^2)$$

$$Br^{NEW} = Br(1 + Tbr1(Temp - Tnom) + Tbr2(Temp - Tnom)^2)$$

Currents Ikf, Ikr, and Irb scale as:

if Tlev = 0, 1, 2

$$Ikf^{NEW} = Ikf(1 + Tikf1(Temp - Tnom) + Tikf2(Temp - Tnom)^2)$$

$$Ikr^{NEW} = Ikr(1 + Tikr1(Temp - Tnom) + Tikr2(Temp - Tnom)^2)$$

$$Irb^{NEW} = Irb(1 + Tirb1(Temp - Tnom) + Tirb2(Temp - Tnom)^2)$$

if Tlev = 3

$$Ikf^{NEW} = Ikf^{(1 + Tikf1(Temp - Tnom) + Tikf2(Temp - Tnom)^2)}$$

$$Ikr^{NEW} = Ikr^{(1 + Tikr1(Temp - Tnom) + Tikr2(Temp - Tnom)^2)}$$

$$Irb^{NEW} = Irb^{(1 + Tirb1(Temp - Tnom) + Tirb2(Temp - Tnom)^2)}$$

Junction depletion capacitance Cjo and Cjsw and junction potentials Vje, Vjc, and Vjs vary as:
if Tlevc = 0

$$Vje^{NEW} = Vje\frac{Temp}{Tnom} + \frac{2kTemp}{q}\ln\left(\frac{n_i(Tnom)}{n_i(Temp)}\right)$$

$$Vjc^{NEW} = Vjc\frac{Temp}{Tnom} + \frac{2kTemp}{q}\ln\left(\frac{n_i(Tnom)}{n_i(Temp)}\right)$$

$$Vjcs^{NEW} = Vjs\frac{Temp}{Tnom} + \frac{2kTemp}{q}\ln\left(\frac{n_i(Tnom)}{n_i(Temp)}\right)$$

$$Cje^{NEW} = Cje\left(1 + Mje\left[1 + 4\times 10^{-4}(Temp - Tnom) - \frac{Vje^{NEW}}{Vje}\right]\right)$$

$$Cjc^{NEW} = Cjc\left(1 + Mjc\left[1 + 4\times 10^{-4}(Temp - Tnom) - \frac{Vjc^{NEW}}{Vjc}\right]\right)$$

$$Cjs^{NEW} = Cjs\left(1 + Mjs\left[1 + 4\times 10^{-4}(Temp - Tnom) - \frac{Vjs^{NEW}}{Vjs}\right]\right)$$

if Tlevc = 1

$$Vje^{NEW} = Vje - Tvje(Temp - Tnom)$$

$$Vjc^{NEW} = Vjc - Tvjc(Temp - Tnom)$$

$$Vjs^{NEW} = Vjs - Tvjs(Temp - Tnom)$$

$$Cje^{NEW} = Cje[1 + Tcje(Temp - Tnom)]$$

$$Cjc^{NEW} = Cjc[1 + Tcjc(Temp - Tnom)]$$

$$Cjs^{NEW} = Cjs[1 + Tcjs(Temp - Tnom)]$$

if Tlevc = 2

$$Vje^{NEW} = Vje - Tvje(Temp - Tnom)$$

$$Vjc^{NEW} = Vjc - Tvjc(Temp - Tnom)$$

$$Vjs^{NEW} = Vjs - Tvjs(Temp - Tnom)$$

$$Cje^{NEW} = Cje\left(\frac{Vje}{Vje^{NEW}}\right)^{Mjc}$$

$$Cjc^{NEW} = Cjc\left(\frac{Vjc}{Vjc^{NEW}}\right)^{Mjc}$$

$$Cjs^{NEW} = Cjs\left(\frac{Vjs}{Vjs^{NEW}}\right)^{Mjs}$$

if Tlevc = 3
if Tlev = 0, 1, 3

$$dVjedT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (1.16 - E_G(Tnom))\frac{Tnom + 2\times 1108}{Tnom + 1108} - Vje\right)\frac{1}{Tnom}$$

$$dVjcdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (1.16 - E_G(Tnom))\frac{Tnom + 2\times 1108}{Tnom + 1108} - Vjc\right)\frac{1}{Tnom}$$

$$dVjsdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (1.16 - E_G(Tnom))\frac{Tnom + 2\times 1108}{Tnom + 1108} - Vjs\right)\frac{1}{Tnom}$$

if Tlev = 2

$$dVjedT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (Eg - E_G(Tnom))\frac{Tnom + 2EgBeta}{Tnom + EgBeta} - Vje\right)\frac{1}{Tnom}$$

$$dVjcdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (Eg - E_G(Tnom))\frac{Tnom + 2EgBeta}{Tnom + EgBeta} - Vjc\right)\frac{1}{Tnom}$$

$$dVjsdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (Eg - E_G(Tnom))\frac{Tnom + 2EgBeta}{Tnom + EgBeta} - Vjs\right)\frac{1}{Tnom}$$

$$Vje^{NEW} = Vje + dVjedT(Temp - Tnom)$$

$$Vjc^{NEW} = Vjc + dVjcdT(Temp - Tnom)$$

$$Vjs^{NEW} = Vjs + dVjsdT(Temp - Tnom)$$

$$Cje^{NEW} = Cje\left(1 - \frac{dVjedT(Temp - Tnom)}{2Vje}\right)$$

$$Cjc^{NEW} = Cjc\left(1 - \frac{dVjcdT(Temp - Tnom)}{2Vjc}\right)$$

$$Cjs^{NEW} = Cjs\left(1 - \frac{dVjsdT(Temp - Tnom)}{2Vjs}\right)$$

Junction grading coefficients Mje, Mjc, and Mjs scale as:

$$Mje^{NEW} = Mje[1 + Tmje1(Temp - Tnom) + Tmje2(Temp - Tnom)^2]$$

$$Mjc^{NEW} = Mjc[1 + Tmjc1(Temp - Tnom) + Tmjc2(Temp - Tnom)^2]$$

$$Mjs^{NEW} = Mjs[1 + Tmjs1(Temp - Tnom) + Tmjs2(Temp - Tnom)^2]$$

Base-collector leakage current parameters Cbo and Gbo scale as:

$$Cbo^{NEW} = Cbo \times Exp[Tcbo(Temp - Tnom)]$$

$$Gbo^{NEW} = Gbo \times Exp[Tgbo(Temp - Tnom)]$$

Noise Model

Thermal noise generated by resistors Rb, Rc, and Re is characterized by the spectral density:

$$\frac{<i_{Rc}^2>}{\Delta f} = \frac{4kT}{Rc}$$

$$\frac{<i_{Rb}^2>}{\Delta f} = \frac{4kT}{Rb} \frac{Rbnoi}{Rb}$$

$$\frac{<i_{Re}^2>}{\Delta f} = \frac{4kT}{Re}$$

Shot noise, flicker noise (Kf, Af, Ffe), and burst noise (Kb, Ab, Fb) generated by the DC base current is characterized by the spectral density:

$$\frac{<i_{be}^2>}{\Delta f} = 2qI_{BE} + Kf\frac{I_{BE}^{Af}}{f^{Ffe}} + Kb\frac{IBE^{Ab}}{1 + (f/Fb)^2}$$

Shot noise generated by the DC collector-to-emitter current is characterized by the spectral density:

$$\frac{<i_{ce}^2>}{\Delta f} = 2qI_{CE}$$

Shot noise generated by the DC collector-to-substrate current (BJT4 only) is characterized by the spectral density:

$$\frac{<i_{cs}^2>}{\Delta f} = 2qI_{CS}$$

In the preceding expressions, *k* is Boltzmann's constant, *T* is the operating temperature in Kelvin, *q* is the electron charge, k_f, a_f, f_{fe}, k_b, a_b, and f_b are model parameters, *f* is the simulation frequency, and Δf is the noise bandwidth.

Area Dependence of the BJT Model Parameters

The AREA factor used for the BJT model determines the number of equivalent parallel devices of a specified model. The BJT model parameters affected by the AREA factor are:

> *Is = Is × AREA*
> *Ise = Ise × AREA*
> *Isc = Isc × AREA*
> *Ikf = Ikf × AREA*
> *Ikr = Ikr × AREA*
> *Irb = Ibr × AREA*
> *Itf = Itf × AREA*
> *Cjc(0) = Cjc(0) × AREA*
> *Cje(0) = Cje(0) × AREA*
> *Cjs(0) = Cjs(0) × AREA*
> *Rb = Rb/AREA*
> *Rbm = Rbm/AREA*
> *Rbnoi = Rbnoi/AREA*
> *Re = Re/AREA*
> *Rc = Rc/AREA*

The default value for the AREA parameter is 1.

DC Operating Point Device Information

Definitions

- Ic (collector current)
- Ib (base current)
- Ie (emitter current)
- Is (substrate current)
- Ice (collection-emitter current)
- power (dissipated power)
  BetaDc Ic/Ib
  where
  Ib = sign(ib) x Max (Abs(Ib), ie-20)

  $$Gm = \frac{dIce}{dVbe} + \frac{dIce}{dVbc}$$

$$Rpi = \frac{1}{\left(\frac{dIb}{dVbc}\right)}$$

$$Rmu = \frac{1}{\left(\frac{dIb}{dVbc}\right)}$$

Rx = RBb

$$Ro = \frac{-1}{\left(\frac{dIce}{dVbc}\right)}$$

Cpi = Cbe
Cmu = Cbc
Cbx = CBx
Ccs = Ccs if vertical BJT
= Cbs if lateral BJT
BetAc = Gm x Rpi

$$Ft = \frac{1}{(2\pi(tau + (Rc + Re)(Cmu + Cbx)))}$$

where

$$tau = \frac{Max(Cpi + Cnm + Cbx, ie - 20)}{Max(Gm, ie - 20)}$$

$$Vbe = \nu(B) - \nu(E)$$

$$Vbc = \nu(B) - \nu(C)$$

$$Vce = \nu(BC) - \nu(E)$$

Additional Information

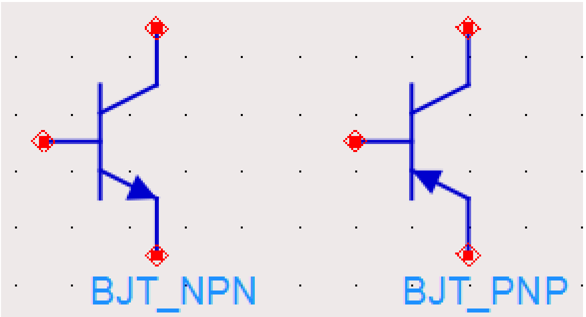
References

- P. Antognetti and G. Massobrio, *Semiconductor device modeling with SPICE*, New York: McGraw-Hill, Second Edition 1993.

BJT NPN, BJT PNP (Bipolar Junction Transistors NPN, PNP)

BJT_NPN, BJT_PNP (Bipolar Junction Transistors NPN, PNP)

Symbol



Parameters

Name	Description	Units	Default
Model	Model instance name	None	BJTM1
Area	Scaling Factor	None	1.0
Region	DC operating region: 0 = off, 1 = on, 2 = rev, 3 = sat	None	on
Temp	device operating temperature	°C	25
Trise	temperature rise over ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (see note 2)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

- The Temp parameter specifies the physical (operating) temperature of the device; if different than the temperature at which the model parameters are valid or extracted (specified by Tnom of the associated model) certain model parameters are scaled such that the device is simulated at its operating temperature. Refer to the model to see which parameter values are scaled.

- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The substrate terminal is connected to ground. The substrate current is affected by the ISS and CJS model parameters. There should be no problems with this except perhaps in a PNP transistor where the ISS model parameter is specified. This could cause excess current flow as the substrate PN junction might end up being forward biased. If the connection of the substrate terminal to ground is not acceptable, use the BJT4 component and connect its substrate terminal to the appropriate place.
- For information on area dependence, refer to the section Area Dependence of the BJT Model Parameters.
- DC operating point parameters that can be sent to the dataset are listed in the following tables according to model.

DC Operating Point Information Model = BJT_Model or EE_BJT2_Model

Name	Description	Units
Ic	Collector current	amperes
Ib	Base current	amperes
Ie	Emitter current	amperes
Is	Substrate current	amperes
Power	DC power dissipation	watts
BetaDc	DC current gain	
Gm	Forward transconductance (dIce/dVbe)	siemens
Rpi	Input resistance 1/(dIbe/dVbe)	ohms
Rmu	Feedback resistance 1/(dIbe/dVbc)	ohms
Rx	Base resistance	ohms
Ro	Output resistance 1/(dIbe/dVbc - dIce/dVbc)	ohms
Cpi	Base-emitter capacitance	farads

Name	Description	Units
Cmu	Base-internal collector capacitance	farads
Cbx	Base-external collector capacitance	farads
Ccs	Substrate capacitance	farads
BetaAc	AC current gain	
Ft	Unity current gain frequency	hertz
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

DC Operating Point Information Model = STBJT_Model

Name	Description	Units
Ic	Collector current	amperes
Is	Substrate current	amperes
Ib	Base current	amperes
Ie	Emitter current	amperes
Power	DC power dissipation	watts
BetaDc	DC current gain	
BetaAc	AC current gain	
fTreal	Unity current gain frequency, full formula	hertz
fTappr	Unity current gain frequency, approximate formula gm/(2*PI*C)	hertz

Name	Description	Units
Gm	Forward transconductance (dIce/dVbe)	siemens
Rpi	Input resistance 1/(dIbe/dVbe)	ohms
Rmu	Reedback resistance 1/(dIbe/dVbc)	ohms
Rx	Base resistance	ohms
Ro	Output resistance 1/(dIbe/dVbc - dIce/dVbc)	ohms
Rcv	Collector resistance	ohms
Cpi	Base-emitter capacitance	farads
Cmu	Base-internal collector capacitance	farads
Cbx	Base-external collector capacitance	farads
Ccs	Internal collector-substrate capacitance	farads
Cbs	Internal base-substrate capacitance	farads
Cxs	External base-substrate capacitance	farads
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

DC Operating Point Information Model = MEXTRAM_Model (503)

Name	Description	Units
Ic	Collector current	amperes
Ib	Base current	amperes

Name	Description	Units
Ie	Emitter current	amperes
Is	Substrate current	amperes
Power	DC power dissipated	watts
dIc2e1_dVb2e1	(dIc2e1/dVb2e1)	siemens
Gb2e1	(dIb2e1/dVb2e1)	siemens
Gb1b2	(dIb1b2/dVb1b2)	siemens
Gb1c1	(dIb1c1/dVb1c1)	siemens
Gbc1	(dIbc1/dVbc1)	siemens
Gb2c2	(dIb2c2/dVb2c2)	siemens
Cb2e1	(dIb2e1/dVb2e1)	siemens
Cb2c2	(dIb2c2/dVb2c2)	siemens
Gb1e1	(dIb1e1/dVb1e1)	siemens
Gc1s	(dIc1s/dVc1s)	siemens
dIc2e1_dVb2c2	(dIc2e1/dVb2c2)	siemens
dIc2e1_dVb2c1	(dIc2e1/dVb2c1)	siemens
dIc1c2_dVb2e1	(dIc1c2/dVb2e1)	siemens
dIc1c2_dVb2c2	(dIc1c2/dVb2c2)	siemens
dIc1c2_dVb2c1	(dIc1c2/dVb2c1)	siemens
dIb2c2_dVb2e1	(dIb2c2/dVb2e1)	siemens

Name	Description	Units
dIb2c2_dVb2c1	(dIb2c2/dVb2c1)	siemens
dIb1b2_dVb2e1	(dIb1b2/dVb2e1)	siemens
dIb1b2_dVb2c2	(dIb1b2/dVb2c2)	siemens
dIb1b2_dVb2c1	(dIb1b2/dVb2c1)	siemens
dIc1s_dVb1c1	(dIc1s/dVb1c1)	siemens
dIc1s_dVbc1	(dIc1s/dVbc1)	siemens
Cb1b2	(dQb1b2/dVb1b2)	farads
Cc1s	(dQc1s/dVc1s)	farads
Cb1c1	(dQb1c1/dVb1c1)	farads
Cbc1	(dQbc1/dVbc1)	farads
dQb2e1_dVb2c2	(dQb2e1/dVb2c2)	farads
dQb2e1_dVb2c1	(dQb2e1/dVb2c1)	farads
dQc2b2_dVb2e1	(dQc2b2/dVb2e1)	farads
dQb2c2_dVb2c1	(dQb2c2/dVb2c1)	farads
dQb1b2_dVb2e1	(dQb1b2/dVb2e1)	farads
dQb1e1_dVb2e1	(dQb1e1/dVb2e1)	farads
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

This device has no default artwork associated with it.

Additional Information

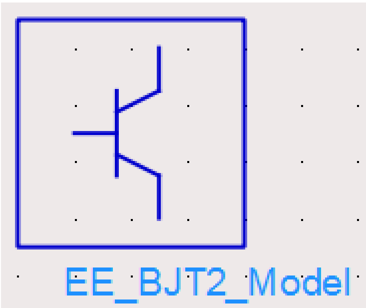
References

- I. E. Getreu, *CAD of Electronic Circuits, 1; Modeling the Bipolar Transistor* , Elsevier Scientific Publishing Company, 1978.
- P. Antognetti and G. Massobrio. *Semiconductor Device Modeling with SPICE* , Second Edition, McGraw-Hill, Inc., 1993.

EE BJT2 Model (EEsof Bipolar Transistor Model)

EE_BJT2_Model (EEsof Bipolar Transistor Model)

Symbol



This model specifies values for BJT_NPN or BJT_PNP devices. EEBJT2 is the second generation BJT model designed by Keysight EEsof. The model has been created specifically for automatic parameter extraction from measured data including DC and S-parameter measurements. The goal of this model is to overcome some of the problems associated with EEBJT1 or Gummel-Poon models limited accuracy and parameter extraction difficulty with regard to silicon rf/microwave transistors. EEBJT2 is not generally equivalent or compatible with the Gummel-Poon or EEBJT1 models. EEBJT2 can provide a reasonably accurate reproduction of transistor behavior, including DC bias solution, bias-dependent S-parameters including the effects of package parasitics, and true nonlinear harmonic output power. The model is quasi-static, analytical, and isothermal. The model does not scale with area because parameters are intended to be extracted directly from measured data and not from layout considerations. Default values of some parameters are chosen from an average of the first EEBJT2 library model parameters.

Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
Type	Model type: 1=NPN or 2=PNP	None	NPN
Nf	forward current emission coefficient	None	1.0
Ne	base emitter leakage emission coefficient	None	1.5
Nbf	forward base ideality factor	None	1.06

Vaf	forward early voltage	V	fixed at infinity †
Ise	base emitter leakage saturation current	A	0.0
Tf	ideal forward transit time (Tr and Tf, along with the depletion-layer capacitances, model base charge storage effects; Tf may be bias-dependent)	sec	0.0
Ikf	corner for forward-beta high current roll-off	A	fixed at infinity †
Xtf	coefficient of bias-dependence for Tf	None	0.0
Vtf	voltage dependence of Tf on base-collector voltage	V	fixed at infinity †
Itf	parameter for high-current effect on Tf	A	0.0
Nbr	reverse base ideality factor	None	1.04
Nr	reverse current emission coefficient	None	1.0
Nc	base collector leakage emission coefficient	None	2.0
Isc	base-collector leakage saturation current	A	0.0
Ikr	corner for reverse-beta high-current roll-off	A	fixed at infinity †
Var	reverse early voltage	V	fixed at infinity †
Tr	ideal reverse transit time (Tr and Tf, along with the depletion-layer capacitances, model base charge storage effects)	sec	0.0
Isf	forward saturation current	A	9.53e-15
Ibif	forward base saturation current	A	1.48e-16
Isr	reverse saturation current	A	1.01e-14
Ibir	reverse base saturation current	A	6.71e-16
Tamb	ambient temperature of measurement and model parameter extraction	°C	25
Cje	base-emitter zero-bias depletion capacitance (Cje, Vje, and Mje determine nonlinear depletion-layer capacitance for base-emitter junction)	F	0.0
Vje	base-emitter junction built-in potential (Cje, Vje, and Mje determine nonlinear depletion-layer capacitance for base-emitter junction)	V	0.75

Mje	base-emitter junction exponential factor (Cje, Vje, and Mje determine nonlinear depletion-layer capacitance for base-emitter junction)	None	fixed at 1/3
Cjc	base-collector zero-bias depletion capacitance (Cjc, Vjc, and Mjc determine nonlinear depletion-layer capacitance for base-collector junction)	F	0.0
Vjc	base-collector junction built-in potential (Cjc, Vjc, and Mjc determine nonlinear depletion-layer capacitance for base-collector junction)	V	0.75
Mjc	base-collector junction exponential factor (Cjc, Vjc, and Mjc determine nonlinear depletion-layer capacitance for base-collector junction)	None	fixed at 1/3
Rb	Zero-bias base resistance	Ohm	1e-4
Re	emitter resistance	Ohm	1e-4
Rc	collector resistance	Ohm	1e-4
Fc	forward-bias depletion capacitance coefficient	None	0.5
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvbe	base emitter reverse breakdown voltage (warning)	V	None
wBvbc	base collector reverse breakdown voltage (warning)	V	None
wVbcfwd	base collector forward bias (warning)	V	None
wIbmax	maximum base current (warning)	A	None
wIcmax	maximum collector current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None
† A value of 0.0 is interpreted as infinity			

- To prevent numerical problems, the setting of some model parameters is trapped by the simulator. The parameter values are changed internally:
  - Mjc and Mje must be ≤ 0.99
  - Fc must be ≤ 0.9999
  - Rb, Rc, and Re must be ≥ 10^{-4}
- The Temp parameter is only used to calculate the noise performance of this device. Temperature scaling of model parameters is not performed for this device.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to DataAccessComponent (Data Access Component) in Introduction to Circuit Components). Note that model parameters that are explicitly specified take precedence over those via AllParams.
- This device has no default artwork associated with it.

Equations

Base-Emitter and Base-Collector Current

The base-emitter current in the BJT has been changed significantly from the Gummel-Poon and other earlier models. These models assume that the non-leakage base-emitter current is related to the collector-emitter current by a simple constant, known as beta. Observation of base-emitter current in both silicon and AlGaAs devices has shown that this assumption is incorrect. Difficulties with this method of modeling base current have been observed for many years. A large, very bias-dependent base resistance in the modified Gummel-Poon model in Berkeley SPICE has been used to attempt to correct the problem with the base-emitter current expressions. This base resistance value and its variation is often extracted from DC data only, with the result that the behavior of the device over frequency is often poorly modeled. This problem is then *solved* by assigning some fraction of the base-collector capacitance to either side of the base in a distributed manner.

Keysight EEsof's experience with EEBJT2 has shown that properly modeled base-emitter current and conductance renders both the large bias-dependent base resistance and distributed base-collector capacitance unnecessary and greatly improves both the DC and AC accuracy of the resulting model.
EE_BJT2 models the base-emitter current with two non-ideal exponential expressions, one for the bulk recombination current (usually dominant in silicon devices), and one for other recombination currents (usually attributed to surface leakage).

$$Ibe = \left(Ibif\left(exp(\frac{Vbe}{(NbfV_T)}) - 1.0\right)\right) + \left(Ise\left(exp(\frac{Vbe}{(Ne \times V_T)}) - 1.0\right)\right)$$

where

$$V_T = \frac{k \times Tamb}{q}$$

where

k is Boltzmann's constant, and q is deviceary charge.

Note that Nbf is not necessarily 1.0, which is effectively the case in the Gummel-Poon model.
The base-collector current is similarly modeled:

$$Ibc = \left(Ibir\left(exp(\frac{Vbc}{(NbrV_T)}) - 1.0\right)\right) + \left(Isc\left(exp(\frac{Vbc}{(Nc \times V_T)}) - 1.0\right)\right)$$

Virtually all silicon rf/microwave transistors are vertical planar devices, so the second current term containing Isc and Nc is usually negligible.

The total base current Ib is the sum of Ibe and Ibc. Note that this method of modeling base current obsoletes the concept of a constant beta.

Collector-Emitter Current

The forward and reverse components of the collector-emitter current are modeled in a manner similar to the Gummel-Poon model, but with more flexibility. Observation of collector-emitter current behavior has shown that the forward and reverse components do not necessarily share identical saturation currents, as in the Gummel-Poon model. The basic expressions in EE_BJT2, not including high-level injection effects and Early effects, are:

$$Icf = Isf \times \left(exp(\frac{Vbe}{(Nf \times V_T)}) - 1.0 \right)$$

$$Icr = Isr \times \left(exp(\frac{Vbc}{(Nr \times V_T)}) - 1.0 \right)$$

where Isf and Isr are not exactly equal but are usually very close. Nf and Nr are not necessarily equal or 1.0, but are usually very close. Careful control of ambient temperature during device measurement is required for precise extraction of all of the saturation currents and emission coefficients in the model.

The effects of high-level injection and bias-dependent base charge storage are modeled via a normalized base charge, similar to the Gummel-Poon model:

$$Ice = \frac{(Icf - Icr)}{Qb}$$

where

$$Qb = \left(\frac{Q1}{2.0}\right) \times (1.0 + \sqrt{1.0 + (4.0 \times Q2)})$$

and

$$Q1 = \frac{1.0}{\left(1.0 - \left(\frac{Vbc}{Vaf}\right) - \left(\frac{Vbe}{Var}\right)\right)}$$

$$Q2 = \left(\left(\frac{Isf}{Ikf}\right) \times \left(exp(\frac{Vbe}{(Nf \times V_T)}) - 1.0\right)\right) + \left(\left(\frac{Isf}{Ikf}\right) \times \left(exp(\frac{Vbc}{(Nr \times V_T)}) - 1.0\right)\right)$$

NOTE: All calculations of the exponential expressions used in the model are linearized to prevent numerical overflow or underflow at large forward or reverse bias conditions, respectively.

Base-Emitter and Base-Collector Capacitances

Diffusion and depletion capacitances are modeled for both junctions of the transistor model in a manner very similar to the Gummel-Poon model.

for Vbc ≤ Fc × Vjc

$$Cbc = Cbc_{diffusion} + Cbc_{depletion}$$

where

$$Cbc_{diffusion} = \frac{Tr \times Icr}{Nr \times V_T}$$

and

$$Cbc_{depletion} = \frac{Cjc}{\left(1.0 - \left(\frac{Vbc}{Vjc}\right)\right)^{Mjc}}$$

for Vbc > Fc × Vjc

$$Cbc_{depletion} = \left(\frac{Cjc}{(1.0 - Fc)^{Mjc}}\right) \times \left(1.0 + \left(\frac{Mjc(Vbc - Fc \times Vjc)}{VJjc(1.0 - Fc)}\right)\right)$$

for Vbe≤ Fc × Vje

$$Cbe = Cbe_{diffusion} + Cbe_{depletion}$$

where

$$Cbe_{depletion} = \frac{Cje}{\left(1.0 - \left(\frac{Vbe}{Vje}\right)\right)^{Mje}}$$

for Vbe > Fc × Vje

$$Cbe_{depletion} = \left(\frac{Cje}{(1.0 - Fc)^{Mje}}\right) \times \left(1.0 + \left(\frac{Mje(Vbe - (Fc \times Vje))}{Vje(1.0 - Fc)}\right)\right)$$

The diffusion capacitance for Cbe is somewhat differently formulated vs. that of Cbc. The transit time is not a constant for the diffusion capacitance for Cbe, but is a function of both junction voltages, formulated in a manner similar to the modified Gummel-Poon model. The total base-emitter charge is equal to the sum of the base-emitter depletion charge (which is a function of Vbe only) and the so-called transit charge (which is a function of both Vbe and Vbc).

$$Q_{transit} = Tff \times \left(\frac{Icf}{Qb}\right)$$

where

$$Tff = Tf \times \left(1.0 + Xtf\left(\frac{Icf}{Icf + Itf}\right)^{2.0} \times exp\left(\frac{Vbc}{1.44 \times Vtf}\right)\right)$$

and

$$Cbe_{diffusion}(Vbe) = \frac{\partial Q_{transit}}{\partial Vbe}$$

and

$$Cbe_{diffusion}(Vbc) = \frac{\partial Q_{transit}}{\partial Vbc}$$

Noise Model

Thermal noise generated by resistors Rb, Rc, and Re is characterized by the following spectral density:

$$\frac{\langle i^2 \rangle}{\Delta f} = \frac{4kT}{R}$$

Shot noise generated by each of the DC currents flowing from base to emitter, base to collector, and collector to emitter is characterized by the following spectral density:

$$\frac{\langle i^2 \rangle}{\Delta f} = 2qI_{DC}$$

In the previous expressions, *k* is Boltzmann's constant, *T* is the operating temperature in Kelvin, *q* is the electron charge, and Δf is the noise bandwidth.

Flicker and burst noise for this device is not modeled in this version of the simulator. However, the bias-dependent noise sources I_NoiseBD and V_NoiseBD can be connected external to the device to model flicker or burst noise.

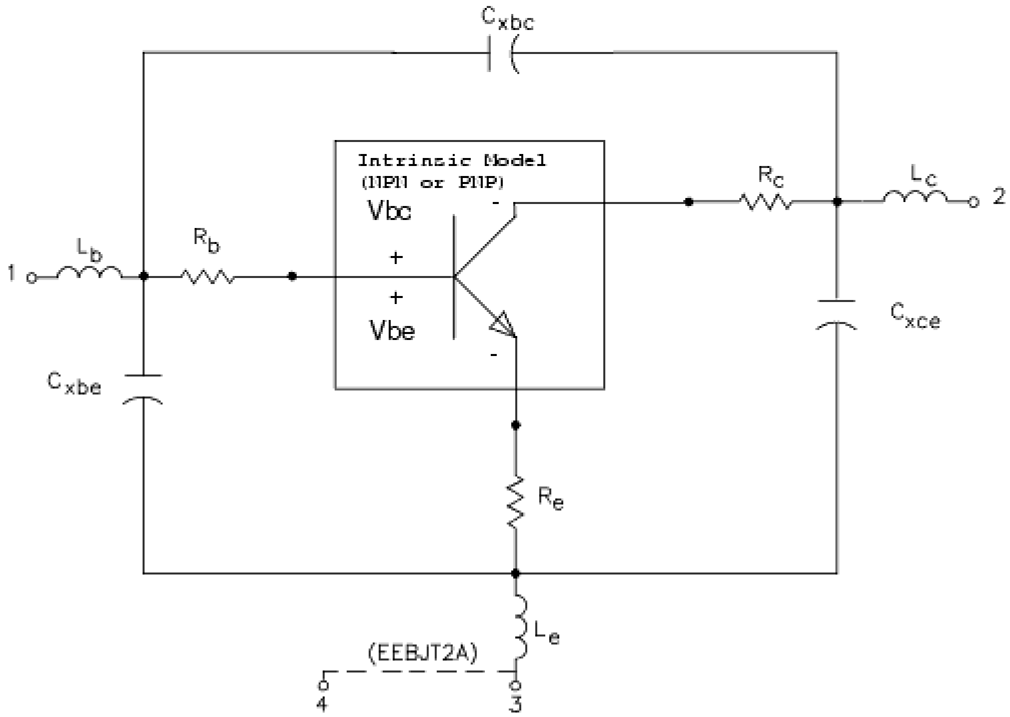
Additional Information

References

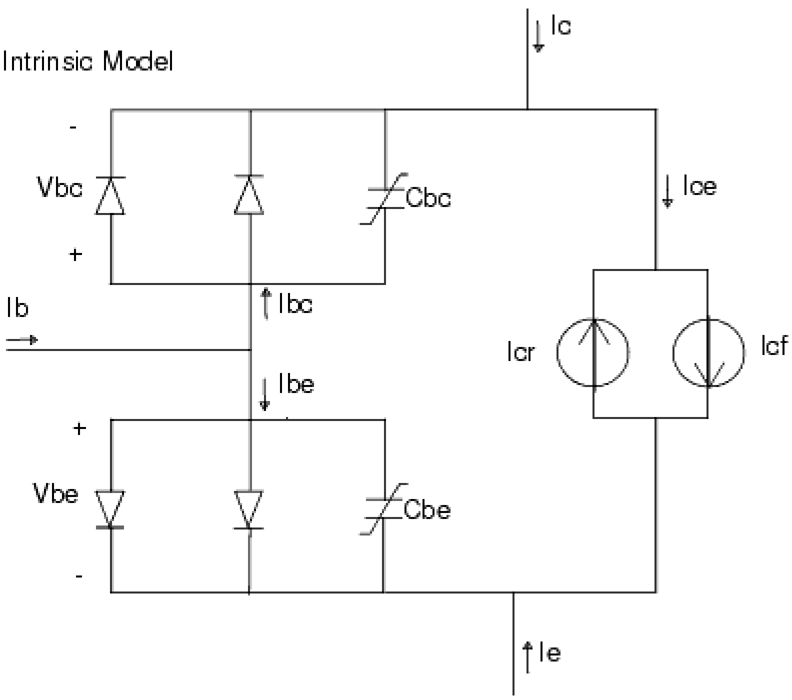
1. J. J. Ebers and J. L. Moll. "Large Signal Behaviour of Junction Transistors," Proc. I.R.E. 42, 1761 (1954).
2. H. K. Gummel and H. C. Poon. "An Integral Charge-Control Relation for Bipolar Transistors," Bell Syst. Techn. J. 49, 1 (1970).
3. SPICE2: A Computer Program to Simulate Semiconductor Circuits, University of California, Berkeley.

4. P. C. Grossman and A. Oki. "A Large Signal DC Model for GaAs/GaxAl1-xAs Heterojunction Bipolar Transistors," Proceedings of the 1989 IEEE Bipolar Circuits and Technology Meeting, pp. 258-262, September 1989.

Equivalent Circuit



Intrinsic Model



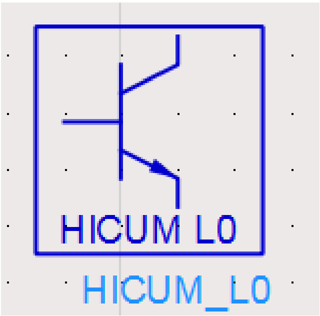
HICUM Level 0

HICUM Level 0

This section lists the supported versions of HICUM Level 0 model and instances.

Symbol

Model



Supported Versions

- HICUM 0 (HICUM BJT Level 0 Instance)
- HICUM 0 Model (HICUM BJT Level 0 Model)
- HICUM 0_1_12 (HICUM BJT Level 0 Version 1.12 Instance)
- HICUM 0_1_12 Model (HICUM BJT Level 0 Version 1.12 Model)
- HICUM 0_1_2 (HICUM BJT Level 0 Version 1.2 Instance)
- HICUM 0_1_2 Model (HICUM BJT Level 0 Version 1.2 Model)
- HICUM 0_1_3 (HICUM BJT Level 0 Version 1.3 Instance)
- HICUM 0_1_3 Model (HICUM BJT Level 0 Version 1.3 Model)
- HICUM 0_1_31 Model (HICUM BJT Level 0 Version 1.3.1 Model)
- HICUM 0_1_32 Model (HICUM BJT Level 0 Version 1.32 Model)

HICUM 0 (HICUM BJT Level 0 Instance)

HICUM 0 (HICUM BJT Level 0 Instance)

Parameters

Name	Description	Units	Default
Mode	Nonlinear spectral model on/off		1
Noise	Noise generation on/off		1
dt	Temperature change for particular transistor	K	0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
ModelName [:Name] c b e s
```

The model statement starts with the required keyword *ModelName*. It is followed by the *[:name]* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM* 0. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

```
model  Npn3  HICUM0 \
  Alfav=8e-5 T0=5e-12
```

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's *HICUM, A* Scalable Physics-based Compact Bipolar Transistor Model at: "http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html".
- DC Operating Point Information lists the DC operating point parameters that can be sent to the dataset.
  DC Operating Point Information

Name	Description	Units
ic	collector terminal current	A
ib	base terminal current	A
ie	emitter terminal current	A
is	substrate terminal current	A
vce	external voltage collector-emitter	V
vbe	external voltage base-emitter	V
vbei	internal voltage between nodes bi and ei	V
vsc	external substrate-collector voltage	V
temp	device temperature	K
tf	total forward transit time	s
tr	total reverse transit time	s
qf	minority charge forward component	coul
qr	minority charge reverse component	coul
qpt	modified hole charge	coul
it	transfer current	A
itf	forward transfer current	A

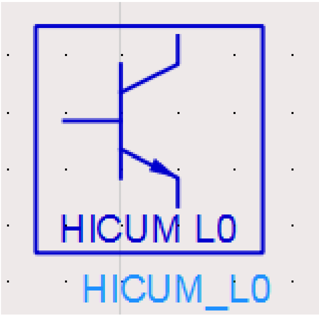
Name	Description	Units
itr	reverse transfer current	A
iavl	avalanche generation current	A
ibici	current between bi and ci	A
ijsc	current for si-ci diode	A
gm	gm	S
rbi	internal base resistance	Ohm
rbx	external base resistance	Ohm
rcx	external collector resistance	Ohm
re	external emittor resistance	Ohm
pwr	power dissipation	W
qjcx	charge between b and ci	coul
qbci	charge between b and ci	coul
cbe	capacitance between b and e	F
qbici	charge between bi and ci	coul
qbiei	charge between bi and ei	coul
qjs	charge between si and ci	coul
cjs	capacitance between si and ci	F
qjei	junction charge between bi and ei	coul
cjei	junction capacitance between bi and ei	F

Name	Description	Units
cbici	dqjci/d_V_BCI	F

HICUM 0 Model (HICUM BJT Level 0 Model)

HICUM 0 Model (HICUM BJT Level 0 Model)

Symbol



Parameters

Name	Description	Units	Default
Tnom	Parameter measurement temperature	°C	27
is	(Modified) saturation current	A	1e-016
mcf	Non-ideality coefficient of forward collector current		1
mcr	Non-ideality coefficient of reverse collector current		1
vef	forward Early voltage (normalization volt.)	V	1e+006
iqf	forward d.c. high-injection toll-off current	A	1e+006
iqr	inverse d.c. high-injection toll-off current	A	1e+006
iqfh	high-injection correction current	A	1e+006
tfh	high-injection correction factor		1e+006
ibes	BE saturation current	A	1e-018

Name	Description	Units	Default
mbe	BE non-ideality factor		1
ires	BE recombination saturation current	A	0
mre	BE recombination non-ideality factor		2
ibcs	BC saturation current	A	0
mbc	BC non-ideality factor		1
cje0	Zero-bias BE depletion capacitance	F	1e-020
vde	BE built-in voltage	V	0.9
ze	BE exponent factor		0.5
aje	Ratio of maximum to zero-bias value		2.5
t0	low current transit time at Vbici=0	s	0
dt0h			0
tbvl	SCR width modulation contribution	s	0
tef0	Storage time in neutral emitter	s	0
gte	Exponent factor for emitter transit time		1
thcs	Saturation time at high current densities	s	0
ahc	Smoothing factor for current dependence		0.1
tr	Storage time at inverse operation	s	0
rci0	Low-field collector resistance under emitter	Ohm	150
vlim	Voltage dividing ohmic and satur.region	V	0.5

Name	Description	Units	Default
vpt	Punch-through voltage	V	100
vces	Saturation voltage	V	0.1
cjci0	Total zero-bias BC depletion capacitance	F	1e-020
vdci	BC built-in voltage	V	0.7
zci	BC exponent factor		0.333
vptci	Punch-through voltage of BC junction	V	100
cjcx0	Zero-bias external BC depletion capacitance	F	1e-020
vdcx	External BC built-in voltage	V	0.7
zcx	External BC exponent factor		0.333
vptcx	Punch-through voltage	V	100
fbc	Split factor = Cjci0/Cjc0		1
rbi0	Internal base resistance at zero-bias	Ohm	0
vr0e	forward Early voltage (normalization volt.)	V	2.5
vr0c	forward Early voltage (normalization volt.)	V	1e+006
fgeo	Geometry factor		0.656
rbx	External base series resistance	Ohm	0
rcx	Emitter series resistance	Ohm	0
re	External collector series resistance	Ohm	0
iscs	SC saturation current	A	0

Name	Description	Units	Default
msc	SC non-ideality factor		1
cjs0	Zero-bias SC depletion capacitance	F	1e-020
vds	SC built-in voltage	V	0.3
zs	External SC exponent factor		0.3
vpts	SC punch-through voltage	V	100
cbcpar	Collector-base isolation (overlap) capacitance	F	0
cbepar	Emitter-base oxide capacitance	F	0
eavl	Exponent factor		0
kavl	Prefactor		0
kf	flicker noise coefficient	$M^{(1-AF)}$	0
af	flicker noise exponent factor		2
vgb	Bandgap-voltage	V	1.2
vge	Effective emitter bandgap-voltage	V	1.17
vgc	Effective collector bandgap-voltage	V	1.17
vgs	Effective substrate bandgap-voltage	V	1.17
f1vg	Coefficient K1 in T-dependent bandgap equation	V/K	0.000102377
f2vg	Coefficient K2 in T-dependent bandgap equation	V/K	0.00043215
alt0	First-order TC of tf0	1/K	0
kt0	Second-order TC of tf0	$1/K^2$	0

Name	Description	Units	Default
zetact	Exponent coefficient in transfer current temperature dependence		3
zetabet	Exponent coefficient in BE junction current temperature dependence		3.5
zetaci	TC of epi-collector diffusivity		0
alvs	Relative TC of satur.drift velocity	1/K	0
alces	Relative TC of vces	1/K	0
zetarbi	TC of internal base resistance		0
zetarbx	TC of external base resistance		0
zetarcx	TC of external collector resistance		0
zetare	TC of emitter resistances		0
alkav	TC of avalanche prefactor	1/K	0
aleav	TC of avalanche exponential factor	1/K	0
rth	Thermal resistance	K/W	0
cth	Thermal capacitance	Ws/K	0
npn	model type flag for npn		1
pnp	model type flag for pnp		0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname HICUM0 [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM0* . The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.
Example:

```
model  Npn3  HICUM0 \
  Alfav=8e-5 T0=5e-12
```

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's *HICUM, A* Scalable Physics-based Compact Bipolar Transistor Model at: "http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html".

HICUM 0_1_12 (HICUM BJT Level 0 Version 1.12 Instance)

HICUM 0_1_12 (HICUM BJT Level 0 Version 1.12 Instance)

Parameters

Name	Description	Units	Default
Mode	Nonlinear spectral model on/off		1
Noise	Noise generation on/off		1
dt	Temperature change for particular transistor	K	0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
ModelName [:Name] c b e s
```

The model statement starts with the required keyword model. It is followed by the modelname that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is HICUM0_1_12. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example

```
Npn3:Ql c b e s t
model Npn3 HICUM0_1_12 is=5e-16 vef=250
```

Additional Information

DC operating point parameters that can be sent to the dataset:

Name	Description	Units
ic	collector terminal current	A
ib	base terminal current	A
ie	emitter terminal current	A
is	substrate terminal current	A
vce	external voltage collector-emitter	V
vbe	external voltage base-emitter	V
vbei	internal voltage between nodes bi and ei	V
vsc	external substrate-collector voltage	V
temp	device temperature	K
tf	total forward transit time	s
tr	total reverse transit time	s
qf	minority charge forward component	coul
qr	minority charge reverse component	coul
qpt	modified hole charge	coul
it	transfer current	A
itf	forward transfer current	A
itr	reverse transfer current	A

Name	Description	Units
iavl	avalanche generation current	A
ibici	current between bi and ci	A
ijsc	current for si-ci diode	A
gm	Gm	S
rbi	internal base resistance	Ohm
rbx	external base resistance	Ohm
rcx	external collector resistance	Ohm
re	external emittor resistance	Ohm
pwr	power dissipation	W
qjcx	charge between b and ci	coul
qbci	charge between b and ci	coul
cbe	capacitance between b and e	F
qbici	charge between bi and ci	coul
qbiei	charge between bi and ei	coul
qjs	charge between si and ci	coul
cjs	capacitance between si and ci	F
qjei	junction charge between bi and ei	coul
cjei	junction capacitance between bi and ei	F
cbici	dqjci/d_V_BCI	F

HICUM 0_1_12 Model (HICUM BJT Level 0 Version 1.12 Model)

HICUM 0_1_12 Model (HICUM BJT Level 0 Version 1.12 Model)

Parameters

Name	Description	Units	Default
Tnom	Parameter measurement temperature	deg C	27
is	(Modified) saturation current	A	1e-16
mcf	Non-ideality coefficient of forward collector current		1
mcr	Non-ideality coefficient of reverse collector current		1
vef	forward Early voltage (normalization volt.)	V	1e+10
iqf	forward d.c. high-injection toll-off current	A	1e+10
iqr	inverse d.c. high-injection roll-off current	A	1e+10
iqfh	high-injection correction current	A	1e+10
tfh	high-injection correction factor		1e+10
ibes	BE saturation current	A	1e-18
mbe	BE non-ideality factor		1
ires	BE recombination saturation current	A	0
mre	BE recombination non-ideality factor		2
ibcs	BC saturation current	A	0
mbc	BC non-ideality factor		1

Name	Description	Units	Default
cje0	Zero-bias BE depletion capacitance	F	1e-20
vde	BE built-in voltage	V	0.9
ze	BE exponent factor		0.5
aje	Ratio of maximum to zero-bias value		2.5
t0	low current transit time at Vbici=0	s	0
dt0h	Base width modulation contribution		0
tbvl	SCR width modulation contribution	s	0
tef0	Storage time in neutral emitter	s	0
gte	Exponent factor for emitter transit time		1
thcs	Saturation time at high current densities	s	0
ahc	Smoothing factor for current dependence		0.1
tr	Storage time at inverse operation	s	0
rci0	Low-field collector resistance under emitter	Ohm	150
vlim	Voltage dividing ohmic and satur.region	V	0.5
vpt	Punch-through voltage	V	100
vces	Saturation voltage	V	0.1
cjci0	Total zero-bias BC depletion capacitance	F	1e-20
vdci	BC built-in voltage	V	0.7
zci	BC exponent factor		0.333

Name	Description	Units	Default
vptci	Punch-through voltage of BC junction	V	100
cjcx0	Zero-bias external BC depletion capacitance	F	1e-20
vdcx	External BC built-in voltage	V	0.7
zcx	External BC exponent factor		0.333
vptcx	Punch-through voltage	V	100
fbc	Split factor = Cjci0/Cjc0		1
rbi0	Internal base resistance at zero-bias	Ohm	0
vr0e	forward Early voltage (normalization volt.)	V	2.5
vr0c	forward Early voltage (normalization volt.)	V	1e+10
fgeo	Geometry factor		0.656
rbx	External base series resistance	Ohm	0
rcx	Emitter series resistance	Ohm	0
re	External collector series resistance	Ohm	0
itss	Substrate transistor transfer saturation current	A	0
msf	Substrate transistor transfer current non-ideality factor		1
iscs	SC saturation current	A	0
msc	SC non-ideality factor		1
cjs0	Zero-bias SC depletion capacitance	F	1e-20
vds	SC built-in voltage	V	0.3

Name	Description	Units	Default
zs	External SC exponent factor		0.3
vpts	SC punch-through voltage	V	100
cbcpar	Collector-base isolation (overlap) capacitance	F	0
cbepar	Emitter-base oxide capacitance	F	0
eavl	Exponent factor		0
kavl	Prefactor		0
kf	flicker noise coefficient	M1-AF	0
af	flicker noise exponent factor		2
vgb	Bandgap-voltage	V	1.2
vge	Effective emitter bandgap-voltage	V	1.17
vgc	Effective collector bandgap-voltage	V	1.17
vgs	Effective substrate bandgap-voltage	V	1.17
f1vg	Coefficient K1 in T-dependent bandgap equation	V/K	-0.000102377
f2vg	Coefficient K2 in T-dependent bandgap equation	V/K	0.00043215
alt0	First-order TC of tf0	1/K	0
kt0	Second-order TC of tf0	1/K2	0
zetact	Exponent coefficient in transfer current temperature dependence		3
zetabet	Exponent coefficient in BE junction current temperature dependence		3.5
zetaci	TC of epi-collector diffusivity		0

Name	Description	Units	Default
alvs	Relative TC of satur.drift velocity	1/K	0
alces	Relative TC of vces	1/K	0
zetarbi	TC of internal base resistance		0
zetarbx	TC of external base resistance		0
zetarcx	TC of external collector resistance		0
zetare	TC of emitter resistances		0
alkav	TC of avalanche prefactor	1/K	0
aleav	TC of avalanche exponential factor	1/K	0
flsh	Flag for self-heating calculation		0
rth	Thermal resistance	K/W	0
cth	Thermal capacitance	Ws/K	0
npn	model type flag for npn		1
pnp	model type flag for pnp		0
version	model version. Not used! Introduced for Spectre compatibility		1.12

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

> *model ModelName [:Name] c b e s*

The model statement starts with the required keyword model. It is followed by the modelname that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is HICUM0_1_12. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example:

```
Npn3:Ql c b e s t
model Npn3 HICUM0_1_12 is=5e-16 vef=250
```

Additional Information

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's HICUM, A Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html.
- The thermal pin can be optionally specified externally. Therefore the instance can be defined either as a 4-pin device (collector, base, emitter, substrate) or a 5-pin device (collector, base, emitter, substrate, thermal).

HICUM 0_1_2 (HICUM BJT Level 0 Version 1.2 Instance)

HICUM 0_1_2 (HICUM BJT Level 0 Version 1.2 Instance)

Parameters

Name (Alias)	Description	Units	Default
Temp	Device operating temperature	°C	25
Trise (Dtemp)	Temperature rise over ambient	°C	0
Mode	Nonlinear spectral model on/off		1
Noise	Noise generation on/off		1
dt	Temperature change for particular transistor	K	0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *ModelName [:Name] c b e s*

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM0_1_2*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example:

```
model  Npn3  HICUM0_1_2 \
  is=8e-15 t0=5e-12
```

Additional Information

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's HICUM, A Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
ic	collector terminal current	A
ib	base terminal current	A
ie	emitter terminal current	A
is	substrate terminal current	A
vce	external voltage collector-emitter	V
vbe	external voltage base-emitter	V
vbei	internal voltage between nodes bi and ei	V
vsc	external substrate-collector voltage	V
temp	device temperature	K
tf	total forward transit time	s
tr	total reverse transit time	s
qf	minority charge forward component	coul
qr	minority charge reverse component	coul
qpt	modified hole charge	coul

Name	Description	Units
it	transfer current	A
itf	forward transfer current	A
itr	reverse transfer current	A
iavl	avalanche generation current	A
ibici	current between bi and ci	A
ijsc	current for si-ci diode	A
gm	gm	S
rbi	internal base resistance	Ohm
rbx	external base resistance	Ohm
rcx	external collector resistance	Ohm
re	external emitter resistance	Ohm
pwr	power dissipation	W
qjcx	charge between b and ci	coul
qbci	charge between b and ci	coul
cbe	capacitance between b and e	F
qbici	charge between bi and ci	coul
qbiei	charge between bi and ei	coul
qjs	charge between si and ci	coul
cjs	capacitance between si and ci	F

Name	Description	Units
qjei	junction charge between bi and ei	coul
cjei	junction capacitance between bi and ei	F
cbici	dqjci/d_V_BCI	F

HICUM 0_1_2 Model (HICUM BJT Level 0 Version 1.2 Model)

HICUM 0_1_2 Model (HICUM BJT Level 0 Version 1.2 Model)

Parameters

Name (Alias)	Description	Units	Default
Gender	+1=N-type, -1=P-type		1(n),-1(p)
Tnom	Parameter measurement temperature	°C	27
is	(Modified) saturation current	A	1e-016
mcf	Non-ideal coefficient of forward collector current		1
mcr	Non-ideal coefficient of reverse collector current		1
vef	forward Early voltage (normalization volt.)	V	1e+030
ver	reverse Early voltage (normalization volt.)	V	1e+030
iqf	forward d.c. high-injection toll-off current	A	1e+030
fiqf	flag for turning on base related critical current		0
iqr	inverse d.c. high-injection roll-off current	A	1e+030
iqfh	high-injection correction current	A	1e+030
tfh	high-injection correction factor		0
ahq	Smoothing factor for the d.c. injection width		0
ibes	BE saturation current	A	1e-018
mbe	BE non-ideal factor		1

Name (Alias)	Description	Units	Default
ires	BE recombination saturation current	A	0
mre	BE recombination non-ideal factor		2
ibcs	BC saturation current	A	0
mbc	BC non-ideal factor		1
cje0	Zero-bias BE depletion capacitance	F	1e-020
vde	BE built-in voltage	V	0.9
ze	BE exponent factor		0.5
aje	Ratio of maximum to zero-bias value		2.5
vdedc	BE charge built-in voltage for d.c. transfer current	V	0.9
zedc	charge BE exponent factor for d.c. transfer current		0.5
ajedc	BE capacitance ratio Ratio maximum to zero-bias value for d.c. transfer current		2.5
t0	low current transit time at Vbici=0	s	0
dt0h			0
tbvlSCR	width modulation contribution	s	0
tef0	Storage time in neutral emitter	s	0
gte	Exponent factor for emmiter transit time		1
thcs	Saturation time at high current densities	s	0
ahc	Smoothing facor for current dependence		0.1
tr	Storage time at inverse operation	s	0

Name (Alias)	Description	Units	Default
rci0	Low-field collector resistance under emitter	Ohm	150
vlim	Voltage dividing ohmic and satur.region	V	0.5
vpt	Punch-through voltage	V	100
vces	Saturation voltage	V	0.1
cjci0	Total zero-bias BC depletion capacitance	F	1e-020
vdci	BC built-in voltage	V	0.7
zci	BC exponent factor		0.333
vptci	Punch-through voltage of BC junction	V	100
cjcx0	Zero-bias external BC depletion capacitance	F	1e-020
vdcx	External BC built-in voltage	V	0.7
zcx	External BC exponent factor		0.333
vptcx	Punch-through voltage	V	100
fbc	Split factor = Cjci0/Cjc0		1
rbi0	Internal base resistance at zero-bias	Ohm	0
vr0e	forward Early voltage (normalization volt.)	V	2.5
vr0c	forward Early voltage (normalization volt.)	V	1e+030
fgeo	Geometry factor		0.656
rbx	External base series resistance	Ohm	0
rcx	Emitter series resistance	Ohm	0

Name (Alias)	Description	Units	Default
re	External collector series resistance	Ohm	0
itss	Substrate transistor transfer saturation current	A	0
msf	Substrate transistor transfer current non-ideal factor		1
iscs	SC saturation current	A	0
msc	SC non-ideal factor		1
cjs0	Zero-bias SC depletion capacitance	F	1e-020
vds	SC built-in voltage	V	0.3
zs	External SC exponent factor		0.3
vpts	SC punch-through voltage	V	100
cbcpar	Collector-base isolation (overlap) capacitance	F	0
cbepar	Emitter-base oxide capacitance	F	0
eavl	Exponent factor		0
kavl	Prefactor		0
kf	flicker noise coefficient	M^(1-AF)	0
af	flicker noise exponent factor		2
vgb	Bandgap-voltage	V	1.2
vge	Effective emitter bandgap-voltage	V	1.17
vgc	Effective collector bandgap-voltage	V	1.17
vgs	Effective substrate bandgap-voltage	V	1.17

Name (Alias)	Description	Units	Default
f1vg	Coefficient K1 in T-dependent bandgap equation	V/K	-0.000102377
f2vg	Coefficient K2 in T-dependent bandgap equation	V/K	0.00043215
alt0	Frist-order TC of tf0	1/K	0
kt0	Second-order TC of tf0	1/K^2	0
zetact	Exponent coefficient in transfer current temperature dependence		3
zetabet	Exponent coefficient in BE junction current temperature dependence		3.5
zetaci	TC of epi-collector diffusivity		0
alvs	Relative TC of satur.drift velocity	1/K	0
alces	Relative TC of vces	1/K	0
zetarbi	TC of internal base resistance		0
zetarbx	TC of external base resistance		0
zetarcx	TC of external collector resistance		0
zetare	TC of emitter resistances		0
zetaiqf	TC of iqf		0
alkav	TC of avalanche prefactor	1/K	0
aleav	TC of avalanche exponential factor	1/K	0
zetarth	Exponent factor for temperature dependent thermal resistance		0
flsh	Flag for self-heating calculation		0

Name (Alias)	Description	Units	Default
rth	Thermal resistance	K/W	0
cth	Thermal capacitance	Ws/K	0
npn	model type flag for npn		1
pnp	model type flag for pnp		0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *model modelname HICUM0_1_2 [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM0_1_2*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, sub-circuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example

```
model  Npn3  HICUM0_1_2 \
is=8e-15 t0=5e-12
```

Additional Information

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's HICUM, A Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html

HICUM 0_1_3 (HICUM BJT Level 0 Version 1.3 Instance)

HICUM 0_1_3 (HICUM BJT Level 0 Version 1.3 Instance)

Parameters

Name (Alias)	Description	Units	Default
Temp	Device operating temperature	°C	25
Trise (Dtemp)	Temperature rise over ambient	°C	0
Mode	Nonlinear spectral model on/off		1
Noise	Noise generation on/off		1
dt	Temperature change for particular transistor	K	0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *ModelName [:Name] c b e s*

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM0_1_3*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case-sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables, and equations, refer to ADS Simulator Input Syntax.

Example

```
model  Npn3  HICUM0_1_3 \
  is=8e-15 t0=5e-12
```

Additional Information

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's HICUM, A Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
ic	collector terminal current	A
ib	base terminal current	A
ie	emitter terminal current	A
is	substrate terminal current	A
vce	external voltage collector-emitter	V
vbe	external voltage base-emitter	V
vbei	internal voltage between nodes bi and ei	V
vsc	external substrate-collector voltage	V
temp	device temperature	K
tf	total forward transit time	s
tr	total reverse transit time	s
qf	minority charge forward component	coul
qr	minority charge reverse component	coul

Name	Description	Units
qpt	modified hole charge	coul
it	transfer current	A
itf	forward transfer current	A
itr	reverse transfer current	A
iavl	avalanche generation current	A
ibici	current between bi and ci	A
ijsc	current for si-ci diode	A
gm	gm	S
rbi	internal base resistance	Ohm
rbx	external base resistance	Ohm
rcx	external collector resistance	Ohm
re	external emitter resistance	Ohm
pwr	power dissipation	W
qjcx	charge between b and ci	coul
qbci	charge between b and ci	coul
cbe	capacitance between b and e	F
qbici	charge between bi and ci	coul
qbiei	charge between bi and ei	coul
qjs	charge between si and ci	coul

Name	Description	Units
cjs	capacitance between si and ci	F
qjei	junction charge between bi and ei	coul
cjei	junction capacitance between bi and ei	F
cbici	dqjci/d_V_BCI	F

HICUM 0_1_3 Model (HICUM BJT Level 0 Version 1.3 Model)

HICUM 0_1_3 Model (HICUM BJT Level 0 Version 1.3 Model)

Parameters

Name (Alias)	Description	Units	Default
Gender	+1=N-type, -1=P-type		1(n),-1(p)
Tnom	Parameter measurement temperature	°C	27
is	(Modified) saturation current	A	1e-016
mcf	Non-ideal coefficient of forward collector current		1
mcr	Non-ideal coefficient of reverse collector current		1
vef	forward Early voltage (normalization volt.)	V	1e+030
ver	reverse Early voltage (normalization volt.)	V	1e+030
iqf	forward d.c. high-injection toll-off current	A	1e+030
fiqf	flag for turning on base related critical current		0
iqr	inverse d.c. high-injection roll-off current	A	1e+030
iqfh	high-injection correction current	A	1e+030
tfh	high-injection correction factor		0
ahq	Smoothing factor for the d.c. injection width		0
ibes	BE saturation current	A	1e-018
mbe	BE non-ideal factor		1

Name (Alias)	Description	Units	Default
ires	BE recombination saturation current	A	0
mre	BE recombination non-ideal factor		2
ibcs	BC saturation current	A	0
mbc	BC non-ideal factor		1
cje0	Zero-bias BE depletion capacitance	F	1e-020
vde	BE built-in voltage	V	0.9
ze	BE exponent factor		0.5
aje	Ratio of maximum to zero-bias value		2.5
vdedc	BE charge built-in voltage for d.c. transfer current	V	0.9
zedc	charge BE exponent factor for d.c. transfer current		0.5
ajedc	BE capacitance ratio Ratio maximum to zero-bias value for d.c. transfer current		2.5
t0	low current transit time at Vbici=0	s	0
dt0h			0
tbvlSCR	width modulation contribution	s	0
tef0	Storage time in neutral emitter	s	0
gte	Exponent factor for emmiter transit time		1
thcs	Saturation time at high current densities	s	0
ahc	Smoothing facor for current dependence		0.1
tr	Storage time at inverse operation	s	0

Name (Alias)	Description	Units	Default
rci0	Low-field collector resistance under emitter	Ohm	150
vlim	Voltage dividing ohmic and satur.region	V	0.5
vpt	Punch-through voltage	V	100
vces	Saturation voltage	V	0.1
cjci0	Total zero-bias BC depletion capacitance	F	1e-020
vdci	BC built-in voltage	V	0.7
zci	BC exponent factor		0.333
vptci	Punch-through voltage of BC junction	V	100
cjcx0	Zero-bias external BC depletion capacitance	F	1e-020
vdcx	External BC built-in voltage	V	0.7
zcx	External BC exponent factor		0.333
vptcx	Punch-through voltage	V	100
fbc	Split factor = Cjci0/Cjc0		1
rbi0	Internal base resistance at zero-bias	Ohm	0
vr0e	forward Early voltage (normalization volt.)	V	2.5
vr0c	forward Early voltage (normalization volt.)	V	1e+030
fgeo	Geometry factor		0.656
rbx	External base series resistance	Ohm	0
rcx	Emitter series resistance	Ohm	0

Name (Alias)	Description	Units	Default
re	External collector series resistance	Ohm	0
itss	Substrate transistor transfer saturation current	A	0
msf	Substrate transistor transfer current non-ideal factor		1
iscs	SC saturation current	A	0
msc	SC non-ideal factor		1
cjs0	Zero-bias SC depletion capacitance	F	1e-020
vds	SC built-in voltage	V	0.3
zs	External SC exponent factor		0.3
vpts	SC punch-through voltage	V	100
cbcpar	Collector-base isolation (overlap) capacitance	F	0
cbepar	Emitter-base oxide capacitance	F	0
eavl	Exponent factor		0
kavl	Prefactor		0
kf	flicker noise coefficient	$M^{(1-AF)}$	0
af	flicker noise exponent factor		2
vgb	Bandgap-voltage	V	1.2
vge	Effective emitter bandgap-voltage	V	1.17
vgc	Effective collector bandgap-voltage	V	1.17
vgs	Effective substrate bandgap-voltage	V	1.17

Name (Alias)	Description	Units	Default
f1vg	Coefficient K1 in T-dependent bandgap equation	V/K	-0.000102377
f2vg	Coefficient K2 in T-dependent bandgap equation	V/K	0.00043215
alt0	Frist-order TC of tf0	1/K	0
kt0	Second-order TC of tf0	$1/K^2$	0
zetact	Exponent coefficient in transfer current temperature dependence		3
zetabet	Exponent coefficient in BE junction current temperature dependence		3.5
zetaci	TC of epi-collector diffusivity		0
alvs	Relative TC of satur.drift velocity	1/K	0
alces	Relative TC of vces	1/K	0
zetarbi	TC of internal base resistance		0
zetarbx	TC of external base resistance		0
zetarcx	TC of external collector resistance		0
zetare	TC of emitter resistances		0
zetaiqf	TC of iqf		0
alkav	TC of avalanche prefactor	1/K	0
aleav	TC of avalanche exponential factor	1/K	0
zetarth	Exponent factor for temperature-dependent thermal resistance		0
flsh	Flag for self-heating calculation		0

Name (Alias)	Description	Units	Default
rth	Thermal resistance	K/W	0
cth	Thermal capacitance	Ws/K	0
npn	model type flag for npn		1
pnp	model type flag for pnp		0
it_mod	Flag for using third order solution for transfer current		0
aver	bias dependence for reverse Early voltage		0
tef_temp	Flag for turning temperature dependence of tef0 on and off		1
zetaver	TC of Reverse Early voltage		-1
zetavgbe	TC of AVER		1
dvgbe	Bandgap difference between base and BE-junction		0
aliqfh	Frist-order TC of iqfh	1/K	0
kiqfh	Second-order TC of iqfh	$1/K^2$	0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *model modelname HICUM0_1_3 [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM0_1_3*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case-sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables, and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example

```
model  Npn3  HICUM0_1_3 \
is=8e-15 t0=5e-12
```

Additional Information

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's HICUM, A Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html

HICUM 0_1_31 Model (HICUM BJT Level 0 Version 1.3.1 Model)

HICUM 0_1_31 Model (HICUM BJT Level 0 Version 1.3.1 Model)

Parameters

Name (Alias)	Description	Units	Default
is	(Modified) saturation current	A	1e-016
mcf	Non-ideal coefficient of forward collector current		1
mcr	Non-ideal coefficient of reverse collector current		1
vef	forward Early voltage (normalization volt.)	V	1e+030
ver	reverse Early voltage (normalization volt.)	V	1e+030
iqf	forward d.c. high-injection toll-off current	A	1e+030
fiqf	flag for turning on base related critical current		0
iqr	inverse d.c. high-injection roll-off current	A	1e+030
iqfh	high-injection correction current	A	1e+030
tfh	high-injection correction factor		0
ahq	Smoothing factor for the d.c. injection width		0
ibes	BE saturation current	A	1e-018
mbe	BE non-ideal factor		1
ires	BE recombination saturation current	A	0
mre	BE recombination non-ideal factor		2

Name (Alias)	Description	Units	Default
ibcs	BC saturation current	A	0
mbc	BC non-ideal factor		1
cje0	Zero-bias BE depletion capacitance	F	1e-020
vde	BE built-in voltage	V	0.9
ze	BE exponent factor		0.5
aje	Ratio of maximum to zero-bias value		2.5
vdedc	BE charge built-in voltage for d.c. transfer current	V	0.9
zedc	charge BE exponent factor for d.c. transfer current		0.5
ajedc	BE capacitance ratio Ratio maximum to zero-bias value for d.c. transfer current		2.5
t0	low current transit time at Vbici=0	s	0
dt0h			0
tbvlSCR	width modulation contribution	s	0
tef0	Storage time in neutral emitter	s	0
gte	Exponent factor for emmiter transit time		1
thcs	Saturation time at high current densities	s	0
ahc	Smoothing facor for current dependence		0.1
tr	Storage time at inverse operation	s	0
rci0	Low-field collector resistance under emitter	Ohm	150
vlim	Voltage dividing ohmic and satur.region	V	0.5

Name (Alias)	Description	Units	Default
vpt	Punch-through voltage	V	100
vces	Saturation voltage	V	0.1
cjci0	Total zero-bias BC depletion capacitance	F	1e-020
vdci	BC built-in voltage	V	0.7
zci	BC exponent factor		0.333
vptci	Punch-through voltage of BC junction	V	100
cjcx0	Zero-bias external BC depletion capacitance	F	1e-020
vdcx	External BC built-in voltage	V	0.7
zcx	External BC exponent factor		0.333
vptcx	Punch-through voltage	V	100
fbc	Split factor = Cjci0/Cjc0		1
rbi0	Internal base resistance at zero-bias	Ohm	0
vr0e	forward Early voltage (normalization volt.)	V	2.5
vr0c	forward Early voltage (normalization volt.)	V	1e+030
fgeo	Geometry factor		0.656
rbx	External base series resistance	Ohm	0
rcx	Emitter series resistance	Ohm	0
re	External collector series resistance	Ohm	0
itss	Substrate transistor transfer saturation current	A	0

Name (Alias)	Description	Units	Default
msf	Substrate transistor transfer current non-ideal factor		1
iscs	SC saturation current	A	0
msc	SC non-ideal factor		1
cjs0	Zero-bias SC depletion capacitance	F	1e-020
vds	SC built-in voltage	V	0.3
zs	External SC exponent factor		0.3
vpts	SC punch-through voltage	V	100
cbcpar	Collector-base isolation (overlap) capacitance	F	0
cbepar	Emitter-base oxide capacitance	F	0
eavl	Exponent factor		0
kavl	Prefactor		0
kf	flicker noise coefficient	$M^{(1-AF)}$	0
af	flicker noise exponent factor		2
vgb	Bandgap-voltage	V	1.2
vge	Effective emitter bandgap-voltage	V	1.17
vgc	Effective collector bandgap-voltage	V	1.17
vgs	Effective substrate bandgap-voltage	V	1.17
f1vg	Coefficient K1 in T-dependent bandgap equation	V/K	-0.000102377
f2vg	Coefficient K2 in T-dependent bandgap equation	V/K	0.00043215

Name (Alias)	Description	Units	Default
alt0	Frist-order TC of tf0	1/K	0
kt0	Second-order TC of tf0	$1/K^2$	0
zetact	Exponent coefficient in transfer current temperature dependence		3
zetabet	Exponent coefficient in BE junction current temperature dependence		3.5
zetaci	TC of epi-collector diffusivity		0
alvs	Relative TC of satur.drift velocity	1/K	0
alces	Relative TC of vces	1/K	0
zetarbi	TC of internal base resistance		0
zetarbx	TC of external base resistance		0
zetarcx	TC of external collector resistance		0
zetare	TC of emitter resistances		0
zetaiqf	TC of iqf		0
alkav	TC of avalanche prefactor	1/K	0
aleav	TC of avalanche exponential factor	1/K	0
zetarth	Exponent factor for temperature-dependent thermal resistance		0
flsh	Flag for self-heating calculation		0
rth	Thermal resistance	K/W	0
cth	Thermal capacitance	Ws/K	0

Name (Alias)	Description	Units	Default
npn	model type flag for npn		1
pnp	model type flag for pnp		0
it_mod	Flag for using third order solution for transfer current		0
aver	bias dependence for reverse Early voltage		0
tef_temp	Flag for turning temperature dependence of tef0 on and off		1
zetaver	TC of Reverse Early voltage		-1
zetavgbe	TC of AVER		1
dvgbe	Bandgap difference between base and BE-junction		0
aliqfh	Frist-order TC of iqfh	1/K	0
kiqfh	Second-order TC of iqfh	$1/K^2$	0
tbvl	SCR width modulation contribution	s	0
alqf	Factor for additional delay time of minority charge		
alit	Factor for additional delay time of transfer current		
flnqs	Flag for turning on and off of vertical NQS effect		

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *model modelname HICUM0_1_31 [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM0_1_3*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case-sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables, and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example

```
model  Npn3  HICUM0_1_31 \
is=8e-15 t0=5e-12
```

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's HICUM, A Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
ic	collector terminal current	A
ib	base terminal current	A
is	substrate terminal current	A
iavl	avalanche generation current	A
vbc	External BC voltage	V
vce	external voltage collector-emitter	V
vbe	external voltage base-emitter	V
vsc	external substrate-collector voltage	V
tf	total forward transit time as calculated in the model	s
ft	transit frequency	Hz

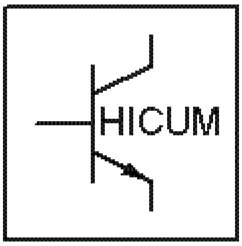
Name	Description	Units
gmi	Transconductance	A/V
BETADC	Common emitter forward current gain	
rbi	internal base resistance	Ohm
rb	total base resistance	Ohm
rcx	external (saturated) collector resistance	Ohm
re	emitter series resistance	Ohm
RPIi	Intrinsic input resistance	Ohm
RMUi	Intrinsic feedback resistance	Ohm
ROi	Output resistance	Ohm
CPIi	Total intrinsic BE capacitance	F
CMUi	Total intrinsic BC capacitance	F
CBCX	Total external BC capacitance	F
CCS	CS junction capacitance	F
BETAAC	Small signal current gain	S

HICUM 0_1_32 Model (HICUM BJT Level 0 Version 1.32 Model)

HICUM 0_1_32 Model (HICUM BJT Level 0 Version 1.32 Model)

The HICUM L0 version 1.32 is based on the L0 version 1.31. The modifications include changing the type selection to a single variable (Type). NPN and PNP are still supported but Type takes precedence. This version uses Rth rather than a temperature dependent version of Rth for power calculation. The parasitic transistor now also uses the Type parameter.

Symbol



This model (version 2.1) supplies values for a HICUM device. The important physical and electrical effects taken into account by HICUM are summarized:

- high-current effects (including quasi-saturation)
- distributed high-frequency model for the external base-collector region
- emitter periphery injection and associated charge storage
- emitter current crowding (through a bias-dependent internal base resistance
- 2- and 3-dimensional collector current spreading
- parasitic (bias independent) capacitances between base-emitter and base-collector terminal
- vertical non-quasi-static (NQS) effects for transfer current and minority charge
- temperature dependence and self-heating
- weak avalanche breakdown at the base-collector junction
- tunneling in the base-emitter junction
- parasitic substrate transistor
- bandgap differences (occurring in HBTs)
- lateral scalability
  For detailed physical and electrical effects, as well as model equations, refer to Michael Schroter's *HICUM, A* Scalable Physics-based Compact Bipolar Transistor Model *, Description of model version 2.1* , December, 2000; a pdf file is available at: "http://www.iee.et.tu-dresden.de/iee/eb/comp_mod.html".

Parameters

Name	Description	Units	Default
Type	Transistor type: 1=NPN, -1=PNP		
C10	ICCR constant (=ISQp0)	$A^2 \times s$	2e-30
Qp0	zero-bias hole charge	$A^2 \times s$	2.0e-14
Ich	high-current correction for 2D/3D-ICCR	A	infinity
Hfe	GICCR weighing factor for QEf in HBTs	None	1.0
Hfc	GICCR weighing factor for Qfc (mainly for HBTs)	None	1.0
Hjei	GICCR weighing factor for Qjei in HBTs	None	1.0
Hjci	GICCR weighing factor for Qjci in HBTs	None	1.0
Mcf	GICCR weighing factor for Qjci in HBTs	None	1.0
Alit	factor for additional delay time of iT	None	0.0
Cjei0	Internal B-E zero-bias depletion capacitance	F	0.0
Vdei	Internal B-E built-in voltage	V	0.9
Zei	Internal B-E grading coefficient	None	0.5
Aljei	Ratio of maximum to zero-bias value of internal B-E capacitance	None	2.5
Cjci0	Internal B-C zero-bias depletion capacitance	F	0.0
Vdci	Internal B-C built-in voltage	V	0.7
Zci	Internal B-C grading coefficient	None	0.4
Vptci	Internal B-C punch-through voltage (=qNCi$^{w2}{}_{Ci}$/(2ε)	V	1e20

Name	Description	Units	Default
T0	Low-current forward transit time at VBC=0	sec	0.0
Dt0h	Time constant for base and B-C space charge layer width modulation	sec	0.0
Tbvl	Time constant for modeling carrier jam at low VCE	sec	0.0
Tef0	neutral emitter storage time	sec	0.0
Gtfe	exponent factor for current dependent emitter storage time	None	1.0
Thcs	saturation time constant at high current densities	sec	0.0
Alhc	smoothing factor for current dependent C and B transit time	sec	0.1
Fthc	partitioning factor for base and collector portion	None	0.0
Alqf	factor for additional delay time of Qf	None	0.0
Rci0	low-field resistance of internal collector region (including scaling)	Ohm	150.0
Vlim	Voltage separating ohmic and saturation velocity regime	V	0.5
Vpt	Collector punch-through voltage	V	3.0
Vces	internal C-E saturation voltage	V	0.1
Tr	Storage time for inverse operation	sec	0.0
Ibeis	Internal B-E saturation current	A	1e-18
Mbei	Internal B-E non-ideality factor	None	1.0
Ireis	Internal B-E recombination saturation current	A	0.0
Mrei	Internal B-E recombination current ideality factor	None	2.0

Name	Description	Units	Default
Ibcis	Internal B-C saturation current	A	1.0e-16
Mbci	Internal B-C non-ideality factor	None	1.0
Favl	Avalanche current factor	1/V	0.0
Qavl	Exponent factor for avalanche current	C	0.0
Rbi0	Zero-bias internal base resistance	Ohm	0.0
Fdqr0	correction factor for modulation by BE and BC SCR	None	0.0
Fgeo	Factor for geometry dependence of emitter current crowding (default value corresponds to long emitter stripe)	None	0.6557
Fqi	ratio of internal to total minority charge	None	1.0
Fcrbi	ration of HF shunt to total internal capacitance	None	0.0
Latb	scaling factor for QfC in bE direction	None	0.0
Latl	scaling factor for QfC in lE direction	None	0.0
Cjep0	Peripheral B-E zero-bias depletion capacitacance	F	0.0
Vdep	Peripheral B-E built-in voltage	V	0.9
Zep	Peripheral B-E grading coefficient	None	0.5
Aljep	factor for adjusting maximum value of Cjep0	None	2.5
Ibeps	Peripheral B-E saturation current	A	0.0
Mbep	Peripheral B-E current ideality factor	None	1.0
Ireps	Peripheral B-E recombination saturation current	A	0.0
Mrep	Peripheral B-E recombination current ideality factor	None	2.0

Name	Description	Units	Default
Ibets	B-E tuneling saturation current	A	0.0
Abet	Exponent factor for tuneling current	None	40.0
Cjcx0	External B-C zero-bias depletion capacitance	F	0.0
Vdcx	External B-C built-in voltage	V	0.7
Zcx	External B-C grading coefficient	None	0.4
Vptcx	External B-C punch-through voltage	V	1.0e20
Ccox	B-C overlap capacitance	F	0.0
Fbc	partitioning factor for Ccbx=Cjcx0+Ccox	None	0.0
Ibcxs	External B-C saturation current	A	0.0
Mbcx	External B-C current ideality factor	None	1.0
Ceox	B-E isolation capacitance	F	0.0
Rbx	External base series resistance	Ohm	0.0
Re	Emitter series resistance	Ohm	0.0
Rcx	External collector series resistance	Ohm	0.0
Itss	Saturation current of substrate transistor transfer current	A	0.0
Msf	Forward ideality factor of substrate transfer current	None	1.0
Msr	Reverse ideality factor of substrate transfer current	None	1.0
Iscs	Saturation current of C-S diode (latch-up modeling)	A	0.0
Msc	Ideality factor of C-S diode	None	1.0

Name	Description	Units	Default
Tsf	Transit time (forward operation) for minority charge	sec	0.0
Cjs0	C-S zero-bias depletion capacitance	F	0.0
Vds	C-S built-in voltage	V	0.6
Zs	C-S grading coefficient	None	0.5
Vpts	C-S punch-through voltage	V	1.0e20
Rsu	Substrate series resistance	Ohm	0.0
Csu	Substrate cap. given by permittivity of bulk material	F	0.0
Kf	Flicker noise factor, no unit only for Af=2	None	0.0
Af	Flicker noise exponent	None	2.0
Krbi	Factor for internal base resistance	None	1.0
Vgb	Bandgap-voltage extrapolated to 0K	V	1.17
Alb	Relative temperature coefficient of current gain	1/K	5.0e-3
Zetaci	Temperature coefficient for Rci0	None	0.0
Alvs	Relative temperature coefficient of saturation drift velocity	1/K	0.0
Alt0	First-order relative temperature coefficient of parameter T0	1/K	0.0
Kt0	Second-order relative temperature coefficient of parameter T0	$1/K^2$	0.0
Alces	Relative temperature coefficient of Vces	1/K	0.0
Zetarbi	Temperature exponent of internal base resistance	None	0.0
Zetarbx	Temperature exponent of external base resistance	None	0.0

Name	Description	Units	Default
Zetarcx	Temperature exponent of external collector resistance	None	0.0
Zetare	Temperature exponent of emitter resistance	None	0.0
Alfav	Relative temperature coefficient for avalanche breakdown Favl	1/K	0.0
Alqav	Relative temperature coefficient for avalanche breakdown Qavl		0.0
Tnom	Temperature at which parameters are specified	°C	25
Trise	Temperature rise over ambient	°C	0
Rth	Thermal resistance	K/W	0.0
Cth	Thermal capacitance	W × s/K	0.0
Imax	Explosion current	A	1e4
Imelt	Explosion current (similar to Imax; refer to note 4); defaults to Imax	A	defaults to Imax
AcModel	Selects which small signal models to use for ac and S-parameter analyses: Small signal=1, consistent with charge model=2; (refer to note 5)	None	1
SelfheatingModel	Selects which power dissipation equations to use for modeling self-heating effect: Simplified model=1, full model=2; (refer to note 6)	None	1
wVsubfwd	Substrate junction forward bias (warning)	V	None
wBvsub	Substrate junction reverse breakdown voltage (warning)	V	None
wBvbe	Base-emitter reverse breakdown voltage (warning)	V	None
wBvbc	Base-collector reverse breakdown voltage (warning)	V	None
wVbcfwd	Base-collector forward bias (warning)	V	None

Name	Description	Units	Default
wIbmax	Maximum base current (warning)	A	None
wIcmax	Maximum collector current (warning)	A	None
wPmax	Maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

- Constant transit time Tf (at dc bias) is used in harmonic balance analysis for It current delay.
- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Small-signal ac model given in the reference cited in note 1 is a derivation of the large-signal charge model. However, it is not fully compatible with the charge model with the small input. The AcModel parameter can be set to either the small-signal model (AcModel=1) or the charge model compatible model (AcModel=2) for small-signal ac and S-parameter analyses.
  The AcModel parameter has no effect on large-signal analysis.
- Two power dissipation formulas for modeling the self-heating effect have been implemented in ADS.
  - When SelfheatingModel = 1, the simplified formula power = It × vce - Iave × vbc will be used.
  - When SelfheatingModel = 2, formula 2.1.16-1 from Schroter's document at: "http://www.iee.et.tu-dresden.de/iee/eb/comp_mod.html" will be used; the formula can be found under *General Description* > *HICUM-Equations* > section 2.1.16, equation 2.1.16-1.
    The simplified formula is implemented in Dr. Schroter's DEVICE program.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

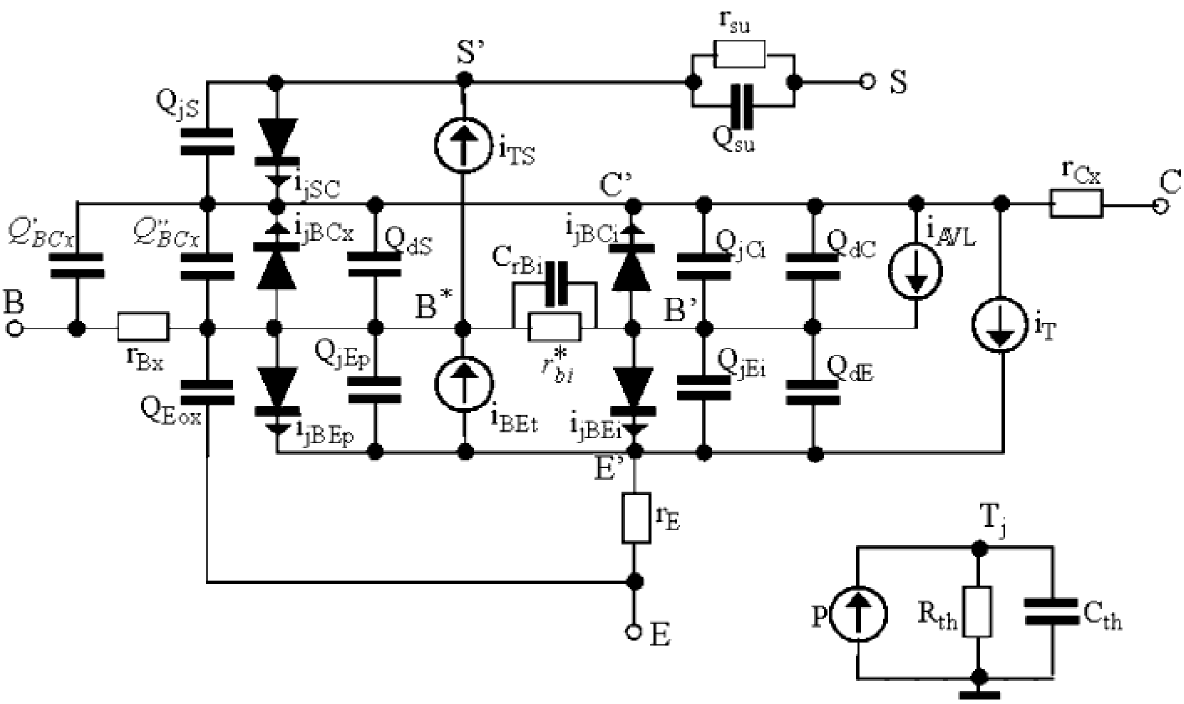
```
model modelname HICUM [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM*. Use either parameter NPN=yes or PNP=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example

```
model  Npn3  HICUM  \
  NPN=yes Alfav=8e-5 T0=5e-12
```

Equivalent Circuit



(a) (b)

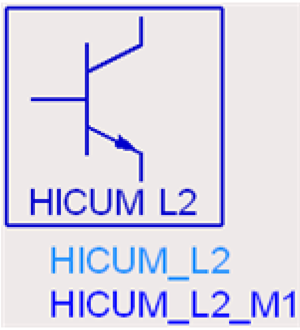
HICUM Level 2

HICUM Level 2

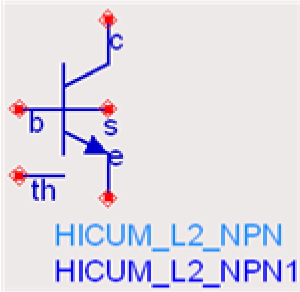
This section lists the supported versions of HICUM Level 2 model and instances.

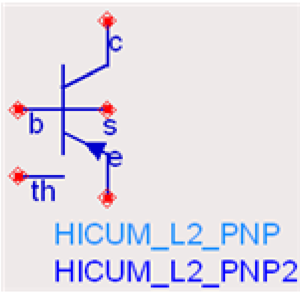
Symbol

Model



Instances (HICUM Level 2 NPN, HICUM Level 2 PNP)





Supported Versions

NOTE

The default value of flcomp parameter relates to 2.1x models (flcomp = 0 or 2.1). Newer features are enabled by flcomp=2.2 or flcomp=2.3, depending on the model features you want to enable. As a rule of thumb, flcomp should always be set equal to the version number of your actual HICUM model if you want to access the latest model equations. It should be set at the time of parameter extraction and not modified by the user.

- HICUM 2_21 (HICUM BJT Version 2.21 Instance)
- HICUM 2_21 Model (HICUM BJT Version 2.21 Model)
- HICUM 2_22 (HICUM BJT Version 2.22 Instance)
- HICUM 2_22 Model (HICUM BJT Version 2.22 Model)
- HICUM 2_23 (HICUM BJT Version 2.23 Instance)
- HICUM 2_23 Model (HICUM BJT Version 2.23 Model)
- HICUM 2_30 (HICUM BJT Version 2.30 Instance)

- HICUM 2_30 Model (HICUM BJT Version 2.30 Model)
- HICUM 2_3x (HICUM BJT Version 2.3x Instance)
- HICUM 2_3x Model (HICUM BJT Version 2.3x Model)
- HICUM 2_4_0 (HICUM BJT Version 2.4.0 Instance)
- HICUM 2_4_0 Model (HICUM BJT Version 2.4.0 Model)

HICUM 2_21 (HICUM BJT Version 2.21 Instance)

HICUM 2_21 (HICUM BJT Version 2.21 Instance)

Parameters

Name	Description	Units	Default
Temp	Device operating temperature	°C	25
Trise	Temperature rise over ambient	°C	0
Mode	Nonlinear spectral model on/off		1
Noise	Noise generation on/off		1
Flsh (Selfheating)	flag for turning on (1 = main currents, 2 = all currents) or off (0) self-heating effects		0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
ModelName [:Name] c b e s
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM2_21*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

```
model  Npn3  HICUM2_21 \
  Alfav=8e-5 T0=5e-12
```

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's *HICUM, A* Scalable Physics-based Compact Bipolar Transistor Model at: "http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html".
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
IC	Collector terminal current	A
IB	Base terminal current	A
IE	Emitter terminal current	A
IS	Substrate terminal current	A
Power	Total dissipated power	W
Temp	intrinsic device temperature	°C
VBE	External BE voltage	V
VBC	External BC voltage	V
VCE	External CE voltage	V
VSC	External SC voltage	V
BETADC	Common emitter forward current gain	
GM	Transconductance	A/V
GMAVL	Transconductance for avalanche current	A/V
GMS	Transconductance of the parasitic substrate PNP	A/V
RPIi	Intrinsic input resistance	Ohm

Name	Description	Units
RPIx	Extrinsic input resistance	Ohm
RMUi	Intrinsic feedback resistance	Ohm
RMUx	Extrinsic feedback resistance	Ohm
RMUs	Intrinsic substrate feedback resistance	Ohm
RO	Output resistance	Ohm
ROs	Output resistance for the parasitic substrate PNP	Ohm
CPIi	Total intrinsic BE capacitance	F
CPIx	Total extrinsic BE capacitance	F
CMUi	Total intrinsic BC capacitance	F
CMUx	Total extrinsic BC capacitance	F
CCS	CS junction capacitance	F
RBI	Internal base resistance as calculated in the model	Ohm
CRBI	Shunt capacitance across RBI as calculated in the model	F
TF	Total forward transit time as calculated in the model	S
FT	Transit frequency	Hz
VEF	Effective forward Early voltage	V
VER	Effective inverse Early voltage	V

HICUM 2_21 Model (HICUM BJT Version 2.21 Model)

HICUM 2_21 Model (HICUM BJT Version 2.21 Model)

Parameters

Name	Description	Units	Default
Tnom	Parameter measurement temperature	°C	27
Trise (Dt)	Temperature rise over ambient	°C	0
Secured	Secured model parameters		0
C10	GICCR constant (C10=IS*QP0)	AC	2e-030
Qp0	Zero-bias hole charge	C	2e-014
Ich	High-current correction for 2D and 3D effects	A	0
Hfe	Emitter minority charge weighting factor in HBTs		1
Hfc	Collector minority charge weighting factor in HBTs		1
Hjei	B-E depletion charge weighting factor in HBTs		1
Hjci	B-C depletion charge weighting factor in HBTs		1
Ibeis	Internal B-E saturation current	A	1e-018
Mbei	Internal B-E current ideality factor		1
Ireis	Internal B-E recombination saturation current	A	0
Mrei	Internal B-E recombination current ideality factor		2

Name	Description	Units	Default
Ibeps	Peripheral B-E saturation current	A	0
Mbep	Peripheral B-E current ideality factor		1
Ireps	Peripheral B-E recombination saturation current	A	0
Mrep	Peripheral B-E recombination current ideality factor		2
Mcf	Non-ideality factor for III-V HBTs		1
Tbhrec	Base current recombination time constant at B-C barrier for high forward injection	s	0
Ibcis	Internal B-C saturation current	A	1e-016
Mbci	Internal B-C current ideality factor		1
Ibcxs	External B-C saturation current	A	0
Mbcx	External B-C current ideality factor		1
Ibets	B-E tunneling saturation current	A	0
Abet	Exponent factor for tunneling current		40
Tunode	Specifies the base node connection for the tunneling current		1
Favl	Avalanche current factor	V^{-1}	0
Qavl	Exponent factor for avalanche current	C	0
Alfav	Relative temperature coefficient for Favl	K^{-1}	0
Alqav	Relative temperature coefficient for QAVL	K^{-1}	0
Rbi0	Zero bias internal base resistance	Ohms	0

Name	Description	Units	Default
Rbx	External base series resistance	Ohms	0
Fgeo (Fge0)	Factor for geometry dependence of emitter current crowding		0.6557
Fdqr0 (Fdqro)	Correction factor for modulation by B-E and B-C space charge layer		0
Fcrbi	Ratio of HF shunt to total internal capacitance (lateral NQS effect)		0
Fqi	Ratio of internal to total minority charge		1
Re	Emitter series resistance	Ohms	0
Rcx	External collector series resistance	Ohms	0
Itss	Substrate transistor transfer saturation current	A	0
Msf	Forward ideality factor of substrate transfer current		1
Iscs	C-S diode saturation current	A	0
Msc	Ideality factor of C-S diode current		1
Tsf	Transit time for forward operation of substrate transistor	s	0
Rsu	Substrate series resistance	Ohms	0
Csu	Substrate shunt capacitance	F	0
Cjei0 (Cjeio)	Internal B-E zero-bias depletion capacitance	F	1e-020
Vdei	Internal B-E built-in potential	V	0.9
Zei	Internal B-E grading coefficient		0.5
Ajei (Aljei)	Ratio of maximum to zero-bias value of internal B-E capacitance		2.5

Name	Description	Units	Default
Cjep0 (Cjepo)	Peripheral B-E zero-bias depletion capacitance	F	1e-020
Vdep	Peripheral B-E built-in potential	V	0.9
Zep	Peripheral B-E grading coefficient		0.5
Ajep (Aljep)	Ratio of maximum to zero-bias value of peripheral B-E capacitance		2.5
Cjci0 (Cjcio)	Internal B-C zero-bias depletion capacitance	F	1e-020
Vdci	Internal B-C built-in potential	V	0.7
Zci	Internal B-C grading coefficient		0.4
Vptci	Internal B-C punch-through voltage	V	100
Cjcx0 (Cjcxo)	External B-C zero-bias depletion capacitance	F	1e-020
Vdcx	External B-C built-in potential	V	0.7
Zcx	External B-C grading coefficient		0.4
Vptcx	External B-C punch-through voltage	V	100
Fbcpar (Fbc)	Partitioning factor of parasitic B-C cap		0
Fbepar	Partitioning factor of parasitic B-E cap		1
Cjs0 (Cjso)	C-S zero-bias depletion capacitance	F	0
Vds	C-S built-in potential	V	0.6
Zs	C-S grading coefficient		0.5
Vpts	C-S punch-through voltage	V	100
T0	Low current forward transit time at VBC=0V	s	0

Name	Description	Units	Default
Dt0h	Time constant for base and B-C space charge layer width modulation	s	0
Tbvl	Time constant for modelling carrier jam at low VCE	s	0
Tef0 (Tefo)	Neutral emitter storage time	s	0
Gtfe	Exponent factor for current dependence of neutral emitter storage time		1
Thcs	Saturation time constant at high current densities	s	0
Ahc (Alhc)	Smoothing factor for current dependence of base and collector transit time		0.1
Fthc	Partitioning factor for base and collector portion		0
Rci0	Internal collector resistance at low electric field	Ohms	150
Vlim	Voltage separating ohmic and saturation velocity regime	V	0.5
Vces	Internal C-E saturation voltage	V	0.1
Vpt	Collector punch-through voltage	V	0
Tr	Storage time for inverse operation	s	0
Cbepar	Total parasitic B-E capacitance	F	0
Cbcpar (Ccox)	Total parasitic B-C capacitance	F	0
Alqf	Factor for additional delay time of minority charge		0
Alit	Factor for additional delay time of transfer current		0
Flnqs	Flag for turning on and off of vertical NQS effect		0
Kf	Flicker noise coefficient		0

Name	Description	Units	Default
Af	Flicker noise exponent factor		2
Cfbe	Flag for determining where to tag the flicker noise source		-1
Latb	Scaling factor for collector minority charge in direction of emitter width		0
Latl	Scaling factor for collector minority charge in direction of emitter length		0
Vgb	Bandgap voltage extrapolated to 0 K	V	1.17
Alt0	First order relative temperature coefficient of parameter T0	K^{-1}	0
Kt0 (Kto)	Second order relative temperature coefficient of parameter T0	$1/K^2$	0
Zetaci	Temperature exponent for RCI0		0
Alvs	Relative temperature coefficient of saturation drift velocity	K^{-1}	0
Alces	Relative temperature coefficient of VCES	K^{-1}	0
Zetarbi	Temperature exponent of internal base resistance		0
Zetarbx	Temperature exponent of external base resistance		0
Zetarcx	Temperature exponent of external collector resistance		0
Zetare	Temperature exponent of emitter resistance		0
Zetacx	Temperature exponent of mobility in substrate transistor transit time		1
Vge	Effective emitter bandgap voltage	V	1.17
Vgc	Effective collector bandgap voltage	V	1.17
Vgs	Effective substrate bandgap voltage	V	1.17

Name	Description	Units	Default
F1vg	Coefficient K1 in T-dependent band-gap equation	V/K	-0.000102377
F2vg	Coefficient K2 in T-dependent band-gap equation	V/K	0.00043215
Zetact	Exponent coefficient in transfer current temperature dependence		3
Zetabet	Exponent coefficient in B-E junction current temperature dependence		3.5
Alb	Relative temperature coefficient of forward current gain for V2.1 model		0
Flsh (SelfheatingModel)	Flag for turning on and off self-heating effect		0
Rth	Thermal resistance	K/W	0
Cth	Thermal capacitance	Ws/K	0
Flcomp	Flag for compatibility with v2.1 model (0=v2.1)		0
NPN	For backward compatibility		1
PNP	For backward compatibility		0
ModelLevel	For backward compatibility		1
ApproxLevel	For backward compatibility		1
AcModel	For backward compatibility		1
wBvbc	For backward compatibility		0
wBvbe	For backward compatibility		0
wBvsub	For backward compatibility		0
wIbmax	For backward compatibility		0

Name	Description	Units	Default
wIcmax	For backward compatibility		0
wPmax	For backward compatibility		0
wVbcfwd	For backward compatibility		0
wVsubfwd	For backward compatibility		0
Imax	For backward compatibility		0
Imelt	For backward compatibility		0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname HICUM2_21 [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM2_21*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

```
model  Npn3  HICUM2_21 \
 Alfav=8e-5 T0=5e-12
```

For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's *HICUM, A* Scalable Physics-based Compact Bipolar Transistor Model at: "http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html".

HICUM 2_22 (HICUM BJT Version 2.22 Instance)

HICUM 2_22 (HICUM BJT Version 2.22 Instance)

Parameters

Name	Description	Units	Default
Temp	Device operating temperature	°C	25
Trise	Temperature rise over ambient	°C	0
Mode	Nonlinear spectral model on/off		1
Noise	Noise generation on/off		1
Flsh (Selfheating)	flag for turning on (1 = main currents, 2 = all currents) or off (0) self-heating effects		0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
ModelName [:Name] c b e s
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM2_22*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example:

```
model  Npn3  HICUM2_22 \
  Alfav=8e-5 T0=5e-12
```

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's *HICUM, A* Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
IC	Collector terminal current	A
IB	Base terminal current	A
IE	Emitter terminal current	A
IS	Substrate terminal current	A
Power	Total dissipated power	W
Temp	Intrinsic device temperature	°C
VBE	External BE voltage	V
VBC	External BC voltage	V
VCE	External CE voltage	V
VSC	External SC voltage	V
BETADC	Common emitter forward current gain	
GM	Transconductance	A/V
GMAVL	Transconductance for avalanche current	A/V
GMS	Transconductance of the parasitic substrate PNP	A/V
RPIi	Intrinsic input resistance	Ohm

Name	Description	Units
RPIx	Extrinsic input resistance	Ohm
RMUi	Intrinsic feedback resistance	Ohm
RMUx	Extrinsic feedback resistance	Ohm
RMUs	Intrinsic substrate feedback resistance	Ohm
RO	Output resistance	Ohm
ROs	Output resistance for the parasitic substrate PNP	Ohm
CPIi	Total intrinsic BE capacitance	F
CPIx	Total extrinsic BE capacitance	F
CMUi	Total intrinsic BC capacitance	F
CMUx	Total extrinsic BC capacitance	F
CCS	CS junction capacitance	F
RBI	Internal base resistance as calculated in the model	Ohm
CRBI	Shunt capacitance across RBI as calculated in the model	F
TF	Total forward transit time as calculated in the model	S
FT	Transit frequency	Hz
VEF	Effective forward Early voltage	V
VER	Effective inverse Early voltage	V

HICUM 2_22 Model (HICUM BJT Version 2.22 Model)

HICUM 2_22 Model (HICUM BJT Version 2.22 Model)

Parameters

Name	Description	Units	Default
Tnom	Parameter measurement temperature	°C	27
Trise (Dt)	Temperature rise over ambient	°C	0
Secured	Secured model parameters		0
C10	GICCR constant	A^{2s}	2e-030
Qp0	Zero-bias hole charge	Coul	2e-014
Ich	High-current correction for 2D and 3D effects	A	0
Hfe	Emitter minority charge weighting factor in HBTs		1
Hfc	Collector minority charge weighting factor in HBTs		1
Hjei	B-E depletion charge weighting factor in HBTs		1
Hjci	B-C depletion charge weighting factor in HBTs		1
Ibeis	Internal B-E saturation current	A	1e-018
Mbei	Internal B-E current ideality factor		1
Ireis	Internal B-E recombination saturation current	A	0
Mrei	Internal B-E recombination current ideality factor		2

Name	Description	Units	Default
Ibeps	Peripheral B-E saturation current	A	0
Mbep	Peripheral B-E current ideality factor		1
Ireps	Peripheral B-E recombination saturation current	A	0
Mrep	Peripheral B-E recombination current ideality factor		2
Mcf	Non-ideality factor for III-V HBTs		1
Tbhrec	Base current recombination time constant at B-C barrier for high forward injection	s	0
Ibcis	Internal B-C saturation current	A	1e-016
Mbci	Internal B-C current ideality factor		1
Ibcxs	External B-C saturation current	A	0
Mbcx	External B-C current ideality factor		1
Ibets	B-E tunneling saturation current	A	0
Abet	Exponent factor for tunneling current		40
tunode	Specifies the base node connection for the tunneling current		1
Favl	Avalanche current factor	1/V	0
Qavl	Exponent factor for avalanche current	Coul	0
Alfav	Relative TC for Favl	1/K	0
Alqav	Relative TC for Qavl	1/K	0
Rbi0	Zero bias internal base resistance	Ohm	0
Rbx	External base series resistance	Ohm	0

Name	Description	Units	Default
Fgeo (Fge0)	Factor for geometry dependence of emitter current crowding		0.6557
Fdqr0 (Fdqro)	Correction factor for modulation by B-E and B-C space charge layer		0
Fcrbi	Ratio of HF shunt to total internal capacitance (lateral NQS effect)		0
Fqi	Ratio of internal to total minority charge		1
Re	Emitter series resistance	Ohm	0
Rcx	External collector series resistance	Ohm	0
Itss	Substrate transistor transfer saturation current	A	0
Msf	Forward ideality factor of substrate transfer current		1
Iscs	C-S diode saturation current	A	0
Msc	Ideality factor of C-S diode current		1
Tsf	Transit time for forward operation of substrate transistor	s	0
Rsu	Substrate series resistance	Ohm	0
Csu	Substrate shunt capacitance	F	0
Cjei0 (Cjeio)	Internal B-E zero-bias depletion capacitance	F	1e-020
Vdei	Internal B-E built-in potential	V	0.9
Zei	Internal B-E grading coefficient		0.5
Ajei (Aljei)	Ratio of maximum to zero-bias value of internal B-E capacitance		2.5
Cjep0 (Cjepo)	Peripheral B-E zero-bias depletion capacitance	F	1e-020

Name	Description	Units	Default
Vdep	Peripheral B-E built-in potential	V	0.9
Zep	Peripheral B-E grading coefficient		0.5
Ajep (Aljep)	Ratio of maximum to zero-bias value of peripheral B-E capacitance		2.5
Cjci0 (Cjcio)	Internal B-C zero-bias depletion capacitance	F	1e-020
Vdci	Internal B-C built-in potential	V	0.7
Zci	Internal B-C grading coefficient		0.4
Vptci	Internal B-C punch-through voltage	V	100
Cjcx0 (Cjcxo)	External B-C zero-bias depletion capacitance	F	1e-020
Vdcx	External B-C built-in potential	V	0.7
Zcx	External B-C grading coefficient		0.4
Vptcx	External B-C punch-through voltage	V	100
Fbcpar (Fbc)	Partitioning factor of parasitic B-C cap		0
Fbepar	Partitioning factor of parasitic B-E cap		1
Cjs0 (Cjso)	C-S zero-bias depletion capacitance	F	0
Vds	C-S built-in potential	V	0.6
Zs	C-S grading coefficient		0.5
Vpts	C-S punch-through voltage	V	100
T0	Low current forward transit time at VBC=0V	s	0

Name	Description	Units	Default
Dt0h	Time constant for base and B-C space charge layer width modulation	s	0
Tbvl	Time constant for modelling carrier jam at low VCE	s	0
Tef0 (Tefo)	Neutral emitter storage time	s	0
Gtfe	Exponent factor for current dependence of neutral emitter storage time		1
Thcs	Saturation time constant at high current densities	s	0
Ahc (Alhc)	Smoothing factor for current dependence of base and collector transit time		0.1
Fthc	Partitioning factor for base and collector portion		0
Rci0	Internal collector resistance at low electric field	Ohms	150
Vlim	Voltage separating ohmic and saturation velocity regime	V	0.5
Vces	Internal C-E saturation voltage	V	0.1
Vpt	Collector punch-through voltage	V	0
Tr	Storage time for inverse operation	s	0
Cbepar	Total parasitic B-E capacitance	F	0
Cbcpar (Ccox)	Total parasitic B-C capacitance	F	0
Alqf	Factor for additional delay time of minority charge		0
Alit	Factor for additional delay time of transfer current		0
Flnqs	Flag for turning on and off of vertical NQS effect		0
Kf	Flicker noise coefficient		0

Name	Description	Units	Default
Af	Flicker noise exponent factor		2
Cfbe	Flag for determining where to tag the flicker noise source		-1
Latb	Scaling factor for collector minority charge in direction of emitter width		0
Latl	Scaling factor for collector minority charge in direction of emitter length		0
Vgb	Bandgap voltage extrapolated to 0 K	V	1.17
Alt0	First order relative temperature coefficient of parameter T0	1/K	0
Kt0 (Kto)	Second order relative TC of parameter T0		0
Zetaci	Temperature exponent for RCI0		0
Alvs	Relative TC of saturation drift velocity	1/K	0
Alces	Relative TC of VCES	1/K	0
Zetarbi	Temperature exponent of internal base resistance		0
Zetarbx	Temperature exponent of external base resistance		0
Zetarcx	Temperature exponent of external collector resistance		0
Zetare	Temperature exponent of emitter resistance		0
Zetacx	Temperature exponent of mobility in substrate transistor transit time		1
Vge	Effective emitter bandgap voltage	V	1.17
Vgc	Effective collector bandgap voltage	V	1.17
Vgs	Effective substrate bandgap voltage	V	1.17

Name	Description	Units	Default
F1vg	Coefficient K1 in T-dependent band-gap equation		-0.000102377
F2vg	Coefficient K2 in T-dependent band-gap equation		0.00043215
Zetact	Exponent coefficient in transfer current temperature dependence		3
Zetabet	Exponent coefficient in B-E junction current temperature dependence		3.5
Alb	Relative TC of forward current gain for V2.1 model	1/K	0
Flsh (SelfheatingModel)	Flag for turning on and off self-heating effect		0
Rth	Thermal resistance	K/W	0
Cth	Thermal capacitance	J/W	0
Flcomp	Flag for compatibility with v2.1 model (0=v2.1)		0
NPN	For backward compatibility		1
PNP	For backward compatibility		0
ModelLevel	For backward compatibility		1
ApproxLevel	For backward compatibility		1
AcModel	For backward compatibility		1
wBvbc	For backward compatibility		0
wBvbe	For backward compatibility		0
wBvsub	For backward compatibility		0
wIbmax	For backward compatibility		0

Name	Description	Units	Default
wIcmax	For backward compatibility		0
wPmax	For backward compatibility		0
wVbcfwd	For backward compatibility		0
wVsubfwd	For backward compatibility		0
Imax	For backward compatibility		0
Imelt	For backward compatibility		0
Ceox	For backward compatibility		0
Krbi	For backward compatibility		1
Msr	For backward compatibility		1

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname HICUM2_22 [parm=value]*
```

The model statement starts with the required keyword *model* . It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM2_22* . The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

```
model  Npn3  HICUM2_22 \
  Alfav=8e-5 T0=5e-12
```

For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's *HICUM, A* Scalable Physics-based Compact Bipolar Transistor Model at: "http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html".

HICUM 2_23 (HICUM BJT Version 2.23 Instance)

HICUM 2_23 (HICUM BJT Version 2.23 Instance)

Parameters

Name	Description	Units	Default
Temp	Device operating temperature	°C	25
Trise (Dtemp)	Temperature rise over ambient	°C	0
Mode	Nonlinear spectral model on/off		1
Noise	Noise generation on/off		1
flsh (Selfheating)	Flag for turning on and off self-heating effect		0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *ModelName [:Name] c b e s [t]*

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM2_23*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example:

```
model  Npn3  HICUM2_23 \
 alfav=8e-5 t0=5e-12
```

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's HICUM, A Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html .
- The following table lists the DC operating point parameters that can be sent to the dataset.
  DC Operating Point Information

Name	Description	Units
IC	Collector terminal current	A
IB	Base terminal current	A
IE	Emitter terminal current	A
IS	Substrate terminal current	A
Power	Total dissipated power	W
Temp	intrinsic device temperature	°C
VBE	External BE voltage	V
VBC	External BC voltage	V
VCE	External CE voltage	V
VSC	External SC voltage	V
BETADC	Common emitter forward current gain	
GM	Transconductance	A/V
GMAVL	Transconductance for avalanche current	A/V
GMS	Transconductance of the parasitic substrate PNP	A/V
RPIi	Intrinsic input resistance	Ohm

Name	Description	Units
RPIx	Extrinsic input resistance	Ohm
RMUi	Intrinsic feedback resistance	Ohm
RMUx	Extrinsic feedback resistance	Ohm
RMUs	Intrinsic substrate feedback resistance	Ohm
RO	Output resistance	Ohm
ROs	Output resistance for the parasitic substrate PNP	Ohm
CPIi	Total intrinsic BE capacitance	F
CPIx	Total extrinsic BE capacitance	F
CMUi	Total intrinsic BC capacitance	F
CMUx	Total extrinsic BC capacitance	F
CCS	CS junction capacitance	F
RBI	Internal base resistance as calculated in the model	Ohm
CRBI	Shunt capacitance across RBI as calculated in the model	F
TF	Total forward transit time as calculated in the model	S
FT	Transit frequency	Hz
VEF	Effective forward Early voltage	V
VER	Effective inverse Early voltage	V

HICUM 2_23 Model (HICUM BJT Version 2.23 Model)

HICUM 2_23 Model (HICUM BJT Version 2.23 Model)

Parameters

Name (Alias)	Description	Units	Default
Gender	+1=N-type, -1=P-type		1(n),-1(p)
Tnom	Parameter measurement temperature	°C	
Trise (dt)	Temperature rise over ambient	°C	0
Secured	Secured model parameters		0
c10	GICCR constant	A^2s	2e-030
qp0	Zero-bias hole charge	Coul	2e-014
ich	High-current correction for 2D and 3D effects	A	0
hfe	Emitter minority charge weighting factor in HBTs		1
hfc	Collector minority charge weighting factor in HBTs		1
hjei	B-E depletion charge weighting factor in HBTs		1
hjci	B-C depletion charge weighting factor in HBTs		1
ibeis	Internal B-E saturation current	A	1e-018
mbei	Internal B-E current ideal factor		1
ireis	Internal B-E recombination saturation current	A	0
mrei	Internal B-E recombination current ideal factor		2

Name (Alias)	Description	Units	Default
ibeps	Peripheral B-E saturation current	A	0
mbep	Peripheral B-E current ideal factor		1
ireps	Peripheral B-E recombination saturation current	A	0
mrep	Peripheral B-E recombination current ideal factor		2
mcf	Non-ideal factor for III-V HBTs		1
tbhrec	Base current recombination time constant at B-C barrier for high forward injection	s	0
ibcis	Internal B-C saturation current	A	1e-016
mbci	Internal B-C current ideal factor		1
ibcxs	External B-C saturation current	A	0
mbcx	External B-C current ideal factor		1
ibets	B-E tunneling saturation current	A	0
abet	Exponent factor for tunneling current		40
tunode	Specifies the base node connection for the tunneling current		1
favl	Avalanche current factor	1/V	0
qavl	Exponent factor for avalanche current	Coul	0
alfav	Relative TC for FAVL	1/K	0
alqav	Relative TC for QAVL	1/K	0
rbi0	Zero bias internal base resistance	Ohm	0
rbx	External base series resistance	Ohm	0

Name (Alias)	Description	Units	Default
fgeo (fge0)	Factor for geometry dependence of emitter current crowding		0.6557
fdqr0 (fdqro)	Correction factor for modulation by B-E and B-C space charge layer		0
fcrbi	Ratio of HF shunt to total internal capacitance (lateral NQS effect)		0
fqi	Ratio of internal to total minority charge		1
re	Emitter series resistance	Ohm	0
rcx	External collector series resistance	Ohm	0
itss	Substrate transistor transfer saturation current	A	0
msf	Forward ideal factor of substrate transfer current		1
iscs	C-S diode saturation current	A	0
msc	Ideal factor of C-S diode current		1
tsf	Transit time for forward operation of substrate transistor	s	0
rsu	Substrate series resistance	Ohm	0
csu	Substrate shunt capacitance	F	0
cjei0 (cjeio)	Internal B-E zero-bias depletion capacitance	F	1e-020
vdei	Internal B-E built-in potential	V	0.9
zei	Internal B-E grading coefficient		0.5
ajei (aljei)	Ratio of maximum to zero-bias value of internal B-E capacitance		2.5
cjep0 (cjepo)	Peripheral B-E zero-bias depletion capacitance	F	1e-020

Name (Alias)	Description	Units	Default
vdep	Peripheral B-E built-in potential	V	0.9
zep	Peripheral B-E grading coefficient		0.5
ajep (aljep)	Ratio of maximum to zero-bias value of peripheral B-E capacitance		2.5
cjci0 (cjcio)	Internal B-C zero-bias depletion capacitance	F	1e-020
vdci	Internal B-C built-in potential	V	0.7
zci	Internal B-C grading coefficient		0.4
vptci	Internal B-C punch-through voltage	V	100
cjcx0 (cjcxo)	External B-C zero-bias depletion capacitance	F	1e-020
vdcx	External B-C built-in potential	V	0.7
zcx	External B-C grading coefficient		0.4
vptcx	External B-C punch-through voltage	V	100
fbcpar (fbc)	Partitioning factor of parasitic B-C cap		0
fbepar	Partitioning factor of parasitic B-E cap		1
cjs0 (cjso)	C-S zero-bias depletion capacitance	F	0
vds	C-S built-in potential	V	0.6
zs	C-S grading coefficient		0.5
vpts	C-S punch-through voltage	V	100
t0	Low current forward transit time at VBC=0V	s	0

Name (Alias)	Description	Units	Default
dt0h	Time constant for base and B-C space charge layer width modulation	s	0
tbvl	Time constant for modeling carrier jam at low VCE	s	0
tef0 (tefo)	Neutral emitter storage time	s	0
gtfe	Exponent factor for current dependence of neutral emitter storage time		1
thcs	Saturation time constant at high current densities	s	0
ahc (alhc)	Smoothing factor for current dependence of base and collector transit time		0.1
fthc	Partitioning factor for base and collector portion		0
rci0	Internal collector resistance at low electric field	Ohm	150
vlim	Voltage separating ohmic and saturation velocity regime	V	0.5
vces	Internal C-E saturation voltage	V	0.1
vpt	Collector punch-through voltage	V	0
tr	Storage time for inverse operation	s	0
cbepar	Total parasitic B-E capacitance	F	0
cbcpar (ccox)	Total parasitic B-C capacitance	F	0
alqf	Factor for additional delay time of minority charge		0
alit	Factor for additional delay time of transfer current		0
flnqs	Flag for turning on and off of vertical NQS effect		0
kf	Flicker noise coefficient		0

Name (Alias)	Description	Units	Default
af	Flicker noise exponent factor		2
cfbe	Flag for determining where to tag the flicker noise source		-1
latb	Scaling factor for collector minority charge in direction of emitter width		0
latl	Scaling factor for collector minority charge in direction of emitter length		0
vgb	Bandgap voltage extrapolated to 0 K	V	1.17
alt0	First order relative TC of parameter T0	1/K	0
kt0 (kto)	Second order relative TC of parameter T0		0
zetaci	Temperature exponent for RCI0		0
alvs	Relative TC of saturation drift velocity	1/K	0
alces	Relative TC of VCES	1/K	0
zetarbi	Temperature exponent of internal base resistance		0
zetarbx	Temperature exponent of external base resistance		0
zetarcx	Temperature exponent of external collector resistance		0
zetare	Temperature exponent of emitter resistance		0
zetacx	Temperature exponent of mobility in substrate transistor transit time		1
vge	Effective emitter bandgap voltage	V	1.17
vgc	Effective collector bandgap voltage	V	1.17
vgs	Effective substrate bandgap voltage	V	1.17

Name (Alias)	Description	Units	Default
f1vg	Coefficient K1 in T-dependent band-gap equation		-0.000102377
f2vg	Coefficient K2 in T-dependent band-gap equation		0.00043215
zetact	Exponent coefficient in transfer current temperature dependence		3
zetabet	Exponent coefficient in B-E junction current temperature dependence		3.5
alb	Relative TC of forward current gain for V2.1 model	1/K	0
flsh (SelfheatingModel)	Flag for turning on and off self-heating effect		0
rth	Thermal resistance	K/W	0
cth	Thermal capacitance	J/W	0
flcomp	Flag for compatibility with v2.1 model (0=v2.1)		0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *model modelname HICUM2_23 [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM2_23* . The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

```
model  Npn3  HICUM2_23 \
 alfav=8e-5 t0=5e-12
```

For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's HICUM, A Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html

HICUM 2_30 (HICUM BJT Version 2.30 Instance)

HICUM 2_30 (HICUM BJT Version 2.30 Instance)

Parameters

Name	Description	Units	Default
Temp	Device operating temperature	°C	25
Trise (Dtemp)	Temperature rise over ambient	°C	0
Mode	Nonlinear spectral model on/off		1
Noise	Noise generation on/off		1
dt	Temperature change for particular transistor	K	0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *ModelName [:Name] c b e s*

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM2_30*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case-sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables, and equations, refer to ADS Simulator Input Syntax.

Example:

```
model  Npn3  HICUM2_30 \
  is=8e-15 t0=5e-12
```

- DC operating point parameters that can be sent to the dataset:

Name	Description	Units
ib	Base terminal current	A
ic	Collector terminal current	A
is	Substrate terminal current	A
vbe	External BE voltage	V
vbc	External BC voltage	V
vce	External CE voltage	V
vsc	External SC voltage	V
BETADC	Common emitter forward current gain	
GM	Transconductance	A/V
GMAVL	Transconductance for avalanche current	A/V
GMS	Transconductance of the parasitic substrate PNP	A/V
RPIi	Intrinsic input resistance	Ohm
RPIx	Extrinsic input resistance	Ohm
RMUi	Intrinsic feedback resistance	Ohm
RMUx	Extrinsic feedback resistance	Ohm
RMUs	Intrinsic substrate feedback resistance	Ohm
RO	Output resistance	Ohm

Name	Description	Units
ROs	Output resistance for the parasitic substrate pnp	Ohm
CPIi	Total intrinsic BE capacitance	F
CPIx	Total extrinsic BE capacitance	F
CMUi	Total intrinsic BC capacitance	F
CMUx	Total extrinsic BC capacitance	F
CCS	CS junction capacitance	F
RBI	Internal base resistance as calculated in the model	Ohm
CRBI	Shunt capacitance across RBI as calculated in the model	F
TF	Total forward transit time as calculated in the model	s
FT	Transit frequency	Hz
VEF	Effective forward Early voltage	V
VER	Effective inverse Early voltage	V

HICUM 2_30 Model (HICUM BJT Version 2.30 Model)

HICUM 2_30 Model (HICUM BJT Version 2.30 Model)

Parameters

Name	Description	Units	Default
Tnom	Parameter measurement temperature	deg C	27
is	(Modified) saturation current	A	1e-16
qp0	Zero-bias hole charge	C	2E-14
ich	High-current correction for 2D and 3D effects	A	0
hfe	Emitter minority charge weighting factor in HBTs	-	1
hfc	Collector minority charge weighting factor in HBTs	-	1
hjei	BE depletion charge weighting factor in HBTs	-	1
hjci	BC depletion charge weighting factor in HBTs	-	1
mcf	non-ideality coefficient of forward collector current	-	1
ibeis	Internal BE saturation current	A	1e-18
mbei	Internal BE current ideality factor	-	1
ireis	Internal BE recombination saturation current	A	0
mrei	Internal BE recombination current ideality factor	-	2
ibeps	Peripheral BE saturation current	A	0
mbep	Peripheral BE current ideality factor	-	1

Name	Description	Units	Default
ireps	Peripheral BE recombination saturation current	A	0
mrep	Peripheral BE recombination current ideality factor	-	2
tbhrec	base current recombination time constant at the BC barrier for high forward injection	s	0
ibcis	Internal BC saturation current	A	1e-16
mbci	Internal BC current ideality factor	-	1
ibcxs	External BC saturation current	A	0
mbcx	External BC current ideality factor	-	1
ibets	BE tunnelling saturation current	A	0
abet	Exponent factor for tunnelling current	-	40
tunode	specifies the base node connection of the tunneling current source	-	1
favl	Avalanche current factor	1/V	0
qavl	Exponent factor for avalanche current	C	0
rbi0	Zero-bias internal base resistance	Ohm	0
rbx	External base series resistance	Ohm	0
fgeo	Geometry factor	-	0.6557
fdqr0	Correction factor for modulation by BE and BC Space charge layer	-	0
fcrbi	Ratio of HF shunt to total internal capacitance	-	0
fqi	Ratio of internal to total minority charge	-	1
re	Emitter series resistance	Ohm	0

Name	Description	Units	Default
rcx	External collector series resistance	Ohm	0
itss	Substrate transistor transfer saturation current	A	0
msf	Substrate transfer current forward ideality factor	-	1
iscs	SC saturation current	A	0
msc	SC ideality factor	-	1
tsf	Transit time	s	0
rsu	Substrate series resistance	Ohm	0
csu	Shunt capacitance	F	0
cje0	Zero-bias BE depletion capacitance	F	1e-20
vde	BE built-in voltage	V	0.9
ze	BE exponent factor	-	0.5
aje	Ratio of maximum to zero-bias value	-	2.5
cjci0	Total zero-bias BC depletion capacitance	F	1e-20
vdci	BC built-in voltage	V	0.7
zci	BC exponent factor	-	0.4
vptci	Punch-through voltage of BC junction	V	100
cjcx0	Zero-bias external BC depletion capacitance	F	1e-20
vdcx	External BC built-in voltage	V	0.7
zcx	External BC exponent factor	-	0.4

Name	Description	Units	Default
vptcx	Punch-through voltage	V	100
cjs0	Zero-bias SC depletion capacitance	F	0
vds	SC built-in voltage	V	0.6
zs	External SC exponent factor	-	0.5
vpts	SC punch-through voltage	V	100
t0	low current transit time at Vbc=0	s	0
dt0h	Base width modulation contribution	s	0
tbvl	Time constant for modelling carrier at low VCE	s	0
tef0	Storage time in neutral emitter	s	0
gte	Exponent factor for emitter transit time	-	1
thcs	Saturation time at high current densities	s	0
ahc	Smoothing factor for current dependence	-	0.1
tr	Storage time at inverse operation	s	0
fthc	Partitioning factor for base and collector portion	-	0
rci0	Low-field collector resistance under emitter	Ohm	150
vlim	Voltage dividing ohmic and saturation region	V	0.5
vpt	Punch-through voltage	V	100
vces	Saturation voltage	V	0.1
cbcpar	Collector-base isolation (overlap) capacitance	F	0

Name	Description	Units	Default
cbepar	Emitter-base oxide capacitance	F	0
fbepar	partitioining factor of emitter-base capacitance	-	1
fbcpar	partitioining factor of collector-base capacitance	-	0
alqf	Minority charge additional delay time factor	-	0
alit	Transfer current additional delay time factor	-	0
flnqs	Flag for vertical NQS effects	-	0
kf	Flicker noise coefficient	M^{1-AF}	0
af	Flicker noise exponent factor	-	2
cfbe	Flag for flicker noise source		/-1
latb	Scaling factor for collector minority charge in direction of emitter width	-	0
latl	Scaling factor for collector minority charge in direction of emitter length	-	2
vgb	Bandgap-voltage	V	1.17
vge	Effective emitter bandgap-voltage	V	1.17
vgc	Effective collector bandgap-voltage	V	1.17
vgs	Effective substrate bandgap-voltage	V	1.17
f1vg	Coefficient K1 in T-dependent bandgap equation	V/K	-0.000102377
f2vg	Coefficient K2 in T-dependent bandgap equation	V/K	0.00043215
alt0	First-order TC of tf0	1/K	0

Name	Description	Units	Default
kt0	Second-order TC of tf0	$1/K^2$	0
zetact	Exponent coefficient in transfer current temperature dependence	-	3
zetabet	Exponent coefficient in BE junction current temperature dependence	-	3.5
zetaci	TC of epi-collector diffusivity	-	0
alvs	Relative TC of saturation drift velocity	1/K	0
alces	Relative TC of vces	1/K	0
zetarbi	TC of internal base resistance	-	0
zetarbx	TC of external base resistance	-	0
zetarcx	TC of external collector resistance	-	0
zetare	TC of emitter resistance	-	0
zetacx	TC of mobility in substrate transistor transit time	-	1
alfav	TC of avalanche prefactor	1/K	0
alqav	TC of avalanche exponential factor	1/K	0
alb	Relative temperature coefficient of forward current gain	-	0
flcomp	Compatibility flag	-	1
flsh	Flag for self-heating calculation	-	0
rth	Thermal resistance	K/W	0
cth	Thermal capacitance	Ws/K	0
hf0	Weight factor for the low current minority charge		1

Name	Description	Units	Default
ahjei	Parameter describing the slope of hjEi		0
rhjei	Smoothing parameter for hjEi at high voltage		1
vcbar	Barrier voltage	V	0
icbar	Normalization parameter	A	0
acbar	Smoothing parameter for barrier voltage		0.01
delck	fitting factor for critical current		2
zetarth	Temperature coefficient for Rth	K/W	0
zetavgbe	Temperature coefficient for hjEi0		1
zetahjei	Temperature coefficient for ahjEi		1
dvgbe	Bandgap difference between B and BE junction used for hjEi0 and hf0	V	0
kfre	Emitter resistance flicker noise coefficient		0
afre	Emitter resistance flicker noise exponent factor		2

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

> *model ModelName [:Name] c b e s*

The model statement starts with the required keyword model. It is followed by the modelname that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is HICUM2_30. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case-sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables, and equations, refer to ADS Simulator Input Syntax.

Example:

```
Npn3:Ql c b e s t
model Npn3 HICUM2_30 is=5e-16 vef=250
```

- For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's HICUM, A Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_doc.html.
- For detailed information on HICUM, see M. Schroter and A. Chakravorty, “Compact hierarchical modeling of bipolar transistors with HICUM”, World Scientific, Singapore, ISBN 978-981-4273-21-3, 2010.

HICUM 2_3x (HICUM BJT Version 2.3x Instance)

HICUM 2_3x (HICUM BJT Version 2.3x Instance)

The following topic lists the HICUM 2.31 and 2.32 instance parameters.

Parameters

Name	Description	Units	Default
flsh	Flag for turning on and off self-heating effect		0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *ModelName [:Name] c b e s*

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM2_31* or *HICUM2_32*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case-sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables, and equations, refer to ADS Simulator Input Syntax.

Example:

```
model  Npn3  HICUM2_31 \
  t0=5e-12
```

Example:

```
model  Npn3  HICUM2_32 \
  t0=5e-12
```

HICUM 2.31 DC Operating Point Parameters
The DC operating point parameters that can be sent to the dataset.

Name	Description	Units
IC	Collector terminal current	A
IB	Base terminal current	A
IE	Emitter terminal current	A
IS	Substrate terminal current	A
Power	Total dissipated power	W
Temp	intrinsic device temperature	deg C
VBE	External BE voltage	V
VBC	External BC voltage	V
VCE	External CE voltage	V
VSC	External SC voltage	V
BETADC	Common emitter forward current gain	
GMi	Transconductance	A/V
GMAVL	Transconductance for avalanche current	A/V
GMS	Transconductance of the parasitic substrate PNP	A/V
RPIi	Intrinsic input resistance	Ohm
RPIx	Extrinsic input resistance	Ohm
RMUi	Intrinsic feedback resistance	Ohm
RMUx	Extrinsic feedback resistance	Ohm

Name	Description	Units
RMUs	Intrinsic substrate feedback resistance	Ohm
ROi	Output resistance	Ohm
ROs	Output resistance for the parasitic substrate PNP	Ohm
CPIi	Total intrinsic BE capacitance	F
CPIx	Total extrinsic BE capacitance	F
CMUi	Total intrinsic BC capacitance	F
CMUx	Total extrinsic BC capacitance	F
CCS	CS junction capacitance	F
RBI	Internal base resistance as calculated in the model	Ohm
CRBI	Shunt capacitance across RBI as calculated in the model	F
TF	Total forward transit time as calculated in the model	S
FT	Transit frequency	Hz
VEF	Effective forward Early voltage	V
VER	Effective inverse Early voltage	V
IAVL	Avalanche Current	A
RB	Total Base Resistance	Ohm
RCX	External (saturated) collector series resistance	Ohm
RE	Emitter series resistance	Ohm
BETAAC	Small signal current gain	S

HICUM 2.32 DC Operating Point Parameters

The DC operating point parameters that can be sent to the dataset.

Name	Description	Units
IC	Collector terminal current	A
IB	Base terminal current	A
IS	Substrate terminal current	A
IAVL	Avalanche Current	A
VBE	External BE voltage	V
VBC	External BC voltage	V
VCE	External CE voltage	V
VSC	External SC voltage	V
BETADC	Common emitter forward current gain	
GMi	Transconductance	A/V
GMS	Transconductance of the parasitic substrate PNP	A/V
RPIi	Intrinsic input resistance	Ohm
RPIx	Extrinsic input resistance	Ohm
RMUi	Intrinsic feedback resistance	Ohm
RMUx	Extrinsic feedback resistance	Ohm
RMUs	Intrinsic substrate feedback resistance	Ohm
ROi	Output resistance	Ohm
CPIi	Total intrinsic BE capacitance	F

Name	Description	Units
CPIx	Total extrinsic BE capacitance	F
CMUi	Total intrinsic BC capacitance	F
CMUx	Total extrinsic BC capacitance	F
CCS	CS junction capacitance	F
RBI	Internal base resistance as calculated in the model	Ohm
RB	Total Base Resistance	Ohm
RCX	External (saturated) collector series resistance	Ohm
RE	Emitter series resistance	Ohm
CRBI	Shunt capacitance across RBI as calculated in the model	F
TF	Total forward transit time as calculated in the model	S
FT	Transit frequency	Hz
TK	Device temperature (including self heating)	K
DTSH	Temperature increase due to selfheating	W
BETAAC	Small signal current gain	S

HICUM 2_3x Model (HICUM BJT Version 2.3x Model)

HICUM 2_3x Model (HICUM BJT Version 2.3x Model)

The supported versions are:

- 2.31
- 2.32
- 2.33
- 2.34
  The HICUM Level 2 version 2.34 vary as described below:
  - The transit time calculation now sets Qbf=0 for low currents
  - The range of capacitance grading coefficients is restricted to less than 1
  - New parameters cscp0, vdsp, zsp, vptsp were added for peripheral substrate capacitor
  - New parameter aick added as smoothing term of ICK
  - Fixes to calculations in avalanche condition

The following topic lists the HICUM 2.3x model parameters.

Parameters

Name (Alias)	Description	Units	Default
Tnom	Parameter measurement temperature	deg C	27
c10	GICCR constant	A^2s	2e-030
qp0	Zero-bias hole charge	Coul	2e-014
ich	High-current correction for 2D and 3D effects	A	0
hf0	Weight factor for the low current minority charge		1
hfe	Emitter minority charge weighting factor in HBTs		1
hfc	Collector minority charge weighting factor in HBTs		1
hjei	B-E depletion charge weighting factor in HBTs		1
ahjei	Parameter describing the slope of hjEi(VBE)		0
rhjei	Smoothing parameter for hjEi(VBE) at high voltage		1

Name (Alias)	Description	Units	Default
hjci	B-C depletion charge weighting factor in HBTs		1
ibeis	Internal B-E saturation current	A	1e-018
mbei	Internal B-E current ideal factor		1
ireis	Internal B-E recombination saturation current	A	0
mrei	Internal B-E recombination current ideal factor		2
ibeps	Peripheral B-E saturation current	A	0
mbep	Peripheral B-E current ideal factor		1
ireps	Peripheral B-E recombination saturation current	A	0
mrep	Peripheral B-E recombination current ideal factor		2
mcf	Non-ideal factor for III-V HBTs		1
tbhrec	Base current recombination time constant at B-C barrier for high forward injection	s	0
ibcis	Internal B-C saturation current	A	1e-016
mbci	Internal B-C current ideal factor		1
ibcxs	External B-C saturation current	A	0
mbcx	External B-C current ideal factor		1
ibets	B-E tunneling saturation current	A	0
abet	Exponent factor for tunneling current		40
tunode	Specifies the base node connection for the tunneling current		1
favl	Avalanche current factor	1/V	0

Name (Alias)	Description	Units	Default
qavl	Exponent factor for avalanche current	Coul	0
alfav	Relative TC for FAVL	1/K	0
alqav	Relative TC for QAVL	1/K	0
rbi0	Zero bias internal base resistance	Ohm	0
rbx	External base series resistance	Ohm	0
fgeo (fge0)	Factor for geometry dependence of emitter current crowding		0.6557
fdqr0 (fdqro)	Correction factor for modulation by B-E and B-C space charge layer		0
fcrbi	Ratio of HF shunt to total internal capacitance (lateral NQS effect)		0
fqi	Ratio of internal to total minority charge		1
re	Emitter series resistance	Ohm	0
rcx	External collector series resistance	Ohm	0
itss	Substrate transistor transfer saturation current	A	0
msf	Forward ideal factor of substrate transfer current		1
iscs	C-S diode saturation current	A	0
msc	Ideal factor of C-S diode current		1
tsf	Transit time for forward operation of substrate transistor	s	0
rsu	Substrate series resistance	Ohm	0
csu	Substrate shunt capacitance	F	0

Name (Alias)	Description	Units	Default
cjei0 (cjeio)	Internal B-E zero-bias depletion capacitance	F	1e-020
vdei	Internal B-E built-in potential	V	0.9
zei	Internal B-E grading coefficient		0.5
ajei (aljei)	Ratio of maximum to zero-bias value of internal B-E capacitance		2.5
cjep0 (cjepo)	Peripheral B-E zero-bias depletion capacitance	F	1e-020
vdep	Peripheral B-E built-in potential	V	0.9
zep	Peripheral B-E grading coefficient		0.5
ajep (aljep)	Ratio of maximum to zero-bias value of peripheral B-E capacitance		2.5
cjci0 (cjcio)	Internal B-C zero-bias depletion capacitance	F	1e-020
vdci	Internal B-C built-in potential	V	0.7
zci	Internal B-C grading coefficient		0.4
vptci	Internal B-C punch-through voltage	V	100
cjcx0 (cjcxo)	External B-C zero-bias depletion capacitance	F	1e-020
vdcx	External B-C built-in potential	V	0.7
zcx	External B-C grading coefficient		0.4
vptcx	External B-C punch-through voltage	V	100
fbcpar (fbc)	Partitioning factor of parasitic B-C cap		0
fbepar	Partitioning factor of parasitic B-E cap		1

Name (Alias)	Description	Units	Default
cjs0 (cjso)	C-S zero-bias depletion capacitance	F	0
vds	C-S built-in potential	V	0.6
zs	C-S grading coefficient		0.5
vpts	C-S punch-through voltage	V	100
t0	Low current forward transit time at VBC=0V	s	0
dt0h	Time constant for base and B-C space charge layer width modulation	s	0
tbvl	Time constant for modeling carrier jam at low VCE	s	0
tef0 (tefo)	Neutral emitter storage time	s	0
gtfe	Exponent factor for current dependence of neutral emitter storage time		1
thcs	Saturation time constant at high current densities	s	0
ahc (alhc)	Smoothing factor for current dependence of base and collector transit time		0.1
fthc	Partitioning factor for base and collector portion		0
rci0	Internal collector resistance at low electric field	Ohm	150
vlim	Voltage separating ohmic and saturation velocity regime	V	0.5
vces	Internal C-E saturation voltage	V	0.1
vpt	Collector punch-through voltage	V	0
tr	Storage time for inverse operation	s	0
vcbar	Barrier voltage	V	0

Name (Alias)	Description	Units	Default
icbar	Normalization parameter	A	0
acbar	Smoothing parameter for barrier voltage		0
delck	fitting factor for critical current		2
cbepar	Total parasitic B-E capacitance	F	0
cbcpar (ccox)	Total parasitic B-C capacitance	F	0
alqf	Factor for additional delay time of minority charge		0
alit	Factor for additional delay time of transfer current		0
flnqs	Flag for turning on and off of vertical NQS effect		0
kf	Flicker noise coefficient		0
af	Flicker noise exponent factor		2
cfbe	Flag for determining where to tag the flicker noise source		-1
flcono	Flag for turning on and off of correlated noise implementation		0
kfre	Emitter resistance flicker noise coefficient		0
afre	Emitter resistance flicker noise exponent factor		2
latb	Scaling factor for collector minority charge in direction of emitter width		0
latl	Scaling factor for collector minority charge in direction of emitter length		0
vgb	Bandgap voltage extrapolated to 0 K	V	1.17
alt0	First order relative TC of parameter T0	1/K	0

Name (Alias)	Description	Units	Default
kt0 (kto)	Second order relative TC of parameter T0		0
zetaci	Temperature exponent for RCI0		0
alvs	Relative TC of saturation drift velocity	1/K	0
alces	Relative TC of VCES	1/K	0
zetarbi	Temperature exponent of internal base resistance		0
zetarbx	Temperature exponent of external base resistance		0
zetarcx	Temperature exponent of external collector resistance		0
zetare	Temperature exponent of emitter resistance		0
zetacx	Temperature exponent of mobility in substrate transistor transit time		1
vge	Effective emitter bandgap voltage	V	1.17
vgc	Effective collector bandgap voltage	V	1.17
vgs	Effective substrate bandgap voltage	V	1.17
f1vg	Coefficient K1 in T-dependent band-gap equation		-0.000102377
f2vg	Coefficient K2 in T-dependent band-gap equation		0.00043215
zetact	Exponent coefficient in transfer current temperature dependence		3
zetabet	Exponent coefficient in B-E junction current temperature dependence		3.5
alb	Relative TC of forward current gain for V2.1 model	1/K	0
dvgbe	Bandgap difference between B and B-E junction used for hjEi0 and hf0	V	0

Name (Alias)	Description	Units	Default
zetahjei	Temperature coefficient for ahjEi		1
zetavgbe	Temperature coefficient for hjEi0		1
flsh (SelfheatingModel)	Flag for turning on and off self-heating effect		0
rth	Thermal resistance	K/W	0
zetarth	Temperature coefficient for Rth		0
alrth	First order relative TC of parameter Rth	1/K	0
cth	Thermal capacitance	J/W	0
flcomp	Flag for compatibility with v2.1 model (0=v2.1)		0
NPN	For backward compatibility		1
PNP	For backward compatibility		0
ModelLevel	For backward compatibility		1
ApproxLevel	For backward compatibility		1
AcModel	For backward compatibility		1
wBvbc	For backward compatibility		0
wBvbe	For backward compatibility		0
wBvsub	For backward compatibility		0
wIbmax	For backward compatibility		0
wIcmax	For backward compatibility		0
wPmax	For backward compatibility		0

Name (Alias)	Description	Units	Default
wVbcfwd	For backward compatibility		0
wVsubfwd	For backward compatibility		0
Imax	For backward compatibility		0
Imelt	For backward compatibility		0
Ceox	For backward compatibility		0
Krbi	For backward compatibility		1
Msr	For backward compatibility		1
alitn	Factor for additional delay time of transfer current for noise only		0
cscp0	Perimeter S-C zero-bias depletion capacitance [0:inf]	F	0
vdsp	Perimeter S-C built-in potential [0:10]	V	0.6
zsp	Perimeter S-C grading coefficient (0:1]		0.5
vptsp	Perimeter S-C punch-through voltage (0:100]	V	100
aick	Smoothing term for ICK		1e-3

NOTE A npn-type device has NPN=1, PNP=0 and a pnp-type has PNP=1, NPN=0.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *model modelname HICUM2_31 [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM2_31* . The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

```
model  NPN3  HICUM2_31 \
 alfav=8e-5 t0=5e-12
```

For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's HICUM, A Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html

HICUM 2_4_0 (HICUM BJT Version 2.4.0 Instance)

HICUM 2_4_0 (HICUM BJT Version 2.4.0 Instance)

The following topic lists the HICUM 2.4.0 instance parameters.

Parameters

Name	Description	Units	Default
flsh	Flag for turning on and off self-heating effect		0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *ModelName [:Name] c b e s*

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM2_40*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case-sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables, and equations, refer to ADS Simulator Input Syntax.

Example:

```
model  Npn3  HICUM2_40 \
  t0=5e-12
```

Example:

```
model  Npn3  HICUM2_40 \
  t0=5e-12
```

HICUM 2.4.0 DC Operating Point Parameters
The DC operating point parameters that can be sent to the dataset.

Name	Description	Units
IC	Collector terminal current	A
IB	Base terminal current	A
IS	Substrate terminal current	A
IAVL	Avalanche current	A
VBE	External BE voltage	V
VBC	External BC voltage	V
VCE	External CE voltage	V
VSC	External SC voltage	V
BETADC	Common emitter forward current gain	
GMi	Internal transconductance	A/V
GMS	Transconductance of the parasitic substrate PNP	A/V
RPIi	Intrinsic input resistance	Ohm
RPIx	Extrinsic input resistance	Ohm
RMUi	Intrinsic feedback resistance	Ohm
RMUx	Extrinsic feedback resistance	Ohm
ROi	Internal output resistance	Ohm
CPIi	Total intrinsic BE capacitance	F
CPIx	Total extrinsic BE capacitance	F

Name	Description	Units
CMUi	Total intrinsic BC capacitance	F
CMUx	Total extrinsic BC capacitance	F
CCS	CS junction capacitance	F
RBI	Internal base resistance as calculated in the model	Ohm
RB	Total base resistance	Ohm
RCX_T	External collector series resistance	Ohm
RE_T	Emitter series resistance	Ohm
BETAAC	Smail signal current gain	
CRBI	Shunt capacitance across R_{BI} as calculated in the model	F
TF	Total forward transit time as calculated in the model	S
FT	Transit frequency	Hz
TK	Absolute device temperature including self-heating	K
DTSH	Increase of device temperature with respect to ambient temperature due to self-heating	K

HICUM 2_4_0 Model (HICUM BJT Version 2.4.0 Model)

HICUM 2_4_0 Model (HICUM BJT Version 2.4.0 Model)

The supported versions are:

- 2.4.0

The following topic lists the HICUM 2.4.0 model parameters.

Parameters

Name (Alias)	Description	Units	Default
Tnom	Parameter measurement temperature	°C	27
dt	Temperature change w.r.t. chip temperature for particular transistor	°C	0
flcomp	Flag for compatibility and model version		2.34
type	For transistor type NPN(+1) or PNP (-1)		1
Transfer current			
Name (Alias)	**Description**	**Units**	**Default**
c10	GICCR constant	A^2*s	2e-30
qp0	Zero-bias hole charge	C	2e-14
ich	High-current correction for 2D and 3D effects (0 signifies infinity)	A	0
hf0	Weight factor for the low current minority charge		1
hfe	Emitter minority charge weighting factor in HBTs		1
hfc	Collector minority charge weighting factor in HBTs		1

hjei	B-E depletion charge weighting factor in HBTs		1
ahjei	Parameter describing the slope of $h_{jEi}(V_{BE})$		0
rhjei	Smoothing parameter for $h_{jEi}(V_{BE})$ at high voltage		1
hjci	B-C depletion charge weighting factor in HBTs		1
mcf	Non-ideal factor for III-V HBTs		1
Base-emitter current components			
Name (Alias)	**Description**	**Unit s**	**Default**
ibeis	Internal B-E saturation current	A	1e-18
mbei	Internal B-E current ideal factor		1
ireis	Internal B-E recombination saturation current	A	0
mrei	Internal B-E recombination current ideal factor		2
ibeps	Peripheral B-E saturation current	A	0
mbep	Peripheral B-E current ideal factor		1
ireps	Peripheral B-E recombination saturation current	A	0
mrep	Peripheral B-E recombination current ideal factor		2
tbhrec	Base current recombination time constant at B-C barrier for high forward injection	s	0
Base-collector current components			
Name (Alias)	**Description**	**Unit s**	**Default**
ibcis	Internal B-C saturation current	A	1e-16

mbci	Internal B-C current ideal factor		1
ibcxs	External B-C saturation current	A	0
mbcx	External B-C current ideal factor		1
Base-emitter tunneling current			
Name (Alias)	**Description**	**Units**	**Default**
ibets	B-E tunneling saturation current	A	0
abet	Exponent factor for tunneling current		40
tunode	Specifies the base node connection for the tunneling current		1
Base-collector avalanche current			
Name (Alias)	**Description**	**Units**	**Default**
favl	Avalanche current factor	1/V	0
qavl	Exponent factor for avalanche current	Coul	0
kavl	Flag/factor for turning strong avalance on or off		0
Series resistances			
Name (Alias)	**Description**	**Units**	**Default**
rbi0	Zero bias internal base resistance	Ohm	0
rbx	External base series resistance	Ohm	0
fgeo	Factor for geometry dependence of emitter current crowding		0.6557
fdqr0	Correction factor for modulation by B-E and B-C space charge layer		0

fcrbi	Ratio of HF shunt to total internal capacitance (lateral NQS effect)		0
fqi	Ratio of internal to total minority charge		1
re	Emitter series resistance	Oh m	0
rcx	External collector series resistance	Oh m	0
Substrate transistor			
Name (Alias)	**Description**	**Unit s**	**Default**
itss	Substrate transistor transfer saturation current	A	0
msf	Forward ideal factor of substrate transfer current		1
iscs	C-S diode saturation current	A	0
msc	Ideal factor of C-S diode current		1
tsf	Transit time for forward operation of substrate transistor	s	0
Intra-device substrate coupling			
Name (Alias)	**Description**	**Unit s**	**Default**
rsu	Substrate series resistance	Oh m	0
csu	Substrate shunt capacitance	F	0
Depletion charge and capacitance components			
Name (Alias)	**Description**	**Unit s**	**Default**
cjei0 (cjeio)	Internal B-E zero-bias depletion capacitance	F	1e-020

vdei	Internal B-E built-in potential	V	0.9
zei	Internal B-E grading coefficient		0.5
ajei	Ratio of maximum to zero-bias value of internal B-E capacitance		2.5
cjep0 (cjepo)	Peripheral B-E zero-bias depletion capacitance	F	1e-020
vdep	Peripheral B-E built-in potential	V	0.9
zep	Peripheral B-E grading coefficient		0.5
ajep	Ratio of maximum to zero-bias value of peripheral B-E capacitance		2.5
cjci0 (cjcio)	Internal B-C zero-bias depletion capacitance	F	1e-020
vdci	Internal B-C built-in potential	V	0.7
zci	Internal B-C grading coefficient		0.4
vptci	Internal B-C punch-through voltage	V	100
cjcx0 (cjcxo)	External B-C zero-bias depletion capacitance	F	1e-020
vdcx	External B-C built-in potential	V	0.7
zcx	External B-C grading coefficient		0.4
vptcx	External B-C punch-through voltage	V	100
cjs0 (cjso)	C-S zero-bias depletion capacitance	F	0
vds	C-S built-in potential	V	0.6
zs	C-S grading coefficient		0.5
vpts	C-S punch-through voltage	V	100
cscp0	Peripheral C-S zero-bias depletion capacitance	F	0

vdsp	Peripheral C-S built-in potential	V	0.6
zsp	Peripheral C-S grade coefficent		0.5
vptsp	Peripheral C-S punch-through voltafe	V	100
Minority charge storage effects			
Name (Alias)	**Description**	**Unit s**	**Default**
t0	Low current forward transit time at VBC=0V	s	0
dt0h	Time constant for base and B-C space charge layer width modulation	s	0
tbvl	Time constant for modeling carrier jam at low VCE	s	0
tef0 (tefo)	Neutral emitter storage time	s	0
gtfe	Exponent factor for current dependence of neutral emitter storage time		1
thcs	Saturation time constant at high current densities	s	0
ahc (alhc)	Smoothing factor for current dependence of base and collector transit time		0.1
fthc	Partitioning factor for base and collector portion		0
rci0	Internal collector resistance at low electric field	Ohm	150
vlim	Voltage separating ohmic and saturation velocity regime	V	0.5
vces	Internal C-E saturation voltage	V	0.1
vpt	Collector punch-through voltage	V	0
delck	fitting factor for critical current		2
aick	Smoothing term for critical current		1e-3
tr	Storage time for inverse operation	s	0

vcbar	Barrier voltage	V	0
icbar	Normalization parameter	A	0
acbar	Smoothing parameter for barrier voltage		0
Parasitic isolation capacitances			
Name (Alias)	**Description**	**Unit s**	**Default**
cbepar	Total parasitic B-E capacitance	F	0
fbepar	Partitioining factor of parasitic BE cap		1.0
cbcpar	Total parasitic B-C capacitance	F	0
fbcpar	Partitioining factor of parasitic BC cap		0.5
Vertical non-quasi-static effects			
Name (Alias)	**Description**	**Unit s**	**Default**
alqf	Factor for additional delay time of minority charge		0
alit	Factor for additional delay time of transfer current		0
flnqs	Flag for turning on and off of vertical NQS effect		0
Noise			
Name (Alias)	**Description**	**Unit s**	**Default**
kf	Flicker noise coefficient		0
af	Flicker noise exponent factor		2
cfbe	Flag for determining where to tag the flicker noise source		-1
flcono	Flag for turning on and off of correlated noise implementation		0

kfre	Emitter resistance flicker noise coefficient		0
afre	Emitter resistance flicker noise exponent factor		2
Lateral geometry scaling			
Name (Alias)	**Description**	**Unit s**	**Default**
latb	Scaling factor for collector minority charge in direction of emitter width		0
latl	Scaling factor for collector minority charge in direction of emitter length		0
Temperature dependence			
Name (Alias)	**Description**	**Unit s**	**Default**
vgb	Bandgap voltage extrapolated to 0 K	V	1.17
f1vg	Coefficient K_1 in T dependent band-gap equation	V/K	-1.02377e-4
f2vg	Coefficient K_2 in T dependent band-gap equation	V/K	4.3215e-4
zetact	Exponent coefficient in transfer current temperature dependence		3
vge	Effective emitter bandgap voltage	V	1.17
zetabet	Exponent coefficient in B-E junction current temperature dependence		3.5
vgc	Effective collector bandgap voltage	V	1.17
vgs	Effective substrate bandgap voltage	V	1.17
dvgbe	Bandgap difference between B and B-E junction used for hjEi0 and hf0	V	0
zetahjei	Temperature coefficient for ahjEi		1
zetavgbe	Temperature coefficient for hjEi0		1

alt0	First order relative TC of parameter T0	1/K	0
kt0 (kto)	Second order relative TC of parameter T0	1/ K^2	0
zetaci	Temperature exponent for RCI0		0
alvs	Relative TC of saturation drift velocity	1/K	0
alces	Relative TC of VCES	1/K	0
zetarbi	Temperature exponent of internal base resistance		0
zetarbx	Temperature exponent of external base resistance		0
zetarcx	Temperature exponent of external collector resistance		0
zetare	Temperature exponent of emitter resistance		0
zetarth	Temperature coefficient for Rth		0
alrth	First order relative TC of parameter Rth	1/K	0
zetacx	Temperature exponent of mobility in substrate transistor transit time		1
alfav	Relative temperature coefficient for FAVL		
alqav	Relative temperature coefficient for QAVL		
alkav	Relative temperature coefficient for KAVL		
alb	Relative TC of forward current gain for V2.1 model	1/K	0
Self-Heating			
Name (Alias)	**Description**	**Units**	**Default**
rth	Thermal resistance	K/W	0

cth	Thermal capacitance	J/W	0
flsh	Flag for turning on and off self-heating effect		0

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *model modelname HICUM2_40 [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM2_40* . The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

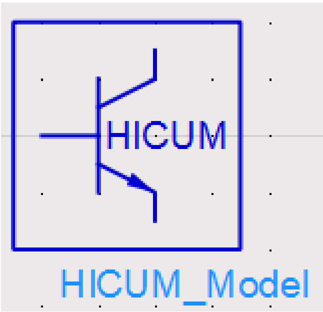
```
model  NPN3  HICUM2_40 \
 alfav=8e-5 t0=5e-12
```

For detailed physical and electrical effects, as well as model equations and documentation, refer to Michael Schroter's HICUM, A Scalable Physics-based Compact Bipolar Transistor Model at: http://www.iee.et.tu-dresden.de/iee/eb/hic_new/hic_start.html

HICUM Model (Bipolar Transistor Model)

HICUM_Model (Bipolar Transistor Model)

Symbol



- This model (version 2.1) supplies values for a HICUM device.
- The important physical and electrical effects taken into account by HICUM are summarized:
  - high-current effects (including quasi-saturation)
  - distributed high-frequency model for the external base-collector region
  - emitter periphery injection and associated charge storage
  - emitter current crowding (through a bias-dependent internal base resistance
  - 2- and 3-dimensional collector current spreading
  - parasitic (bias independent) capacitances between base-emitter and base-collector terminal
  - vertical non-quasi-static (NQS) effects for transfer current and minority charge
  - temperature dependence and self-heating
  - weak avalanche breakdown at the base-collector junction
  - tunneling in the base-emitter junction
  - parasitic substrate transistor
  - bandgap differences (occurring in HBTs)
  - lateral scalability

    For detailed physical and electrical effects, as well as model equations, refer to Michael Schroter's *HICUM, A* Scalable Physics-based Compact Bipolar Transistor Model , *Description of model version 2.1* , December, 2000; a pdf file is available at: "http://www.iee.et.tu-dresden.de/iee/eb/comp_mod.html".

Parameters

Name	Description	Units	Default
NPN	NPN model type: yes, no	None	yes

Name	Description	Units	Default
PNP	PNP model type: yes, no	None	no
C10	ICCR constant (=ISQp0)	$A^2 \times s$	2e-30
Qp0	zero-bias hole charge	$A^2 \times s$	2.0e-14
Ich	high-current correction for 2D/3D-ICCR	A	infinity
Hfe	GICCR weighing factor for QEf in HBTs	None	1.0
Hfc	GICCR weighing factor for Qfc (mainly for HBTs)	None	1.0
Hjei	GICCR weighing factor for Qjei in HBTs	None	1.0
Hjci	GICCR weighing factor for Qjci in HBTs	None	1.0
Mcf	GICCR weighing factor for Qjci in HBTs	None	1.0
Alit	factor for additional delay time of iT	None	0.0
Cjei0	Internal B-E zero-bias depletion capacitance	F	0.0
Vdei	Internal B-E built-in voltage	V	0.9
Zei	Internal B-E grading coefficient	None	0.5
Aljei	Ratio of maximum to zero-bias value of internal B-E capacitance	None	2.5
Cjci0	Internal B-C zero-bias depletion capacitance	F	0.0
Vdci	Internal B-C built-in voltage	V	0.7
Zci	Internal B-C grading coefficient	None	0.4
Vptci	Internal B-C punch-through voltage (=$qNCi^{w2}{}_{Ci}/(2\varepsilon)$)	V	1e20

Name	Description	Units	Default
T0	Low-current forward transit time at VBC=0	sec	0.0
Dt0h	Time constant for base and B-C space charge layer width modulation	sec	0.0
Tbvl	Time constant for modeling carrier jam at low VCE	sec	0.0
Tef0	neutral emitter storage time	sec	0.0
Gtfe	exponent factor for current dependent emitter storage time	None	1.0
Thcs	saturation time constant at high current densities	sec	0.0
Alhc	smoothing factor for current dependent C and B transit time	sec	0.1
Fthc	partitioning factor for base and collector portion	None	0.0
Alqf	factor for additional delay time of Qf	None	0.0
Rci0	low-field resistance of internal collector region (including scaling)	Ohm	150.0
Vlim	Voltage separating ohmic and saturation velocity regime	V	0.5
Vpt	Collector punch-through voltage	V	3.0
Vces	internal C-E saturation voltage	V	0.1
Tr	Storage time for inverse operation	sec	0.0
Ibeis	Internal B-E saturation current	A	1e-18
Mbei	Internal B-E non-ideality factor	None	1.0
Ireis	Internal B-E recombination saturation current	A	0.0
Mrei	Internal B-E recombination current ideality factor	None	2.0

Name	Description	Units	Default
Ibcis	Internal B-C saturation current	A	1.0e-16
Mbci	Internal B-C non-ideality factor	None	1.0
Favl	Avalanche current factor	1/V	0.0
Qavl	Exponent factor for avalanche current	C	0.0
Rbi0	Zero-bias internal base resistance	Ohm	0.0
Fdqr0	correction factor for modulation by BE and BC SCR	None	0.0
Fgeo	Factor for geometry dependence of emitter current crowding (default value corresponds to long emitter stripe)	None	0.6557
Fqi	ratio of internal to total minority charge	None	1.0
Fcrbi	ration of HF shunt to total internal capacitance	None	0.0
Latb	scaling factor for QfC in bE direction	None	0.0
Latl	scaling factor for QfC in lE direction	None	0.0
Cjep0	Peripheral B-E zero-bias depletion capacitacance	F	0.0
Vdep	Peripheral B-E built-in voltage	V	0.9
Zep	Peripheral B-E grading coefficient	None	0.5
Aljep	factor for adjusting maximum value of Cjep0	None	2.5
Ibeps	Peripheral B-E saturation current	A	0.0
Mbep	Peripheral B-E current ideality factor	None	1.0
Ireps	Peripheral B-E recombination saturation current	A	0.0
Mrep	Peripheral B-E recombination current ideality factor	None	2.0

Name	Description	Units	Default
Ibets	B-E tuneling saturation current	A	0.0
Abet	Exponent factor for tuneling current	None	40.0
Cjcx0	External B-C zero-bias depletion capacitance	F	0.0
Vdcx	External B-C built-in voltage	V	0.7
Zcx	External B-C grading coefficient	None	0.4
Vptcx	External B-C punch-through voltage	V	1.0e20
Ccox	B-C overlap capacitance	F	0.0
Fbc	partitioning factor for Ccbx=Cjcx0+Ccox	None	0.0
Ibcxs	External B-C saturation current	A	0.0
Mbcx	External B-C current ideality factor	None	1.0
Ceox	B-E isolation capacitance	F	0.0
Rbx	External base series resistance	Ohm	0.0
Re	Emitter series resistance	Ohm	0.0
Rcx	External collector series resistance	Ohm	0.0
Itss	Saturation current of substrate transistor transfer current	A	0.0
Msf	Forward ideality factor of substrate transfer current	None	1.0
Msr	Reverse ideality factor of substrate transfer current	None	1.0
Iscs	Saturation current of C-S diode (latch-up modeling)	A	0.0
Msc	Ideality factor of C-S diode	None	1.0

Name	Description	Units	Default
Tsf	Transit time (forward operation) for minority charge	sec	0.0
Cjs0	C-S zero-bias depletion capacitance	F	0.0
Vds	C-S built-in voltage	V	0.6
Zs	C-S grading coefficient	None	0.5
Vpts	C-S punch-through voltage	V	1.0e20
Rsu	Substrate series resistance	Ohm	0.0
Csu	Substrate cap. given by permittivity of bulk material	F	0.0
Kf	Flicker noise factor, no unit only for Af=2	None	0.0
Af	Flicker noise exponent	None	2.0
Krbi	Factor for internal base resistance	None	1.0
Vgb	Bandgap-voltage extrapolated to 0K	V	1.17
Alb	Relative temperature coefficient of current gain	1/K	5.0e-3
Zetaci	Temperature coefficient for Rci0	None	0.0
Alvs	Relative temperature coefficient of saturation drift velocity	1/K	0.0
Alt0	First-order relative temperature coefficient of parameter T0	1/K	0.0
Kt0	Second-order relative temperature coefficient of parameter T0	$1/K^2$	0.0
Alces	Relative temperature coefficient of Vces	1/K	0.0
Zetarbi	Temperature exponent of internal base resistance	None	0.0
Zetarbx	Temperature exponent of external base resistance	None	0.0

Name	Description	Units	Default
Zetarcx	Temperature exponent of external collector resistance	None	0.0
Zetare	Temperature exponent of emitter resistance	None	0.0
Alfav	Relative temperature coefficient for avalanche breakdown Favl	1/K	0.0
Alqav	Relative temperature coefficient for avalanche breakdown Qavl		0.0
Tnom	Temperature at which parameters are specified	°C	25
Trise	Temperature rise over ambient	°C	0
Rth	Thermal resistance	K/W	0.0
Cth	Thermal capacitance	W × s/K	0.0
Imax	Explosion current	A	1e4
Imelt	Explosion current (similar to Imax; refer to note 4); defaults to Imax	A	defaults to Imax
AcModel	Selects which small signal models to use for ac and S-parameter analyses: Small signal=1, consistent with charge model=2; (refer to note 5)	None	1
SelfheatingModel	Selects which power dissipation equations to use for modeling self-heating effect: Simplified model=1, full model=2; (refer to note 6)	None	1
wVsubfwd	Substrate junction forward bias (warning)	V	None
wBvsub	Substrate junction reverse breakdown voltage (warning)	V	None
wBvbe	Base-emitter reverse breakdown voltage (warning)	V	None
wBvbc	Base-collector reverse breakdown voltage (warning)	V	None
wVbcfwd	Base-collector forward bias (warning)	V	None

Name	Description	Units	Default
wIbmax	Maximum base current (warning)	A	None
wIcmax	Maximum collector current (warning)	A	None
wPmax	Maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

- Constant transit time Tf (at dc bias) is used in harmonic balance analysis for It current delay.
- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Small-signal ac model given in the reference cited in note 1 is a derivation of the large-signal charge model. However, it is not fully compatible with the charge model with the small input. The AcModel parameter can be set to either the small-signal model (AcModel=1) or the charge model compatible model (AcModel=2) for small-signal ac and S-parameter analyses.
  The AcModel parameter has no effect on large-signal analysis.
- Two power dissipation formulas for modeling the self-heating effect have been implemented in ADS.
  - When SelfheatingModel = 1, the simplified formula power = It × vce - Iave × vbc will be used.
  - When SelfheatingModel = 2, formula 2.1.16-1 from Schroter's document at: "http://www.iee.et.tu-dresden.de/iee/eb/comp_mod.html" will be used; the formula can be found under *General Description* > *HICUM-Equations* > section 2.1.16, equation 2.1.16-1.
    The simplified formula is implemented in Dr. Schroter's DEVICE program.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

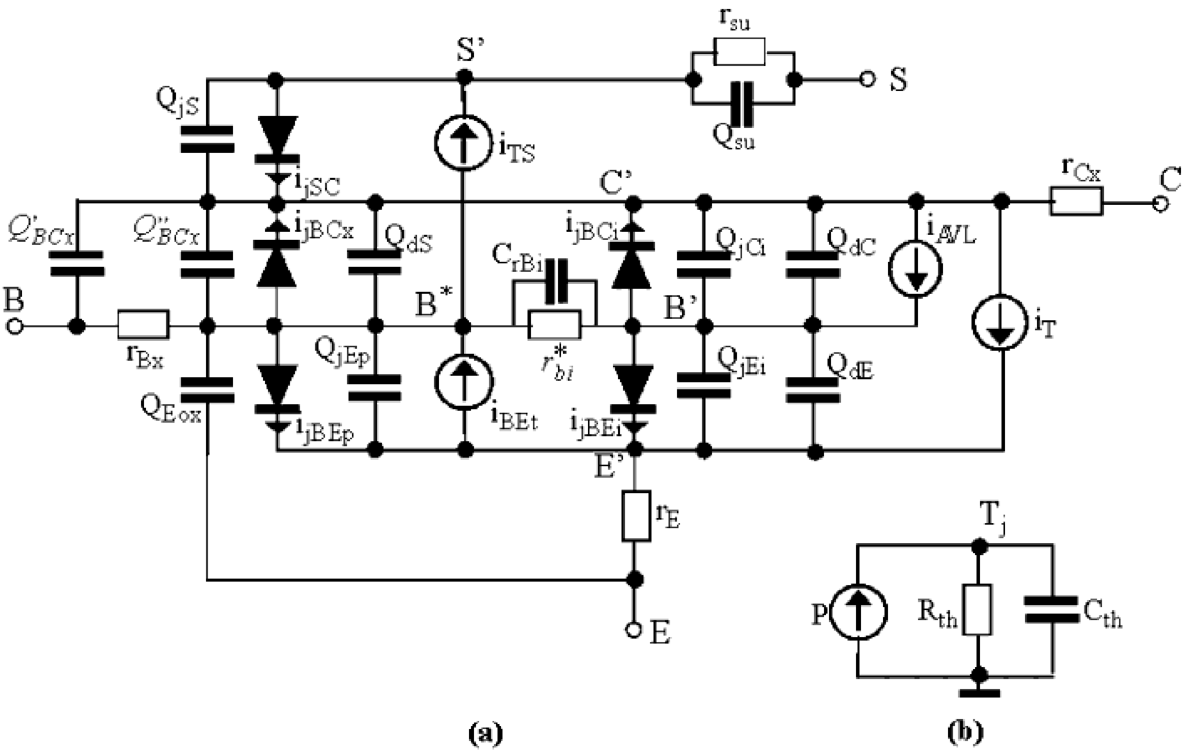
```
model modelname HICUM [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *HICUM*. Use either parameter NPN=yes or PNP=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example

```
model  Npn3  HICUM  \
  NPN=yes Alfav=8e-5 T0=5e-12
```

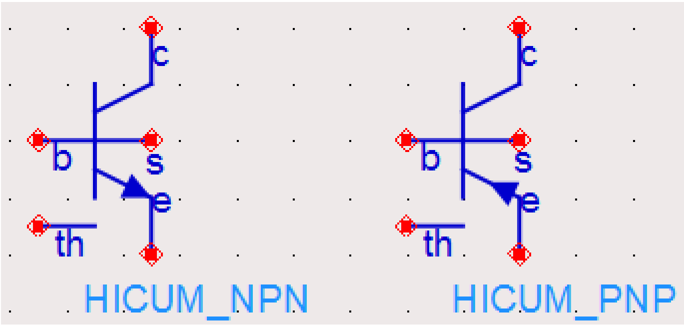
Equivalent Circuit



HICUM NPN, HICUM PNP (HICUM Bipolar Transistors, NPN, PNP)

HICUM_NPN, HICUM_PNP (HICUM Bipolar Transistors, NPN, PNP)

Symbol



Parameters

Name	Description	Units	Default
Model	Model instance name of a HICUM_Model	None	HUCUMM1
Temp	device operating temperature	°C	25
Trise	temperature rise over ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (see note 2)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
Selfheating	Include selfheating effects on/off: yes, no (see note 3)	None	No
_M	number of devices in parallel	None	1

- The Temp parameter specifies the physical (operating) temperature of the device. If this is different than the temperature at which the model parameters are valid or extracted (specified by the Tnom parameter of the associated HICUM_Model) certain model parameters are scaled such that the device is simulated at its operating temperature.

- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The HICUM implements self-heating. As the transistor dissipates power, it causes its temperature to rise above ambient. The model parameters Rth and Cth control this: ΔT = Pdiss x Rth. To enable this, set the Selfheating flag to yes or leave it blank, and ensure that the model parameter Rth is > 0. When self-heating is enabled, it may be necessary to increase the maximum number of iterations due to the additional unknown (temperature rise) that must be solved for. Simulation using self-heating may take 50 to 100% more time than the same simulation without self-heating.
  Self-heating can be used with either an internal or external thermal node.
  - If the *th* (fifth) node is either connected to ground or not given in the netlist, HICUM_NPN and HICUM_PNP use an internal node to keep track of the temperature rise of the transistor.
  - If the *th* (fifth) node is either left open (unconnected) or connected to a thermal coupling network, then HICUM_NPN and HICUM_PNP use this node to keep track of the temperature rise of the transistor.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Ic	Collector current	amperes
Ib	Base current	amperes
Ie	Emitter current	amperes
Is	Substrate current	amperes
Power	DC power dissipated	watts
Gbiei	(dIbiei/dVbiei)	siemens
Cbiei	Base-emitter capacitance	farads
Gbici	(dIbici/dVbici)	siemens
Cbici	Base-collector capacitance	farads
Gbcx	(dI/dV)	siemens
Gbep	(dI/dV)	siemens

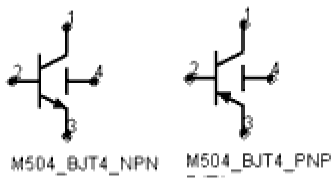
Name	Description	Units
Cbep	(dQ/dV)	farads
Gbet	(dI/dV)	siemens
Gsc	(dI/dV)	siemens
dIt_dVbi	(dIt/dVbi)	siemens
dIt_dVci	(dIt/dVci)	siemens
dIt_dVei	(dIt/dVei)	siemens
Sfbav	(dI/dV)	siemens
Sfcav	(dI/dV)	siemens
Cjs	Substrate-collector capacitance	farads
C1bcx	Base-collector capacitance	farads
C2bcx	Base-collector capacitance	farads
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

- This device has no default artwork associated with it.

M504 BJT4 NPN, M504 BJT4 PNP (Mextram 504 Nonlinear Bipolar Transistors with Substrate Terminal, NPN, PNP)

M504_BJT4_NPN, M504_BJT4_PNP (Mextram 504 Nonlinear Bipolar Transistors with Substrate Terminal, NPN, PNP)

Symbol



Parameters

Name	Description	Units	Default
Model	name of MEXTRAM_504_Model	None	BJTM1
Temp	device operating temperature	°C	25
Trise (Dta)	temperature rise above ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (refer to note 2)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
Selfheating	include selfheating effects: no, yes	None	no
_M	number of devices in parallel	None	1

- The Temp parameter specifies the physical (operating) temperature of the device; if different than the temperature at which the model parameters are valid or extracted (specified by Tnom of the associated model) certain model parameters are scaled such that the device is simulated at its operating temperature. Refer to the model to see which parameter values are scaled.
- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation

time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The fourth terminal (substrate) is available for connection to an external circuit.
- The MEXTRAM 504 implements self-heating. As the transistor dissipates power, it causes its temperature to rise above ambient. Model parameters Rth and Cth control this: $\Delta T = Pdiss \times Rth$. To enable this, set the Selfheating flag to yes, and ensure that the model parameter Rth is > 0. When self-heating is enabled, it may be necessary to increase the maximum number of iterations due to the additional unknown (temperature rise) that must be solved for. Simulation using self-heating may take 50 to 100% more time than the same simulation without self-heating.
  Self-heating can be used with either an internal or external thermal node.
  - M504_BJT_NPN, M504_BJT_PNP, M504_BJT4_NPN, and M504_BJT4_PNP use an internal node to keep track of the temperature rise of the transistor.
  - M504_BJT5_NPN and M504_BJT5_PNP make this thermal node externally available as the fifth terminal. This node can then be used for additional thermal modeling.
- The following table, lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Ic	Collector current	amperes
Ib	Base current	amperes
Ie	Emitter current	amperes
Is	Substrate current	amperes
Power	DC power dissipated	watts
In	Main current from C2-E1	amperes
Ic1c2	Epilayer current from C1-C2	amperes
Ib1b2	Pinched-base current from B1-B2	amperes
Ib1	Ideal forward base current from B2-E1	amperes
SIb1	Ideal sidewall base current from B1-E1	amperes
Ib2	Nonideal forward base current from B2-E1	amperes
Ib3	Nonideal reverse base current from B1-C1	amperes

Name	Description	Units
Iavl	Avalanche current from C2-B2	amperes
Iex	Extrinsic reverse base current from B1-C1	amperes
XIex	Extrinsic reverse base current from B-C1	amperes
Isub	Substrate current from B1-S	amperes
XIsub	Substrate current from B-S	amperes
Isf	Substrate failure current from S-C1	amperes
Ire	Emitter current from E1-E	amperes
Irbc	Base current from B-B1	amperes
Ircc	Collector current from C-C1	amperes
Vc	External collector voltage	volts
Vc1	Internal collector1 voltage	volts
Vc2	Internal collector2 voltage	volts
Vb	External base voltage	volts
Vb1	Internal base1 voltage	volts
Vb2	Internal base2 voltage	volts
Ve	External emitter voltage	volts
Ve1	External emitter1 voltage	volts
Vs	Substrate voltage	volts
gx	Forward transconductance (dIn/dVb2e2)	siemens

Name	Description	Units
gy	Reverse transconductance (dIn/dVb2c2)	siemens
gz	Reverse transconductance (dIn/dVb2c1)	siemens
Sgpi	Base-emitter sidewall conductance (dSIb1/dVb1e1)	siemens
gpix	Base-emitter conductance (d(Ib1 + Ib2)/dVb2e1)	siemens
gpiy	Early effect on recombination base current (dIb1/dVb2c2)	siemens
gpiz	Early effect on recombination base current (dIb1/dVb2c1)	siemens
gmux	Early effect on avalanche current limiting (-dIavl/dVb2e1)	siemens
gmuy	Avalanche current conductance (-dIavl/dVb2c2)	siemens
gmuz	Avalanche current conductance (-dIavl/dVb2c1)	siemens
gmuex	Extrinsic base-collector conductance (d(Iex + Ib3)/dVb1c1)	siemens
Xgmuex	Extrinsic base-collector conductance (dXIex/dVbc1)	siemens
grcvy	Epilayer conductance (dIc1c2/dVb2c2)	siemens
grcvz	Epilayer conductance (dIc1c2/dVb2c1)	siemens
rbv	Base resistance (1/(dIb1b2/dVb1b2))	ohms
grbvx	Early effect on base resistance (dIb1b2/dVb2e1)	siemens
grbvy	Early effect on base resistance (dIb1b2/dVb2c2)	siemens
grbvz	Early effect on base resistance (dIb1b2/dVb2c1)	siemens
gs	Parasitic PNP transistor conductance (dIsub/dVb1c1)	siemens
Xgs	Parasitic PNP transistor conductance (dXIsub/dVbc1)	siemens

Name	Description	Units
gsf	Substrate failure conductance (dIsf/dVsc1)	siemens
Qe	Emitter or emitter neutral charge	coulombs
Qte	Base-emitter depletion charge	coulombs
SQte	Sidewall base-emitter depletion charge	coulombs
Qbe	Base-emitter diffusion charge	coulombs
Qbc	Base-collector diffusion charge	coulombs
Qtc	Base-collector depletion charge	coulombs
Qepi	Epilayer diffusion charge	coulombs
Qb1b2	AC current crowding charge	coulombs
Qtex	Extrinsic base-collector depletion charge	coulombs
XQtex	Extrinsic base-collector depletion charge	coulombs
Qex	Extrinsic base-collector diffusion charge	coulombs
XQex	Extrinsic base-collector diffusion charge	coulombs
Qts	Collector-substrate depletion charge	coulombs
SCbe	Base-emitter sidewall capacitance (dSQte/dVb1e1)	farads
Cbex	Base-emitter capacitance (d(Qte + Qbe + Qe)/dVb2e1)	farads
Cbey	Early effect on base-emitter diffusion charge (dQbe/dVb2c2)	farads
Cbez	Early effect on base-emitter diffusion charge (dQbe/dVb2c1)	farads
Cbcx	Early effect on base-collector diffusion charge (dQbc/dVb2e1)	farads

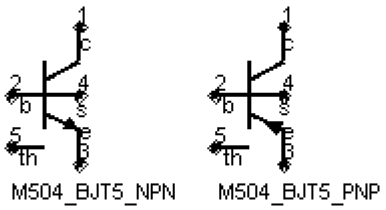
Name	Description	Units
Cbcy	Base-collector capacitance (d(Qtc + Qbc + Qepi)/dVb2c2)	farads
Cbcz	Base-collector capacitance (d(Qtc + Qbc + Qepi)/dVb2c1)	farads
Cbcex	Extrinsic base-collector capacitance (d(Qtex + Qex)/dVb1c1)	farads
XCbcex	Extrinsic base-collector capacitance (d(XQtex + XQex)/dVbc1)	farads
Cb1b2	AC current crowding capacitance (dQb1b2/dVb1b2)	farads
Cb1b2x	AC current crowding transcapacitance (dQb1b2/dVb2e1)	farads
Cb1b2y	AC current crowding transcapacitance (dQb1b2/dVb2c2)	farads
Cb1b2z	AC current crowding transcapacitance (dQb1b2/dVb2c1)	farads
Cts	Substrate-collector capacitance (dQts/dVsc1)	farads
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

- This device has no default artwork associated with it.
- This model was developed by NXP Semiconductors. Documentation is available on their website: http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/bipolar-models/mextram:MEXTRAM

M504 BJT5 NPN, M504 BJT5 PNP (Mextram 504 Nonlinear Bipolar Transistors with Substrate and Thermal Terminals, NPN, PNP)

M504_BJT5_NPN, M504_BJT5_PNP (Mextram 504 Nonlinear Bipolar Transistors with Substrate and Thermal Terminals, NPN, PNP)

Symbol



Parameters

Name	Description	Units	Default
Model	name of MEXTRAM_504_Model	None	BJTM1
Temp	device operating temperature	°C	25
Trise (Dta)	temperature rise above ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (refer to note 2)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
Selfheating	include selfheating effects: no, yes	None	no
_M	number of devices in parallel	None	1

- The Temp parameter specifies the physical (operating) temperature of the device; if different than the temperature at which the model parameters are valid or extracted (specified by Tnom of the associated model) certain model parameters are scaled such that the device is simulated at its operating temperature. Refer to the model to see which parameter values are scaled.
- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation

time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The fourth terminal (substrate) is available for connection to an external circuit.
- The MEXTRAM 504 implements self-heating. As the transistor dissipates power, it causes its temperature to rise above ambient. The model parameters Rth and Cth control this: $\Delta T = Pdiss \times Rth$. To enable this, set the Selfheating flag to yes, and ensure that the model parameter Rth is > 0. When self-heating is enabled, it may be necessary to increase the maximum number of iterations due to the additional unknown (temperature rise) that must be solved for. Simulation using self-heating may take 50 to 100% more time than the same simulation without self-heating.
  Self-heating can be used with either an internal or external thermal node.
  - M504_BJT_NPN, M504_BJT_PNP, M504_BJT4_NPN, and M504_BJT4_PNP use an internal node to keep track of the temperature rise of the transistor.
  - M504_BJT5_NPN and M504_BJT5_PNP make this thermal node externally available as the fifth terminal. This node can then be used for additional thermal modeling.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Ic	Collector current	amperes
Ib	Base current	amperes
Ie	Emitter current	amperes
Is	Substrate current	amperes
Power	DC power dissipated	watts
In	Main current from C2-E1	amperes
Ic1c2	Epilayer current from C1-C2	amperes
Ib1b2	Pinched-base current from B1-B2	amperes
Ib1	Ideal forward base current from B2-E1	amperes
SIb1	Ideal sidewall base current from B1-E1	amperes
Ib2	Nonideal forward base current from B2-E1	amperes
Ib3	Nonideal reverse base current from B1-C1	amperes

Name	Description	Units
Iavl	Avalanche current from C2-B2	amperes
Iex	Extrinsic reverse base current from B1-C1	amperes
XIex	Extrinsic reverse base current from B-C1	amperes
Isub	Substrate current from B1-S	amperes
XIsub	Substrate current from B-S	amperes
Isf	Substrate failure current from S-C1	amperes
Ire	Emitter current from E1-E	amperes
Irbc	Base current from B-B1	amperes
Ircc	Collector current from C-C1	amperes
Vc	External collector voltage	volts
Vc1	Internal collector1 voltage	volts
Vc2	Internal collector2 voltage	volts
Vb	External base voltage	volts
Vb1	Internal base1 voltage	volts
Vb2	Internal base2 voltage	volts
Ve	External emitter voltage	volts
Ve1	External emitter1 voltage	volts
Vs	Substrate voltage	volts
gx	Forward transconductance (dIn/dVb2e2)	siemens

Name	Description	Units
gy	Reverse transconductance (dIn/dVb2c2)	siemens
gz	Reverse transconductance (dIn/dVb2c1)	siemens
Sgpi	Base-emitter sidewall conductance (dSIb1/dVb1e1)	siemens
gpix	Base-emitter conductance (d(Ib1 + Ib2)/dVb2e1)	siemens
gpiy	Early effect on recombination base current (dIb1/dVb2c2)	siemens
gpiz	Early effect on recombination base current (dIb1/dVb2c1)	siemens
gmux	Early effect on avalanche current limiting (-dIavl/dVb2e1)	siemens
gmuy	Avalanche current conductance (-dIavl/dVb2c2)	siemens
gmuz	Avalanche current conductance (-dIavl/dVb2c1)	siemens
gmuex	Extrinsic base-collector conductance (d(Iex + Ib3)/dVb1c1)	siemens
Xgmuex	Extrinsic base-collector conductance (dXIex/dVbc1)	siemens
grcvy	Epilayer conductance (dIc1c2/dVb2c2)	siemens
grcvz	Epilayer conductance (dIc1c2/dVb2c1)	siemens
rbv	Base resistance (1/(dIb1b2/dVb1b2))	ohms
grbvx	Early effect on base resistance (dIb1b2/dVb2e1)	siemens
grbvy	Early effect on base resistance (dIb1b2/dVb2c2)	siemens
grbvz	Early effect on base resistance (dIb1b2/dVb2c1)	siemens
gs	Parasitic PNP transistor conductance (dIsub/dVb1c1)	siemens
Xgs	Parasitic PNP transistor conductance (dXIsub/dVbc1)	siemens

Name	Description	Units
gsf	Substrate failure conductance (dIsf/dVsc1)	siemens
Qe	Emitter or emitter neutral charge	coulombs
Qte	Base-emitter depletion charge	coulombs
SQte	Sidewall base-emitter depletion charge	coulombs
Qbe	Base-emitter diffusion charge	coulombs
Qbc	Base-collector diffusion charge	coulombs
Qtc	Base-collector depletion charge	coulombs
Qepi	Epilayer diffusion charge	coulombs
Qb1b2	AC current crowding charge	coulombs
Qtex	Extrinsic base-collector depletion charge	coulombs
XQtex	Extrinsic base-collector depletion charge	coulombs
Qex	Extrinsic base-collector diffusion charge	coulombs
XQex	Extrinsic base-collector diffusion charge	coulombs
Qts	Collector-substrate depletion charge	coulombs
SCbe	Base-emitter sidewall capacitance (dSQte/dVb1e1)	farads
Cbex	Base-emitter capacitance (d(Qte + Qbe + Qe)/dVb2e1)	farads
Cbey	Early effect on base-emitter diffusion charge (dQbe/dVb2c2)	farads
Cbez	Early effect on base-emitter diffusion charge (dQbe/dVb2c1)	farads
Cbcx	Early effect on base-collector diffusion charge (dQbc/dVb2e1)	farads

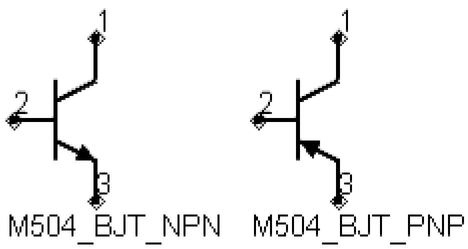
Name	Description	Units
Cbcy	Base-collector capacitance (d(Qtc + Qbc + Qepi)/dVb2c2)	farads
Cbcz	Base-collector capacitance (d(Qtc + Qbc + Qepi)/dVb2c1)	farads
Cbcex	Extrinsic base-collector capacitance (d(Qtex + Qex)/dVb1c1)	farads
XCbcex	Extrinsic base-collector capacitance (d(XQtex + XQex)/dVbc1)	farads
Cb1b2	AC current crowding capacitance (dQb1b2/dVb1b2)	farads
Cb1b2x	AC current crowding transcapacitance (dQb1b2/dVb2e1)	farads
Cb1b2y	AC current crowding transcapacitance (dQb1b2/dVb2c2)	farads
Cb1b2z	AC current crowding transcapacitance (dQb1b2/dVb2c1)	farads
Cts	Substrate-collector capacitance (dQts/dVsc1)	farads
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

- This device has no default artwork associated with it.
- This model was developed by NXP Semiconductors. Documentation is available on their website: http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/bipolar-models/mextram:MEXTRAM

M504 BJT NPN, M504 BJT PNP (Mextram 504 Nonlinear Bipolar Transistors)

M504_BJT_NPN, M504_BJT_PNP (Mextram 504 Nonlinear Bipolar Transistors)

Symbol



Parameters

Name	Description	Units	Default
Model	name of MEXTRAM_504_Model	None	BJTM1
Temp	device operating temperature	°C	25
Trise (Dta)	temperature rise above ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (see note 2)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
Selfheating	include selfheating effects: no, yes	None	no
_M	number of devices in parallel	None	1

- The Temp parameter specifies the physical (operating) temperature of the device; if different than the temperature at which the model parameters are valid or extracted (specified by Tnom of the associated model) certain model parameters are scaled such that the device is simulated at its operating temperature. Refer to the model to see which parameter values are scaled.
- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation

time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.

- The MEXTRAM 504 implements self-heating. As the transistor dissipates power, it causes its temperature to rise above ambient. The model parameters Rth and Cth control this: ΔT = Pdiss x Rth. To enable this, set the *Selfheating* flag to yes, and ensure that the model parameter Rth is > 0. When self-heating is enabled, it may be necessary to increase the maximum number of iterations due to the additional unknown (temperature rise) that must be solved for. Simulation using self-heating may take 50 to 100% more time than the same simulation without self-heating.
  Self-heating can be used with either an internal or external thermal node.
  - M504_BJT_NPN, M504_BJT_PNP, M504_BJT4_NPN, and M504_BJT4_PNP use an internal node to keep track of the temperature rise of the transistor.
  - M504_BJT5_NPN and M504_BJT5_PNP make this thermal node externally available as the fifth terminal. This node can then be used for additional thermal modeling.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Ic	Collector current	amperes
Ib	Base current	amperes
Ie	Emitter current	amperes
Is	Substrate current	amperes
Power	DC power dissipated	watts
In	Main current from C2-E1	amperes
Ic1c2	Epilayer current from C1-C2	amperes
Ib1b2	Pinched-base current from B1-B2	amperes
Ib1	Ideal forward base current from B2-E1	amperes
SIb1	Ideal sidewall base current from B1-E1	amperes
Ib2	Nonideal forward base current from B2-E1	amperes
Ib3	Nonideal reverse base current from B1-C1	amperes

Name	Description	Units
Iavl	Avalanche current from C2-B2	amperes
Iex	Extrinsic reverse base current from B1-C1	amperes
XIex	Extrinsic reverse base current from B-C1	amperes
Isub	Substrate current from B1-S	amperes
XIsub	Substrate current from B-S	amperes
Isf	Substrate failure current from S-C1	amperes
Ire	Emitter current from E1-E	amperes
Irbc	Base current from B-B1	amperes
Ircc	Collector current from C-C1	amperes
Vc	External collector voltage	volts
Vc1	Internal collector1 voltage	volts
Vc2	Internal collector2 voltage	volts
Vb	External base voltage	volts
Vb1	Internal base1 voltage	volts
Vb2	Internal base2 voltage	volts
Ve	External emitter voltage	volts
Ve1	External emitter1 voltage	volts
Vs	Substrate voltage	volts
gx	Forward transconductance (dIn/dVb2e2)	siemens

Name	Description	Units
gy	Reverse transconductance (dIn/dVb2c2)	siemens
gz	Reverse transconductance (dIn/dVb2c1)	siemens
Sgpi	Base-emitter sidewall conductance (dSIb1/dVb1e1)	siemens
gpix	Base-emitter conductance (d(Ib1 + Ib2)/dVb2e1)	siemens
gpiy	Early effect on recombination base current (dIb1/dVb2c2)	siemens
gpiz	Early effect on recombination base current (dIb1/dVb2c1)	siemens
gmux	Early effect on avalanche current limiting (-dIavl/dVb2e1)	siemens
gmuy	Avalanche current conductance (-dIavl/dVb2c2)	siemens
gmuz	Avalanche current conductance (-dIavl/dVb2c1)	siemens
gmuex	Extrinsic base-collector conductance (d(Iex + Ib3)/dVb1c1)	siemens
Xgmuex	Extrinsic base-collector conductance (dXIex/dVbc1)	siemens
grcvy	Epilayer conductance (dIc1c2/dVb2c2)	siemens
grcvz	Epilayer conductance (dIc1c2/dVb2c1)	siemens
rbv	Base resistance (1/(dIb1b2/dVb1b2))	ohms
grbvx	Early effect on base resistance (dIb1b2/dVb2e1)	siemens
grbvy	Early effect on base resistance (dIb1b2/dVb2c2)	siemens
grbvz	Early effect on base resistance (dIb1b2/dVb2c1)	siemens
gs	Parasitic PNP transistor conductance (dIsub/dVb1c1)	siemens
Xgs	Parasitic PNP transistor conductance (dXIsub/dVbc1)	siemens

Name	Description	Units
gsf	Substrate failure conductance (dIsf/dVsc1)	siemens
Qe	Emitter or emitter neutral charge	coulombs
Qte	Base-emitter depletion charge	coulombs
SQte	Sidewall base-emitter depletion charge	coulombs
Qbe	Base-emitter diffusion charge	coulombs
Qbc	Base-collector diffusion charge	coulombs
Qtc	Base-collector depletion charge	coulombs
Qepi	Epilayer diffusion charge	coulombs
Qb1b2	AC current crowding charge	coulombs
Qtex	Extrinsic base-collector depletion charge	coulombs
XQtex	Extrinsic base-collector depletion charge	coulombs
Qex	Extrinsic base-collector diffusion charge	coulombs
XQex	Extrinsic base-collector diffusion charge	coulombs
Qts	Collector-substrate depletion charge	coulombs
SCbe	Base-emitter sidewall capacitance (dSQte/dVb1e1)	farads
Cbex	Base-emitter capacitance (d(Qte + Qbe + Qe)/dVb2e1)	farads
Cbey	Early effect on base-emitter diffusion charge (dQbe/dVb2c2)	farads
Cbez	Early effect on base-emitter diffusion charge (dQbe/dVb2c1)	farads
Cbcx	Early effect on base-collector diffusion charge (dQbc/dVb2e1)	farads

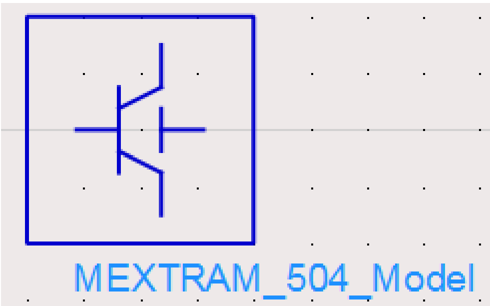
Name	Description	Units
Cbcy	Base-collector capacitance (d(Qtc + Qbc + Qepi)/dVb2c2)	farads
Cbcz	Base-collector capacitance (d(Qtc + Qbc + Qepi)/dVb2c1)	farads
Cbcex	Extrinsic base-collector capacitance (d(Qtex + Qex)/dVb1c1)	farads
XCbcex	Extrinsic base-collector capacitance (d(XQtex + XQex)/dVbc1)	farads
Cb1b2	AC current crowding capacitance (dQb1b2/dVb1b2)	farads
Cb1b2x	AC current crowding transcapacitance (dQb1b2/dVb2e1)	farads
Cb1b2y	AC current crowding transcapacitance (dQb1b2/dVb2c2)	farads
Cb1b2z	AC current crowding transcapacitance (dQb1b2/dVb2c1)	farads
Cts	Substrate-collector capacitance (dQts/dVsc1)	farads
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

- This device has no default artwork associated with it.
- This model was developed by NXP Semiconductors. Documentation is available on their website: http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/bipolar-models/mextram:MEXTRAM

MEXTRAM 504 Model (MEXTRAM 504 Model)

MEXTRAM_504_Model (MEXTRAM 504 Model)

Symbol



Parameters

Name	Description	Units	Default
NPN	NPN model type: yes or no	None	yes
PNP	PNP model type: yes or no	None	no
Tref (Tnom)	Reference temperature	°C	25
Dta (Trise)	Difference between the device and ambient temperature	°C	0.0
Exmod	flag for extended modeling of reverse current gain	None	yes
Exphi	flag for distributed high-frequency effects in transient	None	yes
Exavl	flag for extended modeling of avalanche currents	None	no
Is	collector-emitter saturation current	A	22.0e-18
Ik	high-injection knee current	A	0.1
Ver	Reverse Early voltage	V	2.5

Name	Description	Units	Default
Vef	Forward Early voltage	V	44.0
Bf	Ideal forward current gain	None	215.0
Ibf	Saturation current of the non-ideal forward base current	A	2.7e-15
Mlf	Non-ideality factor of the forward base current	None	2.0
Xibi	Fraction of Ideal Base Current that belongs to the Sidewall	None	0.0
Bri	Ideal reverse current gain	None	7.0
Ibr	Saturation current of the non-ideal reverse base current	None	1.0e-15
Vlr	Cross-over voltage of the non-ideal reverse base current	V	0.2
Xext	Part of Iex, Qtex, Qex and Isub that depends on Vbc1 instead of Vb1c2	None	0.63
Wavl	Epilayer thickness used in weak-avalanche model		1.1e-6
Vavl	Voltage determining curvature of avalanche current		3.0
Sfh	Current spreading factor of avalanche model (when EXAVL=1)	None	0.3
Re	Emitter resistance	Ohm	5.0
Rbc	Constant part of the base resistance	Ohm	23
Rbv	Zero-bias value of the variable part of the base resistance	Ohm	18
Rcc	constant part of collector resistance	Ohm	12
Rcv	Resistance of the un-modulated epilayer	Ohm	150
Scrcv	Space charge resistance of the epilayer	Ohm	1250
Ihc	Critial Current for Velocity Saturation in the Epilayer	A	4.e-3

Name	Description	Units	Default
Axi	Smoothness parameter for the onset of quasi-saturation	None	0.3
Cje	Zero-bias Emitter-Base Depletion Capacitance	F	73.0e-15
Vde	base-emitter diffusion voltage	V	0.95
Pe	base-emitter grading coefficient	None	0.4
Xcje	fraction of base-emitter capacitance that belongs to sidewall	None	0.4
Cbeo (Cbe0)	Fixed capacitance between external base and emitter nodes	F	0.0
Cjc	Zero-bias Collector-Base Depletion Capacitance		78.0e-15
Vdc	base-collector diffusion voltage	V	0.68
Pc	Collector-Base Grading Coefficient	None	0.5
Xp	constant part of Cjc	None	0.35
Mc	collector current modulation coefficient	None	0.5
Xcjc	fraction of base-collector depletion capacitance under emitter area	None	32e-3
Cbco (Cbc0)	Fixed capacitance between external base and collector nodes	None	0.0
Mtau	Non-ideality factor of the emitter stored charge	None	1.0
Taue (Te)	Minimum transit time of stored emitter charge		2.0e-12
Taub (Tb)	Transit time of stored base charge		4.2e-12
Tepi	Transit time of stored epilayer charge		41e-12
Taur (Tr)	Transit time of reverse extrinsic stored base charge		520e-12
Deg	Bandgap difference over the base		0.0

Name	Description	Units	Default
Xrec	Pre-factor of the recombination part of Ib1	None	0.0
Aqbo (Aqb0)	Temperature coefficient of the zero-bias base charge	None	0.3
Ae	Temperature coefficient of the resistivity of the emitter	None	0.0
Ab	Temperature coefficient of the resistivity of the base	None	1.0
Aepi	Temperature coefficient of the resistivity of the epilayer	None	2.5
Aex	Temperature coefficient of the resistivity of the extrinsic base	None	0.62
Ac	Temperature coefficient of the resistivity of the buried layer	None	2.0
dVgbf	Band-gap voltage difference of the forward current gain	V	0.05
dVgbr	Band-gap voltage difference of the reverse current gain	V	0.045
Vgb	Band-gap voltage of the base	V	1.17
Vgc	Band-gap voltage of the collector	V	1.18
Vgj	Band-gap voltage recombination emitter-base junction	V	1.15
dVgte	Band-gap voltage difference of emitter stored charge	V	0.05
Af	Exponent of the flicker-noise	None	2.0
Kf	Flicker-noise coefficient of the ideal base current	None	2e-11
Kfn	Flicker-noise coefficient of the non-ideal base current	None	2e-11
Iss	Base-substrate saturation current	A	48e-18
Iks	Base-substrate high injection knee current	A	250e-6
Cjs	Zero-bias collector-substrate depletion capacitance	F	315e-15

Name	Description	Units	Default
Vds	Collector-substrate diffusion voltage	V	0.62
Ps	Collector-substrate grading coefficient	None	0.34
Vgs	Band-gap voltage of the substrate	V	1.20
As	For a closed buried layer As=Ac and for an open buried layer As=Aepi	None	1.58
Rth	Thermal resistance	None	300
Cth	Thermal capacitance	None	3e-9
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvbe	base-emitter reverse breakdown voltage (warning)	V	None
wBvbc	base-collector reverse breakdown voltage (warning)	V	None
wVbcfwd	base-collector forward bias (warning)	V	None
wIbmax	maximum base current (warning)	A	None
wIcmax	maximum collector current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

- This model supplies values for M504_BJT_NPN, M504_BJT_PNP, M504_BJT4_NPN, M504_BJT4_PNP, M504_BJT5_NPN, and M504_BJT5_PNP devices.
- The MEXTRAM 504 implements self-heating. As the transistor dissipates power, it causes its temperature to rise above ambient. The model parameters Rth and Cth control this: ΔT = Pdiss x Rth. To enable this, set the Selfheating flag to yes, and ensure that the model parameter Rth is > 0. When self-heating is enabled, it may be necessary to increase the maximum number of iterations due to the additional unknown (temperature rise) that must be solved for. Simulation using self-heating may take 50 to 100% more time than the same simulation without self-heating.
  Self-heating can be used with either an internal or external thermal node.

    - M504_BJT_NPN, M504_BJT_PNP, M504_BJT4_NPN, and M504_BJT4_PNP use an internal node to keep track of the temperature rise of the transistor.
    - M504_BJT5_NPN and M504_BJT5_PNP make this thermal node externally available as the fifth terminal. This node can then be used for additional thermal modeling.
- This model was developed by NXP Semiconductors. Documentation is available on their website: http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/bipolar-models/mextram:MEXTRAM
- ADS implements the complete MEXTRAM 504 model, as per the NXP document NL_UR 2000/811, issued April 2001. Differences between the ADS documentation and the NXP documentation are:
    - in equations (4.96) and (4.102), Rcvt is used (not Rcv).
    - resistances are limited to a lower value of $10^{-4}\Omega$ (not $10^{-6}\Omega$)

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname MextramBJT504 [parm=value]*
```

The model statement starts with the required keyword *model* . It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *MextramBJT504*. Use either parameter NPN=yes or PNP=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

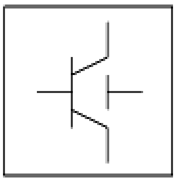
Example

```
model  Npn5 MextramBJT504 \
  NPN=yes Cjc=8e-14 Aepi=2  Vdc=0.6
```

MEXTRAM Model (MEXTRAM Model)

MEXTRAM_Model (MEXTRAM Model)

Symbol



This model (version 503) supplies values for BJT_NPN, BJT_PNP, BJT4_NPN, and BJT4_PNP devices.

For the MEXTRAM bipolar transistor model, model equations are explicit functions of internal branch voltages; therefore, no internal quantities are solved iteratively. Transistor parameters are discussed where relevant; most parameters can be extracted from capacitance, DC, and f_T measurements, and are process and transistor layout (geometry) dependent. Initial/predictive parameter sets can be calculated from process and layout data. This model does not contain extensive geometrical or process scaling rules (only multiplication factors to put transistors in parallel). The extended modeling of reverse behavior, the increase of the avalanche current when the current density in the epilayer exceeds the doping level, and the distributed high-frequency effect are optional and can be switched on by setting flags. Besides the NPN transistor a PNP model description is available, both with and without substrate (discrete transistors) modeling.

Parameters

Name	Description	Units	Default
NPN	NPN model type: yes or no	None	yes
PNP	PNP model type: yes or no	None	no
Release	Selection of MEXTRAM Release 503, 504, 505	None	503

Name	Description	Units	Default
Exmod	flag for extended modeling of reverse current gain	None	yes
Exphi	flag for distributed high-frequency effects in transient	None	yes
Exavl	flag for extended modeling of avalanche currents	None	yes
Is	collector-emitter saturation current	A/m^2	5.0e-17
Bf	ideal forward current gain	None	140.0
Xibi	fraction of ideal base current that belongs to sidewall	None	0.0
Ibf	saturation current of non-ideal forward base current	A/m^2	2.0e-14
Vlf	cross-over voltage of non-ideal forward base current	V	0.5
Ik	high-injection knee current	A/m^2	1.5e-2
Bri	ideal reverse current gain	None	16.0
Ibr	saturation current of non-ideal reverse base current	A/m^2	8.0e-15
Vlr	cross-over voltage of non-ideal reverse base current	V	0.5
Xext	part of IEX, QEX, QTEX and ISUB that depends on base-collector voltage VBC1	None	0.5
Qb0	base charge at zero bias	None	1.2e-12
Eta	factor of built-in field of base (= η)	None	4.0
Avl	weak avalanche parameter	None	50.0
Efi	electric field intercept (with Exavl=1)	None	0.7
Ihc	critical current for hot carriers	A/m^2	3.0e-3

Name	Description	Units	Default
Rcc	constant part of collector resistance	Ohms/ m^2	25.0
Rcv	resistance of unmodulated epilayer	Ohms/ m^2	750.0
Scrcv	space charge resistance of epilayer	Ohms/ m^2	1000.0
Sfh	current spreading factor epilayer	None	0.6
Rbc	constant part of base resistance	Ohms/ m^2	50.0
Rbv	variable part of base resistance at zero bias	Ohms/ m^2	100.0
Re	emitter series resistance	Ohms/ m^2 2	2.0
Taune	minimum delay time of neutral and emitter charge	sec	3.0e-10
Mtau	non-ideality factor of the neutral and emitter charge		1.18
Cje	B-E Zero-bias Junction Capacitance	F/m^2	2.5e-13
Vde	base-emitter diffusion voltage	V	0.9
Pe	base-emitter grading coefficient	None	0.33
Xcje	fraction of base-emitter capacitance that belongs to sidewall	None	0.5
Cjc	base-emitter Zero-bias Junction capacitance	F/m^2	1.3e-13
Vdc	base-collector diffusion voltage	V	0.6
Pc	base-collector grading coefficient variable part	None	0.4

Name	Description	Units	Default
Xp	constant part of Cjc	None	0.2
Mc	collector current modulation coefficient	None	0.5
Xcjc	fraction of base-collector depletion capacitance under emitter area	None	0.1
Tref (Tnom)	reference temperature	°C	25
Dta (Trise)	difference of device temperature to ambient temperature (TDevice=TAmbient+Dta)	°C	0.0
Vge	emitter bandgap voltage	eV	1.01
Vgb	base bandgap voltage	eV	1.18
Vgc	collector bandgap voltage	eV	1.205
Vgj	Recombination E-B Junction Band-Gap Voltage	eV	1.1
Vi	ionization voltage base dope	V	0.04
Na	maximum base dope concentration	cm^{-3}	3.0e+17
Er	temperature coefficient of Vlf and Vlr	None	2.0e-3
Ab	temperature coefficient resistivity base	None	1.35
Aepi	temperature coefficient resistivity of the epilayer	None	2.15
Aex	temperature coefficient resistivity of the extrinsic base	None	1.0
Ac	temperature coefficient resistivity of the buried layer	None	0.4
Kf	flicker noise coefficient ideal base current	None	2.0e-16
Kfn	flicker noise coefficient non-ideal base current	None	2.0e-16

Name	Description	Units	Default
Af	flicker noise exponent	None	1.0
Iss	base-substrate saturation current	A/m^2	6.0e-16
Iks	knee substrate current	A/m^2	5.0e-6
Cjs	C-S Zero-bias Junction Capacitance	F/m^2	1.0e-12
Vds	collector-substrate diffusion voltage	V	0.5
Ps	collector-substrate grading coefficient	None	0.33
Vgs	substrate bandgap voltage	V	1.15
As	for closed buried or an open buried layer	None	2.15
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvbe	base-emitter reverse breakdown voltage (warning)	V	None
wBvbc	base-collector reverse breakdown voltage (warning)	V	None
wVbcfwd	base-collector forward bias (warning)	V	None
wIbmax	maximum base current (warning)	A	None
wIcmax	maximum collector current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

- The Philips model uses the MULT parameter as a scaling factor. In ADS, MULT is implemented as AREA, which has the same mathematical effect. Because the Philips model uses MULT as the multiplier/scaling, the values are in measurements such as Amps. However, in ADS, units of area are m^2, so they

are listed accordingly. This accounts for differences in reporting of some units in the Phillips documentation.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname MextramBJT [parm=value]*
```

The model statement starts with the required keyword *model* . It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *MextramBJT*. Use either parameter NPN=yes or PNP=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example

```
model  Npn4 MextramBJT  \
  NPN=yes Ibf=3e- Qb0=1e-13
```

Survey of Modeled Effects

- Temperature effects
- Charge storage effects
- Substrate effects and parasitic PNP
- High-injection effects
- Built-in electric field in base region
- Bias-dependent Early effect
- Low-level non-ideal base currents
- Hard and quasi-saturation
- Weak avalanche
- Hot carrier effects in the collector epilayer
- Explicit modeling of inactive regions
- Split base-collector depletion capacitance

- Current crowding and conductivity modulation for base resistance
- First-order approximation of distributed high-frequency effects in the intrinsic base (high-frequency current crowding and excess phase-shift).

Active Transistor

Main Current

In the MEXTRAM model the Moll-Ross relation is used to take into account the depletion and diffusion charges:

$$I_n = \frac{(I_f - I_r)}{1 + (Qt_e + Qt_c + Qb_e + Qb_c)/Qb0} \quad \text{(2-1)}$$

$$Qb_e = f_1(n_o) \quad \text{(2-2)}$$

$$Qb_c = f_2(n_b) \quad \text{(2-3)}$$

The depletion charges are represented by Qt_e and Qt_c. The calculation of the diffusion charges Qb_e and Qb_c is based directly on the solution of the differential equation for the majority carriers in the neutral base region and relates the charges to the injected minority carrier concentrations at the emitter (no) and collector edges (nb). These concentrations, in turn, depend on the internal junction voltages Vb_2e_1 and Vb_2c by considering the P-N product at both junctions. In this way high injection, bias-dependent current gain, a current- dependent transit time, and the effect of the built-in electric field are included. The ideal forward and reverse current are given by:

$$I_f - I_r = Is \times (\exp(Vb_2e_1/V_t) - \exp(Vb_2c_2/V_t)) \quad \text{(2-4)}$$

where V_t is the thermal voltage.
The parameters are:

Is = extracted from Gummel plot at low V_{be}
Qb0 = integral of base charge extracted from reverse Early effect
Xcjc = fraction of Cj_c underneath emitter; obtained from forward Early effect
Ik = from gain fall-off: only one knee current
Eta = built-in field in the base due to the doping profile. This parameter is normally between 3 and 6. It is difficult to obtain from direct measurements, and has a weak influence on calculated currents and charges.

Ideal Forward Base Current

The ideal forward base current is defined in the usual way. The total base current has a bottom and a sidewall contribution. The separation is given by the factor XIb1. This factor can be determined by analyzing the maximum current gain of transistors with different geometries.

$$Ib_1 = (1 - Xibi) \times \frac{Is}{Bf}(\exp(Vb_2e_1/V_t) - 1) \tag{2-5}$$

The parameters are:
Bf = ideal forward current gain
Xibi = fraction of ideal base current that belongs to the sidewall

Non-Ideal Forward Base Current

The non-ideal base current originates from the recombination in the depleted base-emitter region:

$$Ib_2 = Ibf \times \frac{\exp(Vb_2e_1/V_t) - 1}{\exp(Vb_2e_1/(2 \times V_t)) + \exp(Vlf/(2 \times V_t))} \tag{2-6}$$

Formulation of the non-ideal base current differs from the Gummel-Poon model. The MEXTRAM formulation is less flexible than the Gummel-Poon model. The formulation is the same when in the MEXTRAM model Vl_f is small (<0.4V), and when in the Gummel-Poon model parameter n_e=2. The parameters are:
Vlf = crossover voltage of the non-ideal forward base current
Ibf = saturation current of the non-ideal forward base current

Base-Emitter Depletion Charge

The base-emitter depletion charge is modeled in the classical way using a grading coefficient. The depletion charge is partitioned in a bottom and a sidewall component by the parameter Xcje.

$$Ct_e = (1 - Xcje) \times \frac{Cje}{1 - (Vb_2e_1/Vde)^{Pe}} \tag{2-7}$$

The capacitance becomes infinity at Vb_2e_1 = Vde. Therefore in the model the integral of equation is slightly modified and consequently Ct_e. The capacitance now has a maximum at the base-emitter diffusion voltage Vde and is symmetrical around the diffusion voltage. The maximum capacitance is determined by the value of K and the grading coefficient Pe. The value of K is a model constant and is taken equal to 0.01. When Pe=0.4, the maximum is approximately three times the capacitance at zero bias. The parameters are:
Cjc = zone bias base-emitter depletion capacitance
Vde = base-emitter diffusion voltage
Pe = base-emitter grading coefficient

Base-Collector Depletion Charge

The base-collector depletion capacitance underneath the emitter Qtc, takes into account the finite thickness of the epilayer and current modulation:

$$Ct_c = Xcjc \times Cjc \times \left(\frac{(1 - Xp) \times f(Vc_1c_2)}{1 - ((Vb_2 \times c_2)/(Vdc))^{Pc}} + Xp \right)$$

(2-8)

$$f(Vc_1 \times c_2) = \left(1 - \frac{Vc_1c_2}{Vc_1c_2 + Ihc \times Rcv} \right)^{Mc}$$

(2-9)

The function $f(Vc_1c_2)$ equals one when $Ic_1c_2 = Vc_1c_2 = 0$, and becomes zero when the current density in the epilayer exceeds the doping level ($Vc_1c_2 > Ihc \times Rcv$). The parameters are:

Cjc = zero bias base-collector depletion capacitance
Xcjc = part of Cjc underneath emitter
Vdc = base-collector diffusion voltage
Pc = base-collector grading coefficient
Xp = depletion layer thickness at zero bias divided by epilayer thickness
Mc = collector current modulation coefficient (0.3 < mc < 0.5)
Cjc, Pc and Xp is obtained from CV measurements; Vdc must be extracted from the quasi-saturation regime; Xcjc is obtained from the forward Early-effect.

Neutral Base and Emitter Diffusion Charge

The neutral base-emitter diffusion charge (Q_n) is given by:

$$Q_n = Qn_0 \times \left(\exp\left(\frac{Vb_2e_1}{Mtau \times V_t} \right) - 1 \right)$$

(2-10)

The charge Qn0 is calculated from the transit time Taune and Mtau. The parameters (extracted from the maximum value of the cut-off frequency, f_T) are:

Taune = minimum delay time of neutral and emitter charge
Mtau = non-ideality factor of the neutral and emitter charge; in most cases Mtau=1

Base-Charge Partitioning

Distributed high-frequency effects are modeled, in first order approximation, both in lateral direction (current crowding) and in vertical direction (excess phase-shift). The distributed effects are an optional feature of the MEXTRAM model, and can be switched on and off by flag Exphi (on: Exphi - 1; off: Exphi = 0). In vertical direction (excess phase-shift), base charge partitioning is used; for simplicity, it is implemented for forward base charge (Qb_e) and low-level injection only. No additional parameters.

$$Q'b_e = (1 - q_c(Eta)) \times Qb_e \quad \textbf{(2-11)}$$

$$Q'b_c = Qb_c + q_c(Eta) \times Qb_e \quad \textbf{(2-12)}$$

Modeling of Epilayer Current Charges

The epilayer resistance depends on the supplied collector voltage and current, imposed primarily by base-emitter voltage. The effective resistance of the epilayer is strongly voltage- and current-dependent because:

- In the forward mode of operation, the internal base charge junction voltage (Vb_2c_2) may become forward-biased at high collector currents (quasi-saturation). When this happens, the region in the collector near the base is injected by carriers from the base, causing the region to become low resistive.
- In the reverse mode of operation, both the external and internal base charge junction voltages are forward biased, flooding the whole epitaxial layer with carriers, which causes it to become low resistive.
- The current flow in the highly-resistive region is ohmic if the carrier density (n) is low ($n \ll N_{epi}$), and space-charge-limited if the carrier density exceeds the doping level (N_{epi}).
- Current spreading in the epilayer reduces the resistance and is of special importance if the carrier density exceeds N_{epi}. In the latter case, the carriers move with the saturated drift velocity, V_{sat} (hot-carrier current-flow).
  A compact modal formulation of quasi-saturation is given by Kull et al [1]. The Kull model is valid only if the collector current density is below the critical current density (J_{hc}) for hot carriers:
  $$J_{hc} = q \times N_{epi} \times v_{sat} \quad \textbf{(2-13)}$$
  The Kull formulation has served as a basis for the epilayer model in MEXTRAM.

Collector Resistance Model

The Kull model is based on charge neutrality ($p + N_{epi} \approx n$) and gives the current through the epilayer (Ic_1c_2) as a function of the internal and external b.c. junction voltage. These voltages are given by the solution vector of the circuit simulator. The final equations of the Kull formulation [1] are:

$$Ic_1c_2 = \frac{E_c + Vb_2c_2 - Vb_2c_1}{Rcv} \quad \textbf{(2-14)}$$

$$E_c = V_t \times \left[K_0 - K_w - \ln\left(\frac{K_0 + 1}{K_w + 1}\right)\right] \quad \textbf{(2-15)}$$

$$K_0 = \sqrt{1 + 4 \times \exp[(Vb_2c_2 - Vd_c)/V_t]} \quad \textbf{(2-16)}$$

$$K_w = \sqrt{1 + 4 \times \exp[(Vb_2c_1 - Vd_c)/V_t]} \quad \text{(2-17)}$$

$$V_t = k \times \frac{T}{q} \quad \text{(2-18)}$$

Voltage source (E_C) takes into account the decrease in resistance due to carriers injected from the base into the collector epilayer. If both junctions are reverse biased (Vb2c1 - Vdc and Vb_2c_2 - Vd_c are negative), E_C is zero and we have a simple constant resistance (Rcv). Because of this, this model does not take into account the hot-carrier behavior (carriers moving with the saturated drift-velocity) in the lightly-doped collector epilayer. The model is valid if the transistor operates in the reverse mode (reverse-biased b.e. junction, forward-biased b.c. junction). Then the entire epilayer is filled with carriers and a space-charge region does not exist. The derivation of the MEXTRAM epilayer resistance model is published in de Graaff and Kloosterman [2]. In the end, the following equations are found:

$$\frac{X_i}{W_{epi}} = \frac{E_c}{Ic_1c_2 \times Rcv} \quad \text{(2-19)}$$

$$I_{low} = \frac{Ihc \times Vc_1c_2}{Vc_1c_2 + Ihc \times Rcv \times (1 - X_i/W_{epi})} \quad \text{(2-20)}$$

$$Ic_1c_2 = (I_{low} + S_f) \times \frac{Vc_1c_2 - I_{low} \times Rcv \times (1 - X_i/W_{epi})}{Scrcv \times (1 - X_i/W_{epi})^2} \quad \text{(2-21)}$$

Where Xi/Wepi is the thickness of the injected region of the epilayer.

Substitution of equations (2-19) and (2-20) into equation (2-21) gives a cubic equation. The epilayer current (Ic1c2) is calculated by solving the cubic equation. The complex calculation can be done with real variables. Summarizing, the epilayer resistance model takes into account:

- Ohmic current flow at low current densities
- Decrease in resistance due to carriers injected from the base if only the internal base-collector junction is forward biased (quasi-saturation), and if both the internal and external base-collector junctions are forward biased (reverse mode of operation)
- Space charge limited current flow at high current densities
- Current spreading in the epilayer

  The model parameters are:

$$Ihc = q \times N_{epi} \times A_{em} \times v_{sat} \times \frac{1 + Sf_l}{\alpha_{cf}} \quad \text{(2-22)}$$

$$Rcv = \frac{W_{epi}}{q \times N_{epi} \times \mu \times A_{em}} \times \frac{\alpha_{cf}}{1 + Sf_l} \quad \text{(2-23)}$$

$$Scrcv = \frac{W^2{}_{epi}}{2 \times \varepsilon \times v_{sat} \times A_{em}} \times \frac{\alpha_{cf}}{1 + Sf_h}$$ (2-24)

$$Vdc = V_t \times \ln\left\{(N_{epi}/n_i)^2\right\}$$ (2-25)

$$Sfh = \frac{2}{3} \times \tan(\alpha_h) \times W_{epi} \times \left(\frac{1}{H_e} + \frac{1}{L_e}\right)$$ (2-26)

where:

$$A_{em} = H_e \times L_e$$ (2-27),

$$Sf_l = \tan(\alpha_h) \times W_{epi} \times \left(\frac{1}{H_e} + \frac{1}{L_e}\right)$$ (2-28),

αl = the spreading angle at low current levels ($Ic_1c_2 < Ihc$)

αh = the spreading angle at high current levels $Ic_1c_2 > Ihc$)

αcf = the fraction of Ic_1c_2 flowing through the emitter floor area

L_e = the length of the emitter stripe.

The turnover from equations (2-20) and (2-21) in the forward mode to equation (2-14) in the reverse mode does not give discontinuities in the first and second derivative. The third derivative is discontinuous. Parameter Sfh depends on transistor geometry and the decrease in gain and cutoff frequency will be affected by this parameter. SF1 is included in Rcv and Ihc, and not needed as a separate parameter. In most cases, Vdc is calculated directly from the doping level. Rcv, Ihc, and Scrcv are extracted from the quasi-saturation regime at low values of Vce.

Diffusion Charge of the Epilayer

The diffusion charge of the epilayer can be easily derived by applying the Moll-Ross relation to the base + collector region (from node e_1 to node c_1):

$$I_n = Ic_1c_2 = \frac{Is \times \{\exp(Vb_2e_1/V_t) - \exp(Vb_2c_1/V_t)\}}{1 + \dfrac{Q_{te} + Q_{tc} + Q_{be} + Q_{bc} + Q_{epi}}{Qb0}}$$ (2-29)

Subtracting equation (2-1), the expression for Q_{epi} becomes:

$$Q_{epi} = Is \times Qb0 \times \frac{\exp(Vb_2c_1/V_t) - \exp(Vb_2c_1/V_t)}{Ic_1c_2} \quad (2\text{-}30)$$

In the transition from forward to reverse mode, Ic_1c_2 passes zero and numerical problems can be expected. Substitution of equation (2-14) into equation (2-29) leads in the case where $Vb_2c_2 \approx Vb_2c_1$ to the following expression for Q_{epi}:

$$p_0 = \frac{2 \times \exp\{(Vb_2c_2 - Vdc)/V_t\}}{1 + K_0} \quad (2\text{-}31)$$

$$p_w = \frac{2 \times \exp\{(Vb_2c_1 - Vdc)/V_t\}}{1 + K_w} \quad (2\text{-}32)$$

$$Q_{epi} = Is \times Qb0 \times Rcv \times \exp(Vdc/V_t) \times \frac{p_0 + p_w}{2 \times V_t} \quad (2\text{-}33)$$

Avalanche Multiplication Model

Due to the high-electric field in the space-charge region, avalanche currents are generated; this generation strongly depends on the maximum electric field. The maximum electric field may reside at the base charge junction or at the buried layer. The generation of avalanche current in Kloosterman and de Graaff [3] is only a function of the electric field at the internal base charge junction. Therefore, the validity of this model is restricted to low current levels (Ic_1c_2<Ihc).

Current spreading in the collector region changes the electric-field distribution and decreases the maximum electric field. Because the generation of avalanche current is sensitive with respect to the maximum electric-field, it is difficult to set up an accurate and still simple model for high collector current densities. Because this operating area (high voltages, high current levels) is not of practical interest (due to power dissipation) and, more importantly, the convergency behavior of the model degrades, we must carefully consider the extension of the avalanche model to the high current regime.

At low current densities (Ic_1c_2<Ihc), the model is essentially the same as in Kloosterman and de Graaff [3]. As an optional feature, the model is extended to current levels exceeding Ihc (negative output resistance: snap-back behavior). Due to negative output resistance, serious convergency problems are imaginable. Without this feature, output resistance can be very small, but is always positive.

The generation of avalanche current is based on Chynoweth's empirical law for the ionization coefficient [4]:

$$P_n = \alpha_n \times \exp\left(\frac{-b_n}{|E|}\right) \quad \text{(2-34)}$$

Because only weak avalanche multiplication is considered, the generated avalanche current is proportional with the main current (I_n):

$$I_g = I_n \times \int_{x=0}^{x=X_d} \alpha_n \times \exp\left(\frac{-b_n}{|E(x)|}\right) \times dx \quad \text{(2-35)}$$

X_d = the boundary of the space-charge region.

To calculate the avalanche current, we must evaluate the integral of equation (2-34) in the space-charge region. This integral is determined by the maximum electric field. We make a suitable approximation around the maximum electric field:

$$E(x) = E_m \times \left(1 - \frac{x}{\lambda}\right) \cong \frac{E_m}{1 + x/\lambda}$$

l = the point where the extrapolated electric-field is zero.

Then the generated avalanche current becomes:

$$\frac{I_g}{I_n} = \frac{\alpha_n}{b_n} \times E_m \times \lambda \times \left\{ \exp\left(\frac{-b_n}{E_m}\right) - \exp\left(\frac{-b_n}{E_m} \times \left(1 + \frac{X_d}{\lambda}\right)\right) \right\}$$

The maximum electric field (E_m), the depletion layer thickness (X_d), and the intersection point (l) are calculated using the charge model of Q_{tc} and the collector resistance model. The model parameters are:

$$Avl = b_n \times \sqrt{\frac{2 \times \varepsilon \times Vdc}{q \times N_{epi}}}$$

$$F_i = 2 \times \frac{1 + 2 \times Sf_l}{1 + 2 \times Sfh} \times \frac{2 + Sf_l + 2 \times Sfh}{2 + 3 \times Sf_l}(-1)$$

Avl = obtained from the decrease of I_b at high V_{cb} and low I_c values

Sfh = equation (2-26)

Sf_l = equation (2-27)

Efi = used in extended avalanche model only

Sfh and Efi are extracted from the output characteristics at high V_{ce} and high I_c. Because most devices are heated due to power dissipation in this operation regime, parameter extraction is cumbersome. Calculating Efi and Sfh is often a good alternative.

Extrinsic Regions

Reverse Base Current

The reverse base current is affected by high injection and partitioned over the two external base-collector branches:

$$ah_b = 2 \times \left(\frac{1 - \exp(-Eta)}{Eta}\right)$$

$$al_b = \exp(-Eta)$$

$$g_1 = \frac{4 \times Is \times ah_b^{\;2} \times \exp\left(\frac{Vb_1c_1}{V_t}\right)}{I_k \times al_b^{\;2}}$$

$$n_{b_{ex}} = al_b \times \frac{g_1}{2 \times (1 + \sqrt{1 + g_1})}$$

$$I_{ex} = \frac{(1 - Xext)}{Bri} \times \left(\frac{al_b + n_{b_{ex}}}{ah_b + n_{b_{ex}}} \times \frac{Ik}{ah_b} \times n_{b_{ex}} - Is\right)$$

The current XI_{ex} is calculated in a similar way using the voltage Vbc1. Because the time to evaluate the extrinsic regions is doubled due to this partitioning, it is an optional feature. The parameters are:
Bri = ideal reverse current gain
Xext = partitioning factor

Non-Ideal Reverse Base Current

The non-ideal reverse base current (Ib3) is modeled in the same way as the forward non-ideal base current. The parameters are:
Ibr = saturation current of the non-ideal reverse base current
Vlr = crossover voltage of the non-ideal reverse base current

Extrinsic Base-Collector Depletion Capacitance

The base-collector depletion capacitance of the extrinsic region is divided over the external-base node b_1 (part: Q_{tex}). The model formulation is obtained by omitting the current modulation term in the formulation of Q_{tc}, equation (2-8).

$$Ctc_{ex} = (1 - Xext) \times (1 - Xcjc) \times Cjc \times \left(\frac{1 - Xp}{1 - (Vb_1c_1/\text{Vdc})^{Pc}} + Xp \right)$$

$$Xctc_{ex} = Xext \times (1 - Xcjc) \times Cjc \times \left(\frac{1 - Xp}{1 - (Vb_1c_1/(Vdc))^{Pc}} + Xp \right)$$

Parameter Xext is partitioning factor for the extrinsic region.
This partitioning factor is important for the output conductance (Y12) at high frequencies.

Diffusion Charge of the Extrinsic Region

These charges are formulated in the same way as Qb_c and Q_{epi}, now using voltages Vc_1b_1 and Vbc_1, and the appropriate area (1 - Xcjc)/Xcjc.

Parasitic PNP

The substrate current of the PNP takes into account high injection. The parameters are:
Iss = substrate saturation current
Iks = knee in the substrate current; when the value of *Iks* is low, the reverse current gain increases at medium reverse current levels
When the collector-substrate junction becomes forward biased, only a signal current (Is_f) is present in the model.

$$Is_f = Iss \times (\exp((Vsc_1)/(Vt)) - 1)$$

No additional parameters.

Collector-Substrate Depletion Capacitance

The collector-substrate charge (Qt_s) is modeled in the usual way:

$$Ct_s = \frac{Cjs}{1 - (Vsc_1/(Vds))^{Ps}}$$

Parameters Cjs, Vds, and P *s* are obtained from collector-substrate CV measurement.

Base-Emitter Sidewall

Base-emitter sidewall base current Sib_1:

$$Sib_1 = Xibi \times \frac{Is}{Bf} \times (\exp(Vb_1e_1/V_t) - 1)$$

Parameter *Xibi* obtained from geometrical scaling of the current gain.
Base-emitter sidewall depletion capacitance SQt_e:

$$SCt_e = \frac{Xcje \times Cje}{1 - (Vb_1e_1/\mathrm{Vde})^{Pe}}$$

Parameter Xcje obtained from geometrical scaling of the capacitances.

Variable Base Resistance

The base resistance is divided in a variable part (R_{bv}) and a constant part (R_{bc}). The variable part is modulated by the base width variation (depletion charges at the junctions Q_{te} and Q_{tc}) and at high current densities it decreases because of the diffusion charges Q_{be} and Q_{bc}. The parameter Rbv is the resistance at zero base-emitter and base-collector voltage. The resistance model also considers DC current crowding. The resistance decreases at high base currents when V_{b1b2} is positive, and it increases when V_{b1b2} is negative (reversal of the base e current).
Charge modulation:

$$R_b = \frac{Rbv}{1 + (Qt_e + Qt_c + Qb_e + Qb_c)/(Qb0)}$$

DC current crowding:

$$Ib_1b_2 = \frac{2 \times V_t}{3 \times R_b} \times (\exp(Vb_1b_2/V_t) - 1) + \frac{Vb_1b_2}{3 \times R_b}$$

Ac current crowding is an optional feature of the model (Exphi=1):

$$Qb_1b_2 = Vb_1b_2 \times (Ct_e + Cb_e + C_n)/5$$

Constant Series Resistances

The model contains three constant series resistors at the base, emitter, and collector terminals (Rbc, Re, Rcc). (Substrate resistance is not incorporated in the model.)

Temperature Scaling Rules

Temperature scaling rules are applied to these parameters.
Resistances: Rbc, Rbv, Re, and Rcc
Capacitances: Cje, Vde, Cjc, Vdc, Xp, Cjs, Vds, Qbo, Qn_0, and Mtau
Saturation Currents: Is and Iss
Gain Modeling: Bf, Ibf, Vif, Bri, Ibr, Vlr, Ik, and Iks

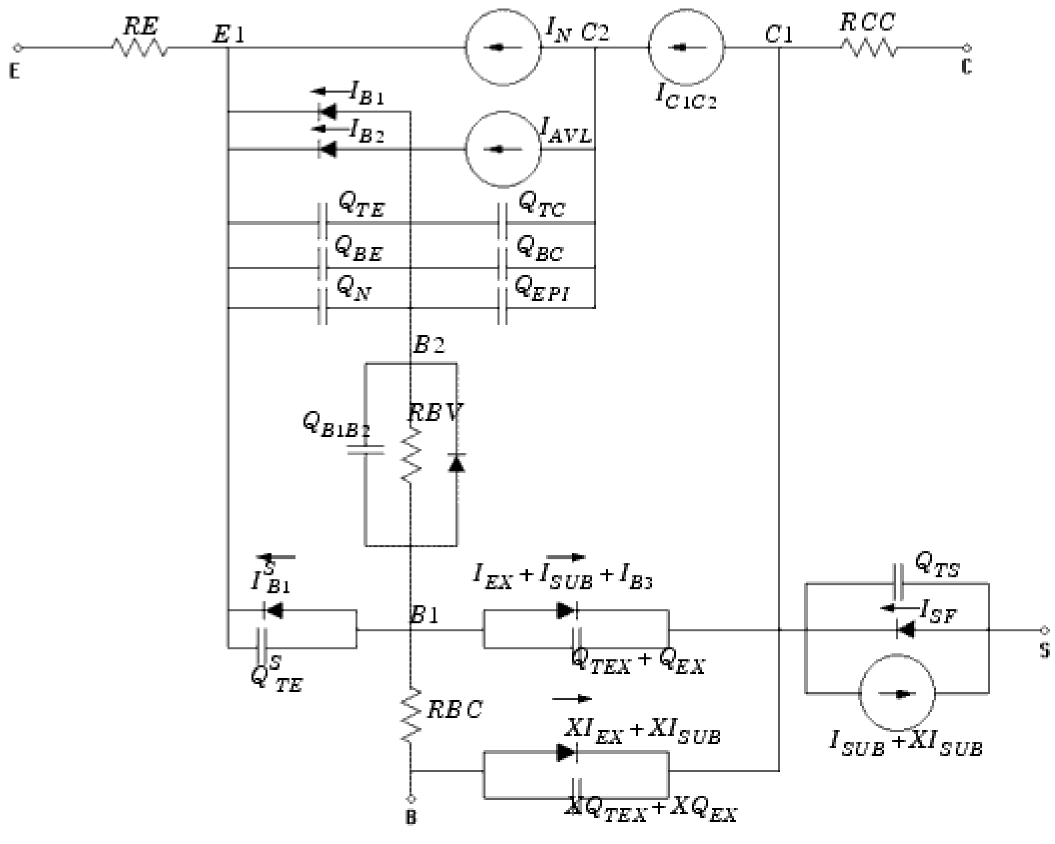
Avalanche: Avl
These parameters are used in the temperature scaling rules:
Bandgap Voltages: Vge, Vgb, Vgc, Vgs, and Vgj
Mobility Exponents: Ab, Aepi, Aex, Ac, and As
Qb0: Vi and Na
Vlf and Vlr: Er

Noise Model

Thermal Noise: Resistances Rbc, Rbv, Re, and Rcc
Shot Noise: I_n, Ib1, Sib1, Ib_2, Ib_3, I_{ex}, and XI_{ex}
1/F noise: Ib_1, SIb_1, Ib_2, and Ib_3
1/F noise parameters: Kf, Kfn, and Af

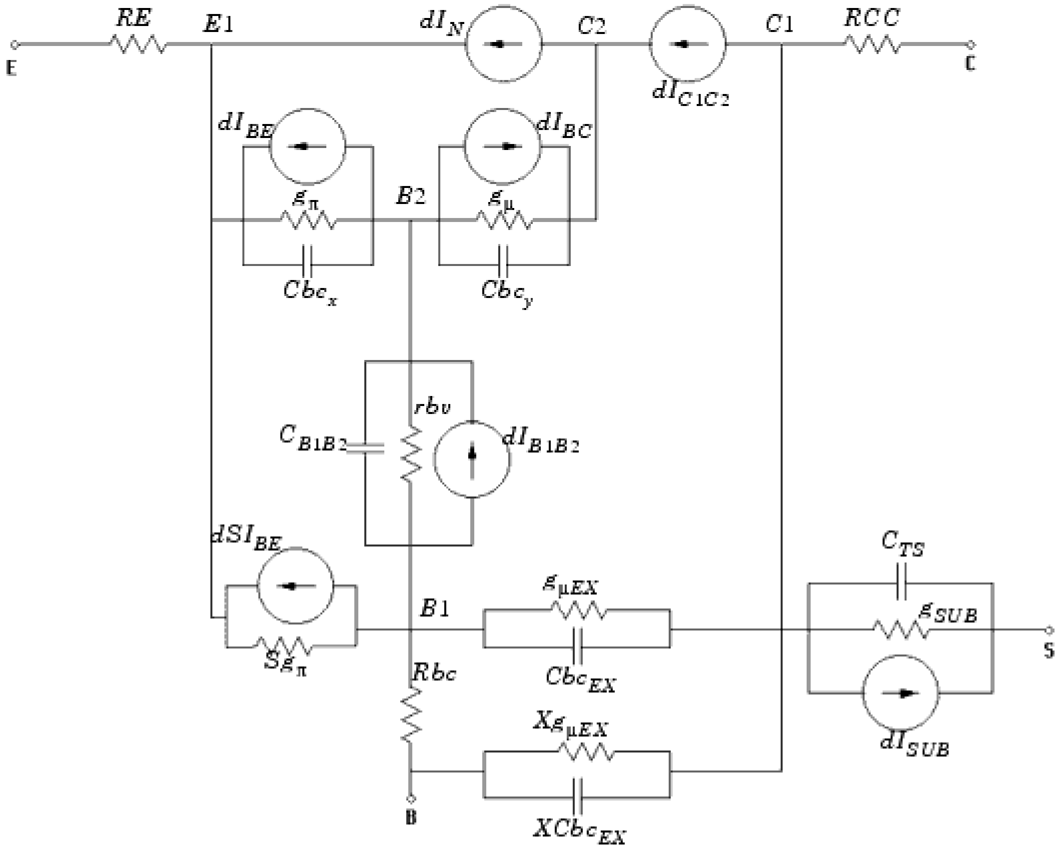
Additional Information

Equivalent Circuits



mextramv.tif

Equivalent Circuit for Vertical NPN Transistor



Small Signal Equivalent Circuit for Vertical NPN Transistor

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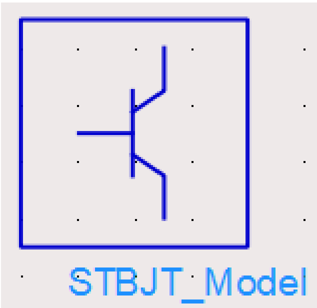
- A.G. Chynoweth: "Ionization rates for electron and holes in silicon." Phys. Rev., Vol. 109, p. 37, 1958.

STBJT Model (ST Bipolar Transistor Model)

STBJT_Model (ST Bipolar Transistor Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
Type	Model type: 1=NPN; 2=PNP	None	1
Tmeas (Tnom)	measurement temperature	°C	25
Is	forward transport saturation current	A	1.0e-16
Isn	reverse transport saturation current; defaults to Is	A	defaults to Is
Bf	ideal forward current gain	None	100.0
Nf	forward current emission coefficient	None	1.0
Br	ideal reverse current gain	None	1.0
Nr	reverse emission coefficient	None	1.0
Isf	ideal B-E junction saturation current; defaults to Is/Bf	A	defaults to Is/Bf
Nbf	ideal B-E junction emission coefficient; defaults to Nf	None	defaults to Nf
Isr	ideal B-C junction saturation current; defaults to Isn/Br	A	defaults to Isn/ Br

Nbr	ideal B-C junction emission coefficient; defaults to Nr	None	defaults to Nr
Ise	B-E recombination saturation current	A	0.0
Ne	B-E recombination emission coefficient	None	2.0
Isc †, ††	B-C recombination saturation current	A	0.0
Nc	B-C recombination emission coefficient	None	1.5
Vaf	forward early voltage	V	fixed at infinity†††
Var	reverse early voltage	V	fixed at infinity†††
Enp	base push out exponent	None	2.0
Rp	BPO fitting parameter	None	1.0e-3
Rw	ratio of collector width to the base	None	0
Vij	modified B-C potential	V	0.8
Vrp	voltage drop across vertical Rc	V	1.0e-9
Bvc	junction breakdown of C-B junction	V	fixed at infinity†††
Mf	exponent of B-C multiplication factor	None	0.0
Fa	Bvcbo/Bvc	None	0.95
Avc	fitting parameter	None	1.0
Bve	junction breakdown of the E-B junction	V	fixed at infinity†††
Mr	exponent of the E-B multiplication factor	None	0.0
Fb	Bvebo/Bve	Hz	0.95
Ave	fitting parameter	None	1.0
Rb	zero-bias base resistance	Ohm	0.0
Irb	current when base resistance falls halfway to its minimum value	A	fixed at infinity†††
Rbm	minimum base resistance at high current (0 means Rb)	Ohm	0.0
Re	emitter resistance	Ohm	0.0
Rc	collector resistance under the emitter	Ohm	0.0
Rcs	collector resistance in saturation	Ohm	0.0
Cje	B-E zero-bias depletion capacitance	F	0.0
Vje	B-E junction built-in potential	V	0.75
Mje	B-E grading coefficient	None	0.33

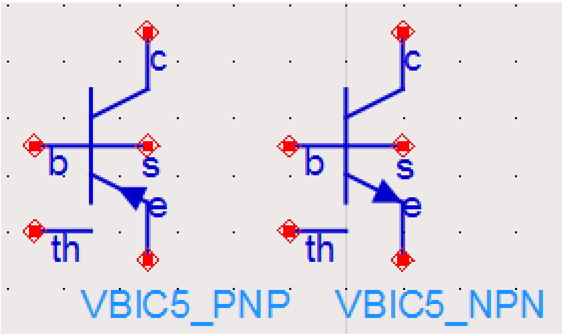
Fc	Forward-bias Depletion Cap. Coefficient	None	0.5
Cjc	B-C zero-bias depletion gap	F	0.0
Vjc	B-C junction built-in potential	V	0.75
Mjc	junction grading coefficient	None	0.33
Xjbc	fraction of Cjc connected to B int node	None	1.0
Cjs	zero-bias collector substrate (ground) cap	F	0.0
Vjs	C-S (B-S) built-in potential	V	0.75
Mjs	C-S (B-S) grading coefficient	None	0.33
Xjbs	fraction of B-S cap connected to B int node	None	1.0
Vert	1=vertical structures; 0=else	None	0
Subsn	1=N substrate; 0=else	None	0
Tf	ideal forward transit time	sec	0.0
Xtf	coefficient of bias dependence for TF	None	0.0
Vtf	voltage dependence of Tf on B-C voltage	V	fixed at infinity†††
Itf	parameter for Tf high currents roll off	A	fixed at infinity†††
Ptf	excess phase	deg	0.0
Tfcc	Tf BPO model: 1=Spice, 0=else	None	0
Tr	ideal reverse transit time	sec	0.0
Kf	flicker noise coefficient	None	0.0
Af	flicker noise exponent	None	1.0
Eg	bandgap voltage at 0K	V	1.11
Xti	temperature exponent	None	3.0
Xtb	temperature exponent for gain currents	None	0.0
Trb1	linear temperature coefficient for Rb	1/°C	0.0
Trb2	quadratic temperature coefficient for Rb	$1/(°C)^2$	0.0
Trbm1	linear temperature coefficient for Rbm	1/°C	0.0
Trbm2	quadratic temperature coefficient for Rbm	$1/(°C)^2$	0.0
Tre1	linear temperature coefficient for Re	1/°C	0.0
Tre2	quadratic temperature coefficient for Re	$1/(°C)^2$	0.0

Trc1	linear temperature coefficient for Rc	1/°C	0.0
Trc2	quadratic temperature coefficient for Rc	1/ $(°C)^2$	0.0
Trcs1	linear temperature coefficient for Rcs	1/°C	0.0
Trcs2	quadratic temperature coefficient for Rcs	1/ $(°C)^2$	0.0
Ikf†††	forward Ik	A	fixed at infinity†††
Ikr†††	reverse Ik	A	fixed at infinity†††
Gmin	minimum conductance	None	1e-12
All Params	Data Access Component (DAC) Based Parameters	None	None
† This parameter value varies with temperature based on model Tnom and device Temp. †† This parameter value scales with Area specified with the BJT or BJT4 model. ††† A value of 0.0 is interpreted as infinity.			

VBIC5 NPN, VBIC5 PNP (VBIC Nonlinear Bipolar Transistors with Thermal Terminal, NPN, PNP)

VBIC5_NPN, VBIC5_PNP (VBIC Nonlinear Bipolar Transistors with Thermal Terminal, NPN, PNP)

Symbol



Parameters

Name	Description	Units	Default
Model	name of a VBIC_Model	None	VCICM1
Scale	scaling factor	None	1.0
Region	dc operating region: 0=off, 1=on, 2=rev, 3=sat	None	on
Temp	device operating temperature	°C	25
Trise	temperature rise above ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (refer to note 2)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes

Name	Description	Units	Default
_M	number of devices in parallel	None	1

- The Temp parameter specifies the physical (operating) temperature of the device. If this is different than the temperature at which the model parameters are valid or extracted (specified by the Tnom parameter of the associated VBIC_Model) certain model parameters are scaled such that the device is simulated at its operating temperature.
- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The VBIC implements self-heating. As the transistor dissipates power, it causes its temperature to rise above ambient. The model parameters Rth, Cth, and Selft control this: ΔT = Pdiss x Rth. (Refer to VBIC_Model note 5.) When self-heating is enabled, it may be necessary to increase the maximum number of iterations due to the additional unknown (temperature rise) that must be solved for. Simulation using self-heating may take 50 to 100% more time than the same simulation without self-heating.
  Self-heating can be used with either an internal or external thermal node.
  - VBIC_NPN and VBIC_PNP use an internal node to keep track of the temperature rise of the transistor.
  - VBIC5_NPN and VBIC5_PNP make this thermal node externally available as the fifth terminal. This node can then be used for additional thermal modeling.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Ic	Collector current	amperes
Ib	Base current	amperes
Ie	Emitter current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gbe	Transconductance gbe	siemens
Cbe	Base-emitter capacitance cbe	farads

Name	Description	Units
Gbc	Transconductance gbc	siemens
Cbc	Base-collector capacitance cbc	farads
Gbex	Transconductance gbex	siemens
Cbex	Base-emitter capacitance cbex	farads
Gbep	Transconductance gbep	siemens
Cbep	Base-emitter capacitance cbep	farads
Gbcp	Transconductance gbcp	siemens
Cbcp	Base-collector capacitance cbcp	farads
dIcc_dVbei	(dIcc/dVbei)	siemens
dIcc_dVbci	(dIcc/dVbci)	siemens
dIccp_dVbep	(dIccp/dVbep)	siemens
dIccp_dVbcp	(dIccp/dVbcp)	siemens
dIccp_dVbci	(dIccp/dVbci)	siemens
dIbc_dVbei	(dIbc/dVbei)	siemens
Grbi	Base conductance grbi	siemens
dIrbi_dVbei	(dIrbi/dVbei)	siemens
dIrbi_dVbci	(dIrbi/dVbci)	siemens
Grbp	Base conductance grbp	siemens
dIrbp_dVbep	(dIrbp/dVbep)	siemens

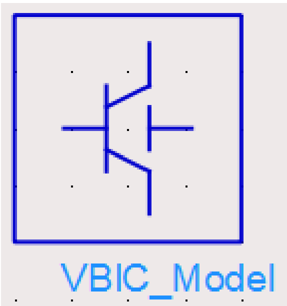
Name	Description	Units
dIrbp_dVbci	(dIrbp/dVbci)	siemens
Grci	Collector conductance grci	siemens
dIrci_dVbci	(dIrci/dVbci)	siemens
dQbe_dVbci	(dQbe/dVbci)	farads
dQbep_dVbci	(dQbep/dVbci)	farads
dQbcx_dVbci	(dQbcx/dVbci)	farads
dQbcx_dVrci	(dQbcx/dVrci)	farads
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

- This device has no default artwork associated with it.

VBIC Model (VBIC Model)

VBIC_Model (VBIC Model)

Symbol



The VBIC vertical BJT model was developed specifically as a replacement for the SPICE Gummel-Poon model by representatives of the IC and CAD industries.   VBIC includes improved modeling of the Early effect (output conductance), substrate current, quasi-saturation, and behavior over temperature-information necessary for accurate modeling of current state-of-the-art devices. However, it has additionally been defined so that, with default parameters, the model will simplify to be as similar as possible to the Gummel-Poon model.
Advantages of VBIC over the Gummel-Poon model include:

- An Early effect model based on the junction depletion charges
- A modified Kull model for quasi-saturation valid into the Kirk regime (the high-injection effect at the collector)
- Inclusion of the parasitic substrate transistor
- An improved single-piece junction capacitance model for all 3 junction capacitances
- Improved static temperature scaling
- First-order modeling of distributed base and emitter AC and DC crowding
- Overall improved high-level diffusion capacitance modeling (including quasi-saturation charge)
- Inclusion of parasitic overlap capacitances; inclusion of the onset of weak avalanche current for the base-collector junction.
- High-order continuity (infinite) in equations. A noise model similar to that of the Gummel-Poon model, with shot, thermal, and 1/f components

Parameters

Name	Definition	Units	Default
NPN	N-channel model type: yes, no	None	yes
PNP	P-channel model type: yes, no	None	no

Name	Definition	Units	Default
Tnom	nominal ambient temperature	°C	25
Trise	temperature rise above ambient	°C	0
Rcx [†, ††]	extrinsic collector resistance	Ohm	0.0
Rci [†, ††]	intrinsic collector resistance	Ohm	0.0
Vo [†]	epi drift saturation voltage	V	0.0
Gamm [†]	epi doping parameter	None	0.0
Hrcf	high-current RC factor	None	1.0
Rbx [†, ††]	extrinsic base resistance	Ohm	0.0
Rbi [†, ††]	intrinsic base resistance	Ohm	0.0
Re [†, ††]	emitter resistance	Ohm	0.0
Rs [†, ††]	substrate resistance	Ohm	0.0
Rbp [†, ††]	parasitic base resistance	Ohm	0.0
Is [†, †††]	transport saturation current	A	1.0e-16
Nf [†]	forward emission coefficient	None	1.0
Nr [†]	reverse emission coefficient	None	1.0
Fc	forward bias junction capacitance threshold	None	0.9
Cbeo [†††]	base-emitter small signal capacitance	F	0.0
Cje [†, †††]	base-emitter zero-bias junction capacitance	F	0.0
Pe [†]	base-emitter grading coefficient	None	0.75
Me	base-emitter junction exponent	None	0.33
Aje	base-emitter capacitance smoothing factor	None	-0.5
Cbco [†††]	base-collector small signal capacitance	F	0.0

Name	Definition	Units	Default
Cjc †, †††	base-collector zero-bias junction capacitance	F	0.0
Qco †††	collector charge at zero bias	C	0.0
Cjep †, †††	base-emitter zero-bias extrinsic capacitance	F	0.0
Pc †	base-collector grading coefficient	None	0.75
Mc	base-collector junction exponent	None	0.33
Ajc	base-collector capacitance smoothing factor	None	-0.5
Cjcp †, †††	base-collector zero-bias extrinsic capacitance	F	0.0
Ps †	collector-substrate grading coefficient	None	0.75
Ms	collector-substrate junction exponent	None	0.33
Ajs	collector-substrate capacitance smoothing factor	None	-0.5
Ibei †, †††	ideal base-emitter saturation current		1.0e-18
Wbe	portion of Ibei from Vbei, 1-Wbe from Vbex	None	1.0
Nei	ideal base-emitter emission coefficient	None	1.0
Iben †, †††	non-ideal base-emitter saturation current		0.0
Nen	non-ideal base-emitter emission coefficient	None	2.0
Ibci †, †††	ideal base-collector saturation current		1.0e-16
Nci	ideal base-collector emission coefficient	None	1.0
Ibcn †, †††	non-ideal base-collector saturation current		0.0
Ncn	non-ideal base-collector emission coefficient	None	2.0
Isp †, †††	parasitic transport saturation current		0.0
Wsp	portion of Iccp from Vbep, 1-Wsp from Vbci	None	1.0
Nfp	parasitic forward emission coefficient	None	1.0
Ibeip †, †††	ideal parasitic base-emitter saturation current		0.0

Name	Definition	Units	Default
Ibenp †, †††	non-ideal parasitic base-emitter saturation current		0.0
Ibcip †, †††	ideal parasitic base-collector saturation current		0.0
Ncip	ideal parasitic base-collector emission coefficient	None	1.0
Ibcnp †, †††	non-ideal parasitic base-collector saturation current		0.0
Avc1	base-collector weak avalanche parameter 1	None	0.0
Avc2 †	base-collector weak avalanche parameter 2	None	0.0
Ncnp	non-ideal parasitic base-collector emission coefficient	None	2.0
Vef	forward Early voltage (0=infinity)	V	infinity
Ver	reverse Early voltage (0=infinity)	V	infinity
Ikf †††	forward knee current (0=infinity)	A	infinity
Ikr †††	reverse knee current	A	0.0
Ikp †††	parasitic knee current	A	0.0
Tf	forward transit time		0.0
Qtf	variation of Tf with base-width modulation	None	0.0
Xtf	coefficient of Tf bias dependence	None	0.0
Vtf	coefficient of Tf dependence on Vbc	None	0.0
Itf	coefficient of Tf dependence on Icc	None	0.0
Tr	ideal reverse transit time		0.0
Td	forward excess-phase delay time		0.0
Kfn	flicker noise coefficient	None	0.0
Afn	flicker noise exponent	None	1.0
Bfn	flicker noise frequency exponent	None	1.0
Xre	temperature exponent of emitter resistance	None	0.0
Xrb	temperature exponent of base resistance	None	0.0

Name	Definition	Units	Default
Xrc	temperature exponent of collector resistance	None	0.0
Xrs	temperature exponent of substrate resistance	None	0.0
Xvo	temperature exponent of Vo	None	0.0
Ea	activation energy for Is	eV	1.12
Eaie	activation energy for Ibei	eV	1.12
Eaic	activation energy for Ibci/Ibeip	eV	1.12
Eais	activation energy for Ibcip	eV	1.12
Eane	activation energy for Iben	eV	1.12
Eanc	activation energy for Ibcn/Ibenp	eV	1.12
Eans	activation energy for Ibcnp	eV	1.12
Xis	temperature exponent of Is	None	3.0
Xii	temperature exponent of Ibei/Ibci/Ibeip/Ibcip	None	3.0
Xin	temperature exponent of Iben/Ibcn/Ibenp/Ibcnp	None	3.0
Tnf	temperature coefficient of Nf	None	0.0
Tavc	temperature coefficient of Avc	None	0.0
Rth [††]	thermal resistance	Ohm	0.0
Cth [†††]	thermal capacitance	F	0.0
Imax	explosion current	A	1.0
Imelt	explosion current, similar to Imax; defaults to Imax (refer to note 4).	A	defaults to Imax
Selft	flag denoting self-heating: yes, no; (refer to note 5).	None	None
Dtmax	maximum expected device temperature	°C	500
wVsubfwd (Vsubfwd)	substrate junction forward bias (warning)	V	None
wBvsub (Bvsub)	substrate junction reverse breakdown voltage (warning)	V	None
wBvbe (Bvbe)	base-emitter reverse breakdown voltage (warning)	V	None

Name	Definition	Units	Default
wBvbc (Bvbc)	base-collector reverse breakdown voltage (warning)	V	None
wVbcfwd (Vbcfwd)	base-collector forward bias (warning)	V	None
wIbmax	maximum base current (warning)	A	None
wIcmax	maximum collector current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
AllParams	name of DataAccessComponent for file-based model parameter values	None	None
† This parameter value varies with temperature based on model Tnom and device Temp. †† This parameter value scales inversely with the device parameter Scale. ††† This parameter value scales directly with the device parameter Scale			

- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- If the Selft parameter is not set, the value of Rth will determine whether self-heating is taken into account or not, as in previous versions (Rth>0 implies self-heating is on). If Selft is set, then it will take priority in determining whether self-heating is on or off.

  NOTE When inserting a new component, the Selft default value is blank.

- Rth and Cth Parameters
  The Rth parameter's units is shown as Ohms. Strictly speaking it should be power/temp, such as W/degK. The units of Ohms is acceptable given the following explanation.
  In terms of an electrical analogue of the thermal equations it is acceptable to use the electrical units for the thermal circuit.
  The thermal circuit (electrical model) consists of a current source, a resistance and a capacitance (all in parallel), and using electrical units is a convenience. The relation to the actual units comes from the way that electrical model is constructed.
  The reality is that the value of the *current* source is the power dissipated in the device and the node *voltage* represents the temperature (rise). The *current* in Rth thus represents power and therefore the true unit of Rth (in thermal equations) is degK/W (or degC/W). Similarly, the true unit of the Cth *capacitance* is J/degC (or J/degK), and not F.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to DataAccessComponent). Note that model parameters that are explicitly specified take precedence over those via AllParams.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelname VBIC [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by transistor components to refer to the model. The third parameter indicates the type of model; for this model it is *VBIC* . Use either parameter NPN=yes or PNP=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example

```
model  Npn2 VBIC \
  NPN=yes Gamm=8e-10  Cje=1e-13
```

Additional Information

- More information about this model is available at: http://www.designers-guide.org/VBIC/references.html

References

- C. McAndrew, AT&T/Motorola; J. Seitchik, Texas Instruments; D. Bowers, Analog Devices; M. Dunn, Hewlett-Packard; M. Foisy, Motorola; I. Getreu, Analogy; M. McSwain, MetaSoftware; S. Moinian, AT&T Bell Laboratories; J. Parker, National Semiconductor; P. van Wijnen, Intel/Philips; L. Wagner, IBM, *VBIC95: An Improved Vertical, IC Bipolar Transistor Model*.
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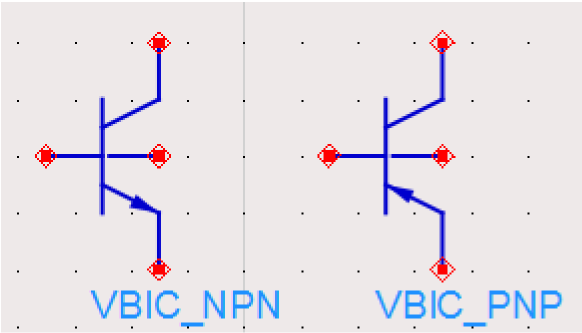
- McAndrew and Nagel. "Spice Early Model," *IEEE 1994 BCTM*.
- J. Berkner, SMI System Microelectronic Innovation GmbH, Frankfurt/Oder, Germany. *A Survey of DC Methods for Determining the Series Resistance of Bipolar Transistors Including the New Delta ISub Method*.

VBIC NPN, VBIC PNP (VBIC Nonlinear Bipolar Transistors, NPN, PNP)

VBIC_NPN, VBIC_PNP (VBIC Nonlinear Bipolar Transistors, NPN, PNP)

Symbol



Parameters

Name	Description	Units	Default
Model	name of a VBIC_Model	None	VBICM1
Scale	scaling factor	None	1.0
Region	dc operating region: 0=off, 1=on, 2=rev, 3=sat	None	on
Temp	device operating temperature	°C	25
Trise	temperature rise above ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (refer to note 2)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

- The Temp parameter specifies the physical (operating) temperature of the device. If this is different than the temperature at which the model parameters are valid or extracted (specified by the Tnom parameter of the associated VBIC_Model) certain model parameters are scaled such that the device is simulated at its operating temperature.

- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The VBIC implements self-heating. As the transistor dissipates power, it causes its temperature to rise above ambient. The model parameters Rth, Cth, and Selft control this: ΔT = Pdiss x Rth. (Refer to VBIC_Model note 5.) When self-heating is enabled, it may be necessary to increase the maximum number of iterations due to the additional unknown (temperature rise) that must be solved for. Simulation using self-heating may take 50 to 100% more time than the same simulation without self-heating.
  Self-heating can be used with either an internal or external thermal node.
  - VBIC_NPN and VBIC_PNP use an internal node to keep track of the temperature rise of the transistor.
  - VBIC5_NPN and VBIC5_PNP make this thermal node externally available as the fifth terminal. This node can then be used for additional thermal modeling.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Ic	Collector current	amperes
Ib	Base current	amperes
Ie	Emitter current	amperes
Is	Substrate current	amperes
Power	DC power dissipated	watts
Gbe	Transconductance gbe	siemens
Cbe	Base-emitter capacitance cbe	farads
Gbc	Transconductance gbc	siemens
Cbc	Base-collector capacitance cbc	farads
Gbex	Transconductance gbex	siemens

Name	Description	Units
Cbex	Base-emitter capacitance cbex	farads
Gbep	Transconductance gbep	siemens
Cbep	Base-emitter capacitance cbep	farads
Gbcp	Transconductance gbcp	siemens
Cbcp	Base-collector capacitance cbcp	farads
dIcc_dVbei	(dIcc/dVbei)	siemens
dIcc_dVbci	(dIcc/dVbci)	siemens
dIccp_dVbep	(dIccp/dVbep)	siemens
dIccp_dVbcp	(dIccp/dVbcp)	siemens
dIccp_dVbci	(dIccp/dVbci)	siemens
dIbc_dVbei	(dIbc/dVbei)	siemens
Grbi	Base conductance grbi	siemens
dIrbi_dVbei	(dIrbi/dVbei)	siemens
dIrbi_dVbci	(dIrbi/dVbci)	siemens
Grbp	Base conductance grbp	siemens
dIrbp_dVbep	(dIrbp/dVbep)	siemens
dIrbp_dVbci	(dIrbp/dVbci)	siemens
Grci	Collector conductance grci	siemens
dIrci_dVbci	(dIrci/dVbci)	siemens

Name	Description	Units
dQbe_dVbci	(dQbe/dVbci)	farads
dQbep_dVbci	(dQbep/dVbci)	farads
dQbcx_dVbci	(dQbcx/dVbci)	farads
dQbcx_dVrci	(dQbcx/dVrci)	farads
Vbe	Base-emitter voltage	volts
Vbc	Base-collector voltage	volts
Vce	Collector-emitter voltage	volts

- This device has no default artwork associated with it.

Devices and Models, Diode

Devices and Models, Diode

Bin Model

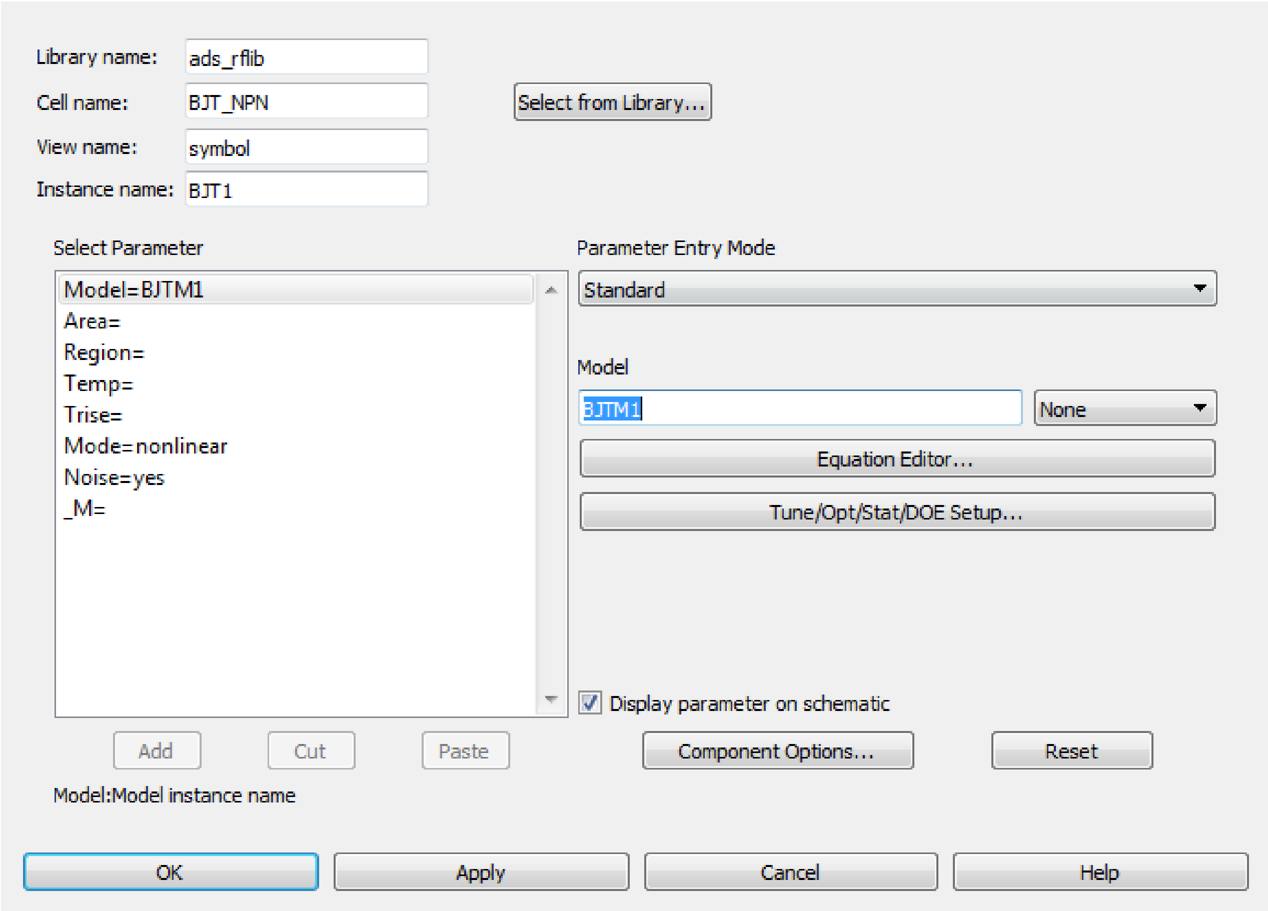
The BinModel in the Diodes library enables you to sweep a parameter (usually a geometry, such as gate length), then enable the simulator to automatically select between different model cards. This alleviates the problem that one scalable model typically does not work for all sizes of a device.

For information on the use of the binning feature, refer to BinModel (For Automatic Model Selection).

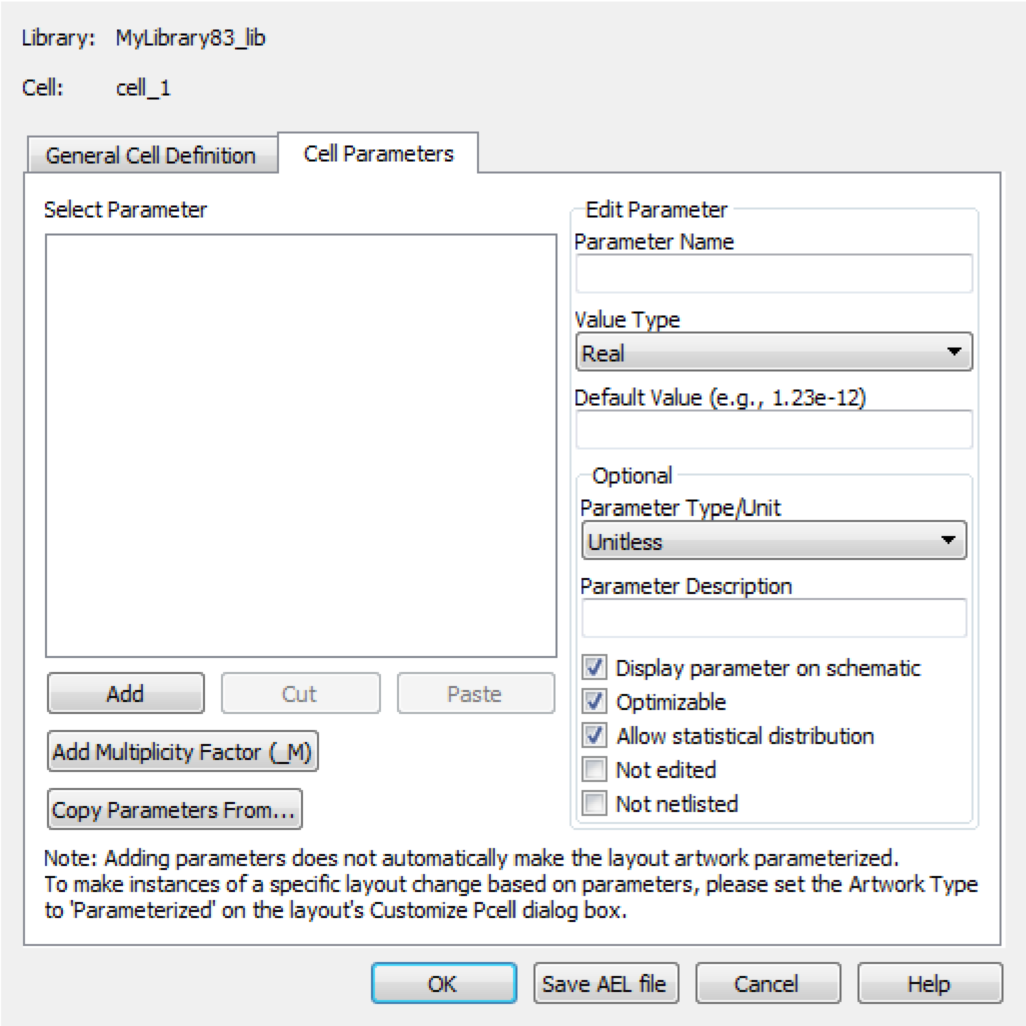
Multiplicity Parameter _M

The multiplicity feature provides a way to scale components or entire sub-circuits containing many components and sub-circuits. Given a component with a multiplicity value *M* , the simulator treats this component as if there were *M* such components all connected in parallel. Sub-circuits within sub-circuits will be appropriately scaled.

The _M parameter is available at the component level as shown here. (For components that do not explicitly have a Multiplicity parameter, the same functionality can be achieved by placing the component in a sub-circuit and using the sub-circuit's Multiplicity parameter, as described next.)



For sub-circuits, the parameter is enabled by selecting **File** > **Design Parameters** from the Schematic window. In the dialog box, select the **Parameters** tab. To add the Multiplicity parameter, click **Add Multiplicity Factor_M**.



Netlist Syntax

Models for the ADS circuit simulator have the following syntax:

> *model modelname modeltype [param=value]**

where `model` is a keyword, `modelname` is the user-defined name for the model and `modeltype` is one of the predefined model types (e.g., Diode, BJT, MOSFET). After these three required fields comes zero or more `param=value` pairs. `param` is a model keyword and value is its user-assigned value. There is no required order for the `param=value` pairs. Model keywords that are not specified take on their default values. Refer to documentation for each model type to see the list of model parameters, their meanings and default values.

The model statement must be on a single line. Use the backslash "\" as a line continuation character. Instance and model parameter names are case sensitive; most (not all) model parameters have their first character capitalized and the rest are lower case. Scale factors (e.g.,

$p=10^{-12}$, $n=10^{-9}$, $u=10^{-6}$, $m=10^{-3}$, $k=10^{+3}$, $M=10^{+6}$) can be used with numbers for numeric values. For more information about the circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

A netlist translator is available for translating models and subcircuits from Pspice, Hspice, and Spectre syntax to the form used by the ADS Circuit Simulator. Refer to Netlist Translator for SPICE for more information.

Parameter Aliases

For compatibility with other simulators, some models accept two or more different keywords for the same parameter. For example, the Diode model accepts both model keywords Is and Js for the saturation current. In the documentation, the parameter Name column lists the aliases in parentheses after the main parameter name. The main parameter name is the one that appears in the ADS dialog box for the model.

Tnom

All nonlinear device models have a parameter that specifies the temperature at which the model parameters were extracted. Normally called Tnom, some models may use Tref, Tr, or Tmeas. The default value for Tnom is specified on the Options item in the Tnom field. If Options.Tnom is not specified it defaults to 25 °C. This is true for all nonlinear devices.

It is strongly suggested that the user explicitly set Tnom in each model and not depend on its default value. First, this provides a self-documenting model; other users of the device will not have to guess at what Tnom should be. Second, different users of the same model would get different results for the same circuit if they simulate with different values of Options.Tnom.

Temp and Trise

Advanced Design System enables you to directly specify the temperature of each individual device instance. This is done with the device instance parameter Temp which is the device temperature in degrees Celsius. If it is not specified, it defaults to the ambient temperature set with Options.Temp, which defaults to 25 °C.

For compatibility with other simulators, many of the nonlinear devices enable you to specify Trise for each device instance, which specifies actual device temperature as an increase from ambient. It defaults to zero. The Trise instance value is used only if the Temp instance value is not specified. If you do not specify Trise on the instance, a default value for Trise can also be specified in the model. It defaults to zero. The following shows the logic of how the instance temperature is calculated if it is not explicitly specified.

```
if Instance.Temp is not specified
if instance.Trise is not specified
Instance.Temp = Options.Temp + Model.Trise
else
Instance.Temp = Options.Temp + Instance.Trise
```

ADSDiode (ADS Root Diode)

ADSDiode (ADS_Root Diode)

Symbol

Range of Usage

Area > 0

Parameters

Name	Description	Units	Default
Model	model instance name	None	ADSDIODEM1
Area	junction		1.0
_M	number of devices in parallel	None	1

DC Operating Point Parameters

- Following table lists the DC operating point parameters that can be sent to the dataset.

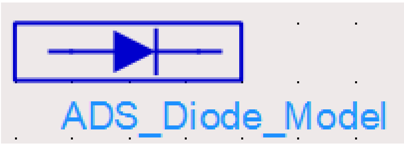
Name	Description	Units
Id	Diode current	amperes
Power	DC power dissipated	watts
Rd	Series resistance	ohms

Name	Description	Units
Cd	Junction capacitance	farads
Vd	Anode-cathode voltage	volts

ADS Diode Model (ADS Root Diode Model)

ADS_Diode_Model (ADS_Root Diode Model)

Symbol



Parameters

Name	Description	Units	Default
File	name of rawfile	None	None
Rs	series resistance		fixed at 0
Ls	parasitic inductance		fixed at 0
Tt	transit time	sec	0.0
All Params	Data Access Component (DAC) Based Parameters	None	None

- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those via AllParams.
- Because this model is measurement-based, extrapolation warning messages may occur if the Newton iteration exceeds the measurement range. If these messages occur frequently, check that the measurement data is within the simulation range.

Additional Information

References

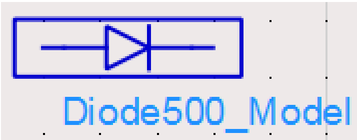
- D. Root, "Technology independent large signal non quasi static FET model by direct construction from automatically characterized device data," in *21st EuMC* , 1991, p. 927.

- D. E. Root, S. Fan, and J. Meyer, "Technology-independent large-signal FET models: A measurement-based approach to active device modeling," in *Proc. th ARMMS Conf., Bath, U.K.* , Sept. 1991, pp. 1-21.
- D. E. Root, M. Pirola, S. Fan, W. J. Anklam, and A. Cognata, "Measurement-based large-signal diode modeling system for circuit and device design," *IEEE Trans. Microwave Theory Tech.* , vol. 41, pp. 2211-2217, Dec. 1993.
- D. E. Root and B. Hughes, "Principles of nonlinear active device modeling for circuit simulation," in *32nd ARFTG Conf. Dig* ., Tempe, AZ, 1988, pp. 3-26.
- D. E. Root, S. Fan, and J. Meyer, "Technology-independent large-signal non quasi static FET models by direct extraction from automatically characterized device data," in *21st European Microwave Conf. Proc.* , Stuttgart, Germany, 1991, pp. 927-932.
- D. E. Root and S. Fan, "Experimental evaluation of large-signal modeling assumptions based on vector analysis of bias-dependent S-parameters data from MESFET's and HEMT's," in *IEEE MTT-S Int. Microwave Symp. Tech. Dig.* , 1992, pp. 927-932.

dio500 (Diode Level 500)

dio500 (Diode Level 500)

Symbol



Description

The *dio500* model provides a detailed description of the diode currents in forward and reverse biased Si-diodes. Please see the following NXP pdf file for detailed documention: http://www.nxp.com/files-static/nxp/other_type/d500.pdf

Parameters

Instance Parameters

Name	Description	Default
area	Multiplication factor	1.0
mult	Alias of area factor	
m	Multiplicity factor	1.0
Mode	Simulation mode: nonlinear or linear	Nonlinear
Noise	Noise generation option: yes, no	yes

Model Parameters

Name	Description	Units	Default
is	Saturation current	A	7.13e-13
n	Junction emission coefficient		1.044
vlc	Voltage dependence at low forward currents	V	0.0
vbr	Breakdown voltage	V	7.459
emvbr	Electric field at breakdown	V/cm	1.36e+06
csrh	Shockley-Read-Hall generation	A/cm	7.44e-07
cbbt	Band to band tunneling	A/V	3.255
ctat	Trap assisted tunneling	A/cm	3.31e-06
rs	Series resistance	Ohm	0.0
tau	Transit time	s	500.0e-12
cj	Zero-bias depletion capacitance	F	7.0e-12
vd	Diffusion voltage	V	0.9
p	Grading coefficient		0.4
tref	Reference temperature. Default set by option *tnom*.	C	
tnom	Alias of *tref*	C	
tr	Alias of *tref*	C	
vg	Bandgap voltage	V	1.206
ptrs	Power for temperature dependence of *rs*		0.0
kf	Flickernoise coefficient		0.0

Name	Description	Units	Default
af	Flickernoise exponent		1.0
dta	Difference between device temperature and ambient temperature	K	0.0
trise	Alias of *dta*	K	
imax	Explosion current	A	1.0

- In extension to the modelbook description a minimum conductance *gmin* is inserted between the diode nodes to aid convergence. The value of *gmin* is set by an options statement, default is gmin = 1.0e-12 S . The *imax* parameter is used to aid convergence and to prevent numerical overflow. The junction characteristics of the diode are accurately modeled for currents up to *imax*. For currents above *imax*, the junction is modeled as a linear resistor.
- Sample Instance Statement:

  > *modelName: D1 1 2 area = 2*

  Sample Model Statement:

  > *model phdiode dio500 is = model modelName dio500 is =3.5e-12 rs=26.3 n=2.7 imax=1e20 vlc=1.8 vbr=9.63 cj=2.65e-11 dta=12.88 tau=7.5e-10 tnom=25*
- This device is supported within altergroups.
- The following table lists the DC operating point parameters that can be sent to the dataset.

Name	Description	Units
vak	Diode voltage, measured from anode to cathode (including rs)	V
id	Total resistive diode current	A
qd	Diffusion charge	Coul
qt	Depletion charge	Coul
rst	Series resistance (temperature updated)	Ohm
rl	AC linearized resistance	Ohm
cl	AC linearized capacitance	F
pwr	Power dissipation	W

Diode_CMC 2.0

Diode_CMC 2.0

The diode_cmc was developed and released by the Compact Model Coalition. It is based on the NXP JUNCAP2 model, which models the behavior of the diodes that are formed by the source, drain, or well-to-bulk junctions in MOSFETs, with the addition of a reverse current recovery model.

A complete description of the model equations and parameters can be found on the Si2 website.

Parameters

Instance Parameters

Name	Description	Units	Default
AB	Junction area	m^2	1.00E-12
LS	STI-edge part of junction perimeter	m	1.00E-06
LG	Gate-edge part of junction perimeter	m	0
MULT	Number of devices in parallel		1

Model Parameters

Name	Description	Units	Default
LEVEL	Model level must be 2002		2002
VERSION	Model version		2
SUBVERSION	Model subversion		0
REVISION	Model revision		0
TYPE	Type parameter, in output value 1 reflects n-type, -1 reflects p-type		1
DTA	Temperature offset with respect to ambient temperature	C	0
IMAX	Maximum current up to which forward current behaves exponentially	A	1000

Name	Description	Units	Default
TRJ	Reference temperature	C	21
CJORBOT	Zero-bias capacitance per unit-of-area of bottom component	Fm^-2	1.00E-03
CJORSTI	Zero-bias capacitance per unit-of-length of STI-edge component	Fm^-1	1.00E-09
CJORGAT	Zero-bias capacitance per unit-of-length of gate-edge component	Fm^-1	1.00E-09
VBIRBOT	Built-in voltage at the reference temperature of bottom component	V	1
VBIRSTI	Built-in voltage at the reference temperature of STI-edge component	V	1
VBIRGAT	Built-in voltage at the reference temperature of gate-edge component	V	1
PBOT	Grading coefficient of bottom component		0.5
PSTI	Grading coefficient of STI-edge component		0.5
PGAT	Grading coefficient of gate-edge component		0.5
PHIGBOT	Zero-temperature bandgap voltage of bottom component	V	1.16
PHIGSTI	Zero-temperature bandgap voltage of STI-edge component	V	1.16
PHIGGAT	Zero-temperature bandgap voltage of gate-edge component	V	1.16
IDSATRBOT	Saturation current density at the reference temperature of bottom component	Am^-2	1.00E-12
IDSATRSTI	Saturation current density at the reference temperature of STI-edge component	Am^-1	1.00E-18
IDSATRGAT	Saturation current density at the reference temperature of gate-edge component	Am^-1	1.00E-18
CSRHBOT	Shockley-Read-Hall prefactor of bottom component	Am^-3	1.00E+02
CSRHSTI	Shockley-Read-Hall prefactor of STI-edge component	Am^-2	1.00E-04
CSRHGAT	Shockley-Read-Hall prefactor of gate-edge component	Am^-2	1.00E-04
XJUNSTI	Junction depth of STI-edge component	m	1.00E-07
XJUNGAT	Junction depth of gate-edge component	m	1.00E-07
CTATBOT	Trap-assisted tunneling prefactor of bottom component	Am^-3	1.00E+02

Name	Description	Units	Default
CTATSTI	Trap-assisted tunneling prefactor of STI-edge component	Am^-2	1.00E-04
CTATGAT	Trap-assisted tunneling prefactor of gate-edge component	Am^-2	1.00E-04
MEFFTATBOT	Effective mass (in units of m0) for trap-assisted tunneling of bottom component		0.25
MEFFTATSTI	Effective mass (in units of m0) for trap-assisted tunneling of STI-edge component		0.25
MEFFTATGAT	Effective mass (in units of m0) for trap-assisted tunneling of gate-edge component		0.25
CBBTBOT	Band-to-band tunneling prefactor of bottom component	AV^-3m	1.00E-12
CBBTSTI	Band-to-band tunneling prefactor of STI-edge component	AV^-3m	1.00E-18
CBBTGAT	Band-to-band tunneling prefactor of gate-edge component	AV^-3m	1.00E-18
FBBTRBOT	Normalization field at the reference temperature for band-to-band tunneling of bottom component	Vm^-1	1.00E+09
FBBTRSTI	Normalization field at the reference temperature for band-to-band tunneling of STI-edge component	Vm^-1	1.00E+09
FBBTRGAT	Normalization field at the reference temperature for band-to-band tunneling of gate-edge component	Vm^-1	1.00E+09
STFBBTBOT	Temperature scaling parameter for band-to-band tunneling of bottom component	K^-1	-1.00E-03
STFBBTSTI	Temperature scaling parameter for band-to-band tunneling of STI-edge component	K^-1	-1.00E-03
STFBBTGAT	Temperature scaling parameter for band-to-band tunneling of gate-edge component	K^-1	-1.00E-03
VBRBOT	Breakdown voltage of bottom component	V	10
VBRSTI	Breakdown voltage of STI-edge component	V	10
VBRGAT	Breakdown voltage of gate-edge component	V	10
PBRBOT	Breakdown onset tuning parameter of bottom component	V	4
PBRSTI	Breakdown onset tuning parameter of STI-edge component	V	4
PBRGAT	Breakdown onset tuning parameter of gate-edge component	V	4
FREV	Additional parameter for current after breakdown		1.00E+03

Name	Description	Units	Default
RSBOT	Series resistance per unit-of-area of bottom component	VA^-1m^2	0
RSSTI	Series resistance per unit-of-length of STI-edge component	VA^-1m	0
RSGAT	Series resistance per unit-of-length of gate-edge component	VA^-1m	0
RSCOM	Common series resistance, no scaling	ohm	0
STRS	Temperature scaling parameter for series resistance		0
KF	KF parameter for flicker noise		0
AF	AF parameter for flicker noise		1
TT	Transit time	s	0
STVBRBOT1	Temp. co of breakdown voltage bottom component	1/K	0
STVBRBOT2	Temp. co of breakdown voltage bottom component	1/K^2	0
STVBRSTI1	Temp. co of breakdown voltage STI-edge component	1/K	0
STVBRSTI2	Temp. co of breakdown voltage STI-edge component	1/K^2	0
STVBRGAT1	Temp. co of breakdown voltage gate-edge component	1/K	0
STVBRGAT2	Temp. co of breakdown voltage gate-edge component	1/K^2	0
NFABOT	ideality factor bottom component		1
NFASTI	ideality factor STI-edge component		1
NFAGAT	ideality factor gate-edge component		1
ABMIN	minimum allowed junction area	m^2	0
ABMAX	maximum allowed junction area	m^2	1
LSMIN	minimum allowed junction STI-edge	m	0
LSMAX	maximum allowed junction STI-edge	m	1
LGMIN	minimum allowed junction gate-edge	m	0
LGMAX	maximum allowed junction gate-edge	m	1
TEMPMIN	minimum allowed junction temp	C	-55

Name	Description	Units	Default
TEMPMAX	maximum allowed junction temp	C	155
VFMAX	maximum allowed forward junction bias	V	0
VRMAX	maximum allowed reverse junction bias	V	0
XTI	Temp. co of saturation current		3
SCALE	Scale parameter		1
SHRINK	Scale parameter		0
SWJUNEXP	Flag for JUNCAP-express; 0=full model, 1=express model		0
VJUNREF	Typical maximum junction voltage; usually about 2*VSUP		2.5
FJUNQ	Fraction below which junction capacitance components are considered negligible		0.03
CORECOVERY	Flag for recovery equations; 0=original, 1=Hiroshima		0
NJH	High-injection emission coefficient		1
NJDV	Transition slope of emission coefficient	1/V	0.1
NDIBOT	Doping concentration of drift region	cm^-3	1.00E+16
NDIGAT	Doping concentration of drift region	cm^-3	1.00E+16
NDISTI	Doping concentration of drift region	cm^-3	1.00E+16
INJ1	For carrier density		1
INJ2	For carrier density in high-injection condition		10
NQS	Carrier delay time	sec	5.00E-09
TAU	Carrier lifetime	sec	2.00E-07
WI	Length of drift region	m	5.00E-06
DEPNQS	Depletion delay time	sec	0
TNOM	Alias reference temperature	C	21
TAUT	Temp. co of carrier lifetime		0
INJT	Temp. co of carrier density in high-injection condition		0

Usage

- With model card:

> *<modelname>: <instanceName> <node1> <node2> <instanceParameters>*
>
> *model <modelName> diode_cmc <modelParameters>*

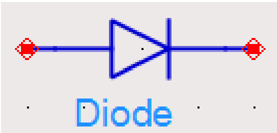
- Without model card:

> *diode_cmc:<instanceName> <node1> <node2> <instanceParameters?*

Diode (PN-Junction Diode)

Diode (PN-Junction Diode)

Symbol



Range of Usage

Area > 0
Periph ≥ 0
Scale > 0

Parameters

Name	Description	Units	Default
Model	Model instance name	None	DIODEM1
Area	Scaling Factor	None	1.0
Periph (Perim)	Scaling Factor that affects the sidewall	None	0
Width (W) †	Geometric width of diode junction	meter	0
Length (L) †	Geometric length of diode junction	meter	0
Scale	Scaling Factor that scales Area, Periph, Width and Length	None	1.0
Region	DC operating region, 0=off, 1=on (gives the DC simulator a good initial guess to enhance its convergence properties)	None	on
Temp	Device operating temperature	°C	25
Trise	Temperature rise over ambient	°C	0
Mode	Simulation mode: Nonlinear, Linear, Standard (refer to Note 3)	None	Nonlinear
Noise	Noise generation option; yes=1, no=0	None	yes
_M	Number of devices in parallel	None	1

† Each instance parameter whose dimension contains a power of meter will be multiplied by the Scale to the same power. For example, a parameter with a dimension of *m* will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. Note that only parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains *cm* instead of meter is not scaled.

- The size of the diode may be specified geometrically using the Width and Length parameters if the Area and Periph parameters are not explicitly specified. Default values for the width and length are taken from the width and length specified in the model if they are not specified in the instance. The model parameters Shrink and Dwl are also used. Exact area and periphery calculations are described in the model Notes section. The area must be greater than 0. The periphery can be 0, in which case the sidewall components are not simulated.
- The Temp parameter specifies the physical (operating) temperature of the device. If this is different than the temperature at which the model parameters are valid or extracted (specified by the Tnom parameter of the associated Diode_Model), certain model parameters are scaled such that the device is simulated at its operating temperature (refer to Diode_Model (PN-Junction Diode Model) to see which parameter values are scaled).
- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The table below lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Parameters

Name	Description	Units
Id	Diode current	amperes
Power	DC power dissipated	watts
Rd	Junction series resistance	ohms
Rdsw	Sidewall series resistance	ohms
Cd	Junction capacitance	farads
Cdsw	Sidewall capacitance	farads
Vd	Anode-cathode voltage	volts

- This device has no default artwork associated with it.

Additional Information

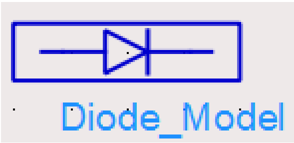
References

- *SPICE2: A Computer Program to Simulate Semiconductor Circuits*, University of California, Berkeley.
- P. Antognetti and G. Massobrio. S *emiconductor Device Modeling with SPICE*, Second Edition, McGraw-Hill, Inc., 1993.

Diode Model (PN-Junction Diode Model)

Diode_Model (PN-Junction Diode Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
Level	Model level selector (1=standard, 3=Hspice geometry 11=Spectre)	None	1
Is (Js) †, ††	Saturation Current, A (with N, determines diode DC characteristics)	A	1.0e-14
Rs †††	Ohmic Resistance	Ohm	fixed at 0
Gleak †	Bottom junction leakage conductance	S	0
N	Emission Coefficient (with Is, determines diode DC characteristics)	None	1.0
Tt	Transit Time	sec	0.0
Cd †	Linear capacitance	F	0.0
Cjo †, ††	Zero-bias Junction capacitance	F	0.0
Vj (Pb) ††	Junction Potential	V	1.0
M	Grading Coefficient	None	fixed at 0.5
Fc	Forward-bias Depletion Capacitance Coefficient	None	0.5
Imax	Explosion current beyond which diode junction current is linearized	A	1.0
Imelt	Explosion current (similar to Imax; refer to Note 4); defaults to Imax	A	defaults to Imax

Isr †, ††	Recombination current	A	0.0
Nr	Emission coefficient for Isr	None	2.0
Ikf (Ik) †	High-injection knee current	A	infinity
Ikr †	Reverse high injection knee current	A	0
IkModel	Model to use for Ikf/Ikr: 1=ADS/Libra/Pspice, 2=Hspice/Spectre	None	1
Bv	Reverse breakdown voltage	V	infinity ‡
Ibv †	Current at reverse breakdown voltage	A	0.001
Nbv (Nz)	Reverse breakdown ideality factor	None	1.0
Ibvl †	Low-level reverse breakdown knee current	A	0.0
Nbvl	Low-level reverse breakdown ideality factor	None	1.0
Kf	Flicker noise coefficient	None	0.0
Af	Flicker noise exponent	None	1.0
Ffe	Flicker noise frequency exponent	None	1.0
Jsw (Isw) †† ‡‡	Sidewall saturation current	None	0.0
Rsw ‡‡‡	Sidewall series resistance	Ohm	0.0
Gleaksw ‡‡	Sidewall junction leakage conductance	S	0.0
Ns	Sidewall emission coefficient	None	if (Level=11) Ns=1, else Ns=N
Ikp ‡‡	high-injection knee current for sidewall; defaults to Ikf	A	Ikf
Cjsw †† ‡‡	Sidewall zero-bias capacitance	None	0.0
Msw (Mjsw)	Sidewall grating coefficient	None	0.33
Vjsw (Pbsw) ††	Sidewall junction potential; defaults to Vj	None	1: when level=11; defaults to Vj
Fcsw	Sidewall forward-bias depletion capacitance coefficient	None	0.5; Fc: when level=11
Area	Default area for diode	None	1
Periph (Perim)	Default periphery for diode	None	0
Width	Default width for diode	meter	0
Length	Default length for diode	meter	0
Etch	Sidewall narrowing due to etching per side	meter	0

Etchl	Sidewall length reduction due to etching per side; defaults to Etch	meter	defaults to Etch
Dwl	Geometry width and length addition	meter	0
Shrink	Geometry shrink factor	None	1.0
AllowScaling	Allow scale option and instance scale parameter to affect geometry parameters: yes or no	None	no
Tnom	Nominal ambient temperature	^oC	25
Trise	Temperature rise over ambient	°C	0
Tlev	Temperature equation selector (0/1/2)	None	0
Tlevc	Temperature equation selector for capacitance (0/1/2/3)	None	0
Xti	Saturation-current temperature exponent (with Eg, helps define the dependence of Is on temperature)	None	3.0
Eg	Energy gap (with Xti, helps define the dependence of Is on temperature)	eV	1.11
EgAlpha (Gap1)	Energy gap temperature coefficient alpha	$eV/^oC$	7.02e-4
EgBeta (Gap2)	Energy gap temperature coefficient beta	K	1108
Tcjo (Cta)	Cjo linear temperature coefficient	$1/^oC$	0
Tcjsw (Ctp)	Cjsw linear temperature coefficient	$1/^oC$	0
Ttt1	Tt linear temperature coefficient	$1/^oC$	0
Ttt2	Tt quadratic temperature coefficient	$1/(^oC)^2$	0
Tm1	Mj linear temperature coefficient	$1/^oC$	0
Tm2	Mj quadratic temperature coefficient	$1/(^oC)^2$	0
Tvj (Pta)	Vj linear temperature coefficient	$1/^oC$	0
Tvjsw (Ptp)	Vjsw linear temperature coefficient	$1/^oC$	0
Trs	Rs linear temperature coefficient	$1/^oC$	0
Trs2	Rs quadratic temperature coefficient	$1/(^oC)^2$	0
Tgs	Gleak, Gleaksw linear temperature coefficient	$1/^oC$	0

Tgs2	Gleak, Gleaksw quadratic temperature coefficient	$1/(^oC)^2$	0
Tbv (Tbv1)	Bv linear temperature coefficient	$1/^oC$	0
Tbv2	Bv quadratic temperature coefficient	$1/(^oC)^2$	0
wBv (Bvj)	Diode reverse breakdown voltage (warning)	V	infinity ‡
wPmax	Maximum power dissipation (warning)	W	infinity ‡
AllParams	Data Access Component (DAC) Based Parameters	None	None
† Parameter value is scaled with Area specified with the Diode device. †† Value varies with temperature based on model Tnom and device Temp. ††† Parameter value is scaled with 1/Area. ‡ Value 0.0 is interpreted as infinity. ‡‡ Parameter value is scaled with the Periph specified with the Diode device. ‡‡‡ Parameter value is scaled with 1/Periph.			

- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to DataAccessComponent (Data Access Component) in Introduction to Circuit Components. Note that model parameters that are explicitly specified take precedence over those specified via AllParams.
- **Area and Periph**
  When Level is set to 1 (standard):
  Device Area will be used if specified and > 0; otherwise the model Area will be used. Device Periph will be used if specified; otherwise the model Periph will be used.
  When Level is set to 3(Hspice geometry): Device Width and Length will be used if specified; otherwise the model Width and Length will be used. If Width > 0 and Length > 0

  > *Area = w × l*
  > *Periph = 2 × (w + l)*
  > *where w = Width × Shrink + Dwl*
  > *l = Length × Shrink + Dwl*
  > *otherwise the Area and Periph specified in the device or model*
  > *(follow the same logic described when Level=1)*
  > *will be used to calculate the new area and periph.*

  Area = area (from device/model) × $Shrink^2$
  Periph = periph (from device/model) × Shrink **When Level is set to 11**(Spectre): Device Area will be used if it is specified and > 0; Otherwise if Length and Width in device or model (in this order) are specified and > 0,

  > *Area = Weff × Leff*
  > *where*
  > *Weff = Width - Etch*
  > *Leff = Length - Etchl*

  otherwise use model Area if it is specified and > 0 otherwise, Area = 1 (default) Device Periph will be used if it is specified and > 0 Otherwise, if Length and Width in device or model (in this order) are specified and > 0,

> *Periph = 2 × (Weff + Leff)*
> *where*
> *Weff = device Width - Etch*
> *Leff = device Length - Etchl*

otherwise use model Periph if it is specified and > 0
otherwise, Periph = 0 (default) If model parameter Allowscaling is set to yes, the diode geometry parameters Periph, Width, and Length are multiplied by Scale, while Area is multiplied by Scale × Scale (for Level = 11 only).

- **Imax and Imelt Parameters**
  Imax and Imelt specify the P-N junction explosion current ExplI which is used in the following equations. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value. If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) ExplI = Imelt; otherwise, if Imax is specified (in the model or in Options) ExplI = Imax; otherwise, ExplI = model Imelt default value (which is the same as the model Imax default value).
- **Currents and Conductances**
  Is and Isr in the following equations have been multiplied by the effective area factor aeff.
  If vd > vmax

> *idexp = [Imax + (vd - vmax) × gmax]*
> *gdexp = gmax*

where

$$vmax = N \times vt \times ln\left(\frac{ExplI}{Is} + 1\right) \quad gmax = \frac{ExplI + Is}{N \times vt}$$

vt is thermal voltage If vmax ≥ vd ≥ - 10 × N × vt

$$idexp = Is\left(e^{\frac{vd}{N \times vt}} - 1\right) \quad gdexp = \frac{Is}{N \times vt} \times e^{\frac{vd}{N \times vt}}$$

If vd < -10 × N × vt

$$idexp = [Is(e^{-10} - 1) + gdexp(vd + 10 \times N \times vt)]$$

$$gdexp = \frac{Is}{N \times vt} \times e^{-10}$$

Breakdown current contribution is considered if Bv is specified and Ibv is not equal to zero. If -(vd + Bv) > vbmax

> *ib= -{ExplI + [-(vd + Bv) - vbmax] × gbmax - ibo}*
> *gb = gbmax*

where

$$vbmax = Nbv \times vt \times ln\left(\frac{ExplI}{Ibv}\right) \quad gbmax = \left(\frac{ExplI}{Nbv \times vt}\right)$$

If vbmax ≥ -(vd + Bv) > -MAXEXP × Nbv × vt

$$ib = -Ibv \times e^{-\frac{vd + Bv}{Nbv \times vt}} + ibo \quad gb = \frac{-ib}{Nbv \times vt}$$

Otherwise

ib = 0

gb = 0

For ibo If Bv < MAXEXP × Nbv × vt

$$ibo = Ibv \times e^{\frac{-Bv}{Nbv \times vt}}$$

Otherwise

ibo = 0

MAXEXP is the maximum exponent supported by the machine; value range is 88 to 709.
Low level reverse breakdown current is considered if Ibvl is specified and not equal to zero. If -(vd + Bv) > vlbmax

ilb = -{ExplI + [-(vd + Bv) - vlbmax] × glbmax - ilbo}

glb = glbmax

where

$$vlbmax = Nbvl \times vt \times ln\left(\frac{ExplI}{Ibvl}\right) \quad glbmax = \left(\frac{ExplI}{Nbvl \times vt}\right)$$

If vlbmax ≥ -(vd + Bv) > - MAXEXP × bvl × vt

$$ilb = -Ibvl \times e^{\frac{-(vd + Bv)}{Nbvl \times vt}} + ilbo \quad glb = \frac{-ilb}{Nbvl \times vt}$$

Otherwise

ilb = 0

glb = 0

For ilbo
If Bv < MAXEXP × Nbvl × vt

$$ilbo = Ibvl \times e^{\frac{-Bv}{Nbvl \times vt}}$$

Otherwise

ilbo = 0

Recombination current is considered if Isr is specified and not equal to zero.
If vd > vrmax

ir = ExplI + (vd - vrmax) × grmax

| gr = grmax

$$vrmax = Nr \times vt \times \ln\left(\frac{ExplI}{Isr} + 1\right) \quad grmax = \frac{ExplI + Isr}{Nr \times vt}$$

where

If vrmax ≥ vd ≥ - 10 × Nr × vt

$$ir = Isr\left(e^{\frac{Vd}{Nr \times vt}} - 1\right) \quad gr = \frac{Isr}{Nr \times vt} \times e^{\frac{vd}{Nr \times vt}}$$

If vd < - 10 × Nr × vt

$$ir = [Isr(e^{-10} - 1) + gr(vd + 10 \times Nr \times vt)]$$

$$gr = \frac{Isr}{Nr \times vt} \times e^{-10}$$

iexp = idexp + ib + ilb
gexp = gdexp + gb + glb

There are two ways to model high-injection effect. When IkModel is set to ADS/Libra/Pspice and when

$$idh = iexp\sqrt{\frac{Ikf}{Ikf+iexp}}$$

Ikf ≠ 0 and iexp > 0.

$$gdh = gexp\,\frac{1}{2}\left(1+\frac{Ikf}{Ikf+iexp}\right)\sqrt{\frac{Ikf}{Ikf+iexp}}$$

When IkModel is set to Hspice:

If Ikf is not equal to zero and iexp > 0

$$idh = iexp\,\frac{1}{1+\sqrt{\frac{iexp}{Ikf}}}\quad gdh = gexp\left(\frac{1}{1+\sqrt{\frac{iexp}{Ikf}}}\right)\times\left(1-\frac{\sqrt{\frac{iexp}{Ikf}}}{2\left(1+\sqrt{\frac{iexp}{Ikf}}\right)}\right)$$

$$idh = iexp\frac{1}{1+\sqrt{\frac{-iexp}{Ikr}}}$$

Otherwise if Ikr is not equal to zero and iexp < 0

$$gdh = gexp\left(\frac{1}{1+\sqrt{\frac{-iexp}{Ikr}}}\right)\times\left(1-\frac{\sqrt{\frac{-iexp}{Ikr}}}{2\left(1+\sqrt{\frac{-iexp}{Ikr}}\right)}\right)$$

The total diode DC current and conductance

id = idh + ir
Id = id + Gleak × vd + Gmin × vd
gd = gdh + gr
Gd = gd + Gleak + Gmin

where Gmin is minimum junction conductance. Sidewall diode: Sidewall diode equations have been multiplied by Periph, Isw, Ibv, Ikp, Gleaksw. If vdsw > vmaxsw

idexpsw = [ExplI + (vdsw - vmaxsw) × gmaxsw]
gdexpsw = gmaxsw

$$vmaxsw = Ns\times vt\times\ln\left(\frac{ExplI}{Isw}+1\right)$$

where vdsw is sidewall diode voltage

$$gmaxsw = \frac{ExplI+Isw}{Ns\times vt}$$

$$idexpsw = Isw\left(e^{\frac{vdsw}{Ns\times vt}}-1\right)$$

vt is thermal voltage If vmaxsw ≥ vdsw ≥ - 10 × Ns × vt

$$gdexswp = \frac{Isw}{Ns \times vt} \times e^{\frac{vdsw}{Ns \times vt}}$$

If vdsw < -10 × Ns × vt

$$idexpsw = [Isw(e^{-10} - 1) + gdexpsw(vdsw + 10 \times Ns \times vt)]$$

$$gdexpsw = \frac{Isw}{Ns \times vt} \times e^{-10}$$

Breakdown current contribution is considered if Bv is specified and Ibv ≠ 0 and Level ≠ 11. If -(vdsw + Bv) > vbmaxsw

> *ibsw = -{ExplI + [-(vdsw + Bv) - vbmaxsw] × gbmaxsw - ibosw}*
> *gbsw = gbmaxsw*

where

$$vbmaxsw = Nbv \times vt \times \ln\left(\frac{ExplI}{Ibv}\right) \quad gbmaxsw = \left(\frac{ExplI}{Nbv \times vt}\right)$$

If vbmaxsw ≥ -(vd + Bv) > -MAXEXP × Nbv × vt

$$ibsw = -Ibv \times e^{\frac{-(vd + Bv)}{Nbv \times vt}} + ibosw$$

$$gbsw = \frac{-ibsw}{Nbv \times vt}$$

Otherwise

> *ibsw = 0*
> *gbsw = 0*

For ibosw If (vd + Bv) < MAXEXP × Nbv × vt

$$ibosw = Ibv \times e^{\frac{-Bv}{Nbv \times vt}}$$

Otherwise ibosw = 0
MAXEXP is the maximum exponent supported by the machine; value range is 88 to 709.

> *iexpsw = idexpsw + ibsw*
> *gexp = gdexp + gb*

There are two ways to model sidewall diode high-injection effect. When IkModel is set to ADS/Libra/Pspice and when Ikp ≠ 0 and iexp > 0.

$$idsw = iexpsw\sqrt{\frac{Ikp}{Ikp + iexpsw}}$$

$$gdsw = gexpsw\frac{1}{2}\left(1 + \frac{Ikp}{Ikp + iexpsw}\right)\sqrt{\frac{Ikp}{Ikp + iexpsw}}$$

When IkModel is set to Hspice: If Ikp ≠ 0 and iexp > 0

$$idsw = iexpsw\frac{1}{1 + \sqrt{\frac{iexpsw}{Ikp}}}$$

$$gdsw = gexpsw\left(\frac{1}{1+\sqrt{\frac{iexpsw}{Ikp}}}\right)\times\left(1-\frac{\sqrt{\frac{iexpsw}{Ikp}}}{2\left(1+\sqrt{\frac{iexp}{Ikp}}\right)}\right)$$

The total diode DC current and conductance

> *Idsw = idsw + Gleaksw × vdsw + Gmin × vdsw*
> *Gdsw = gdsw + Gleaksw + Gmin*

- **Diode Capacitances**
  For main diode capacitance
  Diffusion capacitance

  > *Cdiff = Tt × gdexp*

  Junction capacitance
  If vd ≤ Fc × Vj

  $$Cj = Area \times Cjo \times \left(1-\frac{vd}{Vj}\right)^{-M}$$

  If Vd > Fc × Vj

  $$Cj = Area \times \frac{Cjo}{(1-Fc)^{M}}\left[1+\left(\frac{M}{Vj\times(1-Fc)}\right)\times(vd-Fc\times Vj)\right]$$

  Total main capacitance

  > *Cdj = Cdiff + Cj + Cd × Area*

  For sidewall capacitance
  If vdsw ≤ Fcsw × Vjsw

  $$Cjsw = Periph \times Cjsw\left(1-\frac{vdsw}{Vjsw}\right)^{-Msw}$$

  If vdsw > Fcsw × Vjsw

  $$Cjsw = Periph\frac{Cjsw}{(1-Fcsw)^{Msw}}\left[1+\left(\frac{Msw}{Vjsw\times(1-Fcsw)}\right)\times(vdsw-Fcsw\times Vjsw)\right]$$

- **Temperature Scaling**
  Parameters Is, Jsw, Isr, Cjo, Cjsw, Vj, Vjsw, Bv, Tt, and Rs are temperature dependent.

NOTE

Expressions for the temperature dependence of the energy bandgap and the intrinsic carrier concentration are for silicon only. Depletion capacitance for non-silicon diodes may not scale properly with temperature, even if values of Eg and Xti are altered from the default values given in the parameters list.

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device item Temp parameter. (Temperatures in the following equations are in Kelvin.) The energy bandgap E_G varies as:

$$E_G(T) = 1.16 - \frac{7.02 \times 10^{-4} T^2}{T + 1108}$$

if *Tlev* = 0, 1

$$E_G(T) = Eg - \frac{EgAlphaT^2}{T + EgBeta}$$

if *Tlev* = 2

The intrinsic carrier concentration n_i for silicon varies as:

$$n_i(T) = 1.45 \times 10^{10}\left(\frac{T}{300.15}\right)^{3/2} \exp\left(\frac{E_G(300.15)}{2k300.15/q} - \frac{E_G(T)}{2kT/q}\right)$$

The saturation currents Is, Isr, and Jsw scale as: if Tlev = 0 or Tlev = 1

$$Is^{NEW} = Is \times \exp\left[\frac{Eg}{NkTnom/q} - \frac{Eg}{NkTemp/q} + \frac{Xti}{N}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Isr^{NEW} = Isr \times \exp\left[\frac{Eg}{NrkTnom/q} - \frac{Eg}{NrkTemp/q} + \frac{Xti}{Nr}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Jsw^{NEW} = Jsw \times \exp\left[\frac{Eg}{NkTnom/q} - \frac{Eg}{NkTemp/q} + \frac{Xti}{N}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

else if Tlev = 2

$$Is^{NEW} = Is \times \exp\left[\frac{E_G(Tnom)}{NkTnom/q} - \frac{E_G(Temp)}{NkTemp/q} + \frac{Xti}{N}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Isr^{NEW} = Isr \times \exp\left[\frac{E_G(Tnom)}{NrkTnom/q} - \frac{E_G(Temp)}{NrkTemp/q} + \frac{Xti}{Nr}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Jsw^{NEW} = Jsw \times \exp\left[\frac{E_G(Tnom)}{NkTnom/q} - \frac{E_G(Temp)}{NkTemp/q} + \frac{Xti}{N}\ln\left(\frac{Temp}{Tnom}\right)\right]$$

The breakdown voltage Bv scales as: if Tlev = 0 $Bv^{NEW} = Bv - Tbv(Temp - Tnom)$

if Tlev = 1 or Tlev = 2 $Bv^{NEW} = Bv - Tbv[1 - Tbv(Temp - Tnom)]$

The breakdown current Ibv does not scale with temperature. The transit time Tt scales as:

$$Tt^{NEW} = Tt[1 + Ttt1(Temp - Tnom) + Ttt2(Temp - Tnom)^2]$$

The series resistance Rs scales as: $Rs^{NEW} = Rs[1 + Trs(Temp - Tnom)]$ The depletion capacitances Cjo and Cjsw and the junction potentials Vj and Vjsw vary as:

$$Vj^{NEW} = Vj\frac{Temp}{Tnom} + \frac{2kTemp}{q}\ln\left(\frac{n_i(Tnom)}{n_i(Temp)}\right)$$

if Tlevc = 0

$$Vjsw^{NEW} = Vjsw\frac{Temp}{Tnom} + \frac{2kTemp}{q}\ln\left(\frac{n_i(Tnom)}{n_i(Temp)}\right)$$

$$Cj^{NEW} = Cj\left(1 + M\left[1 + 4\times10^{-4}(Temp - Tnom) - \frac{Vj^{NEW}}{Vj}\right]\right)$$

$$Cjsw^{NEW} = Cjsw\left(1 + Msw\left[1 + 4\times10^{-4}(Temp - Tnom) - \frac{Vjsw^{NEW}}{Vjsw}\right]\right)$$

if Tlevc = 1

$$Vj^{NEW} = Vj - Tvj(Temp - Tnom)$$

$$Vjsw^{NEW} = Vjsw - Tvjsw(Temp - Tnom)$$

$$Cj^{NEW} = Cj[1 + Tcj(Temp - Tnom)]$$

$$Cjsw^{NEW} = Cjsw[1 + Tcjsw(Temp - Tnom)]$$

if Tlevc = 2

$$Vj^{NEW} = Vj - Tvj(Temp - Tnom)$$

$$Vjsw^{NEW} = Vjsw - Tvjsw(Temp - Tnom)$$

$$Cj^{NEW} = Cj\left(\frac{Vj}{Vj^{NEW}}\right)^{M} \quad Cjsw^{NEW} = Cjsw\left(\frac{Vjsw}{Vjsw^{NEW}}\right)^{Msw}$$

if Tlevc = 3 if Tlev = 2

$$dVjdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (Eg - E_G(Tnom))\frac{Tnom + 2EgBeta}{Tnom + EgBeta} - Vj\right)\frac{1}{Tnom}$$

$$dVjswdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (Eg - E_G(Tnom))\frac{Tnom + 2EgBeta}{Tnom + EgBeta} - Vjsw\right)\frac{1}{Tnom}$$

if Tlev = 0 or Tlev = 1

$$dVjdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (1.16 - E_G(Tnom))\frac{Tnom + 2\times1108}{Tnom + 1108} - Vj\right)\frac{1}{Tnom}$$

$$dVjswdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (1.16 - E_G(Tnom))\frac{Tnom + 2\times1108}{Tnom + 1108} - Vjsw\right)\frac{1}{Tnom}$$

$$Vj^{NEW} = Vj + dVjdT(Temp - Tnom)$$

$$Vjsw^{NEW} = Vjsw + dVjswdT(Temp - Tnom)$$

$$Cj^{NEW} = Cj\left(1 - \frac{dVjdT(Temp - Tnom)}{2Vj}\right)$$

$$Cjsw^{NEW} = Cjsw\left(1 - \frac{dVjswdT(Temp - Tnom)}{2Vjsw}\right)$$

The junction grading coefficient M scales as:

$$M^{NEW} = M[1 + Tm1(Temp - Tnom) + Tm2(Temp - Tnom)^2]$$

The sidewall grading coefficient Msw does not scale.

- **Noise Model**
  Thermal noise generated by resistor Rs is characterized by the following spectral density:
  $$\frac{<i^2>}{\Delta f} = \frac{4kT}{Rs}$$
  Shot noise and flicker noise (Kf, Af, Ffe) generated by the DC current flow
  $$\frac{<i_d^2>}{\Delta f} = 2qI_D + Kf\frac{I_D^{Af}}{f^{Ffe}}$$
  through the diode is characterized by the following spectral density:
  In the preceding expressions, *k* is Boltzmann's constant, *T* is the operating temperature in Kelvin, *q* is the electron charge, *Kf*, *Af*, and *Ffe* are model parameters, *f* is the simulation frequency, and Δ *f* is the noise bandwidth.
- The sidewall model parameters model a second ideal diode that scales with the instance parameter Periph, in parallel with the main diode that scales with the instance parameter Area. The series resistance Rs scales only with Area, not with Periph.
- To model a Zener diode, the model parameters Bv and Ibv can be used. Bv should be set to the Zener reverse breakdown voltage as a positive number. Ibv is set to the breakdown current that flows at that voltage as a positive number; typically this is in the range of 1 to 10 mA. The series resistance Rs should also be set; a typical value is 1 Ohm.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelname Diode [parm=value]*
```

The model statement starts with the required keyword *diode*. It is followed by the *modelname* that will be used by diode components to refer to the model. The third parameter indicates the type of model; for this model it is *Diode*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example

```
model SimpleDiode Diode \
Is=1e-9 Rs=4 Cjo=1.5e-12
```

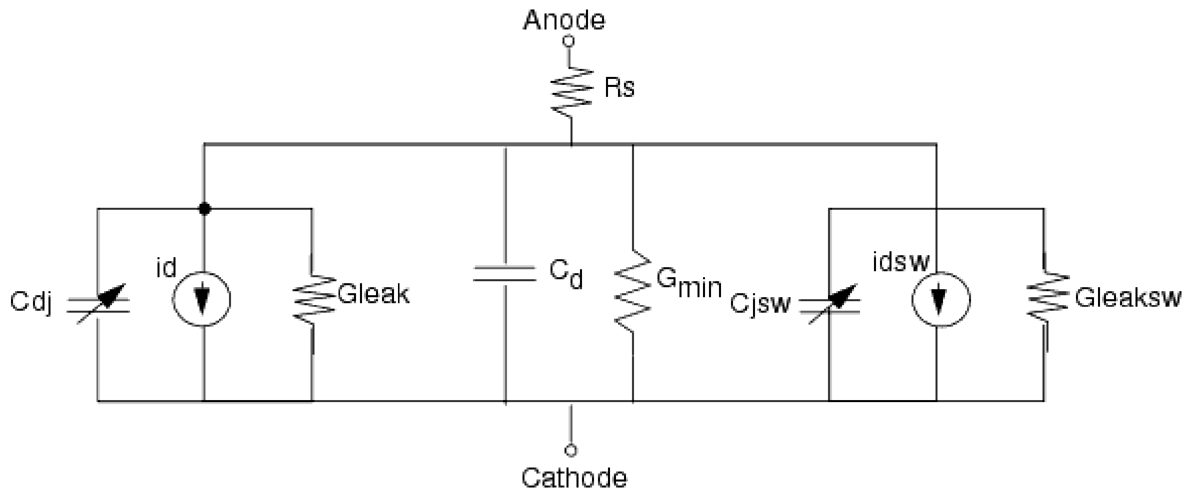
Additional Information

References

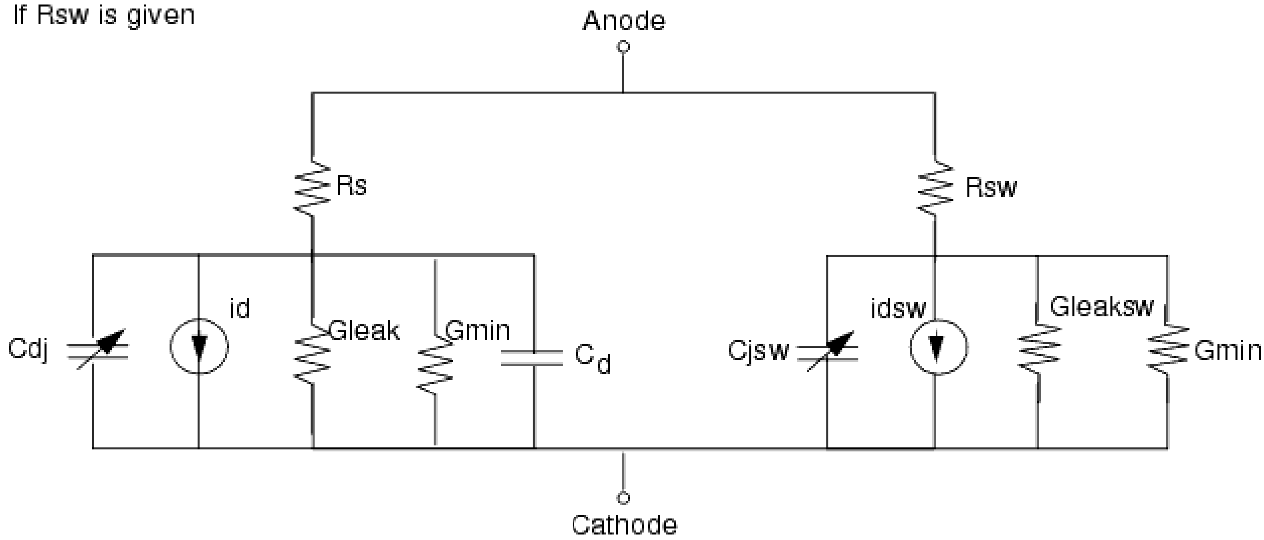
- Antognetti and G. Massobrio. *Semiconductor device modeling with SPICE*, New York: McGraw-Hill, Second Edition 1993.

Equivalent Circuit

If Rsw is not given



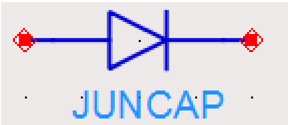
If Rsw is given



JUNCAP (Philips JUNCAP Device)

JUNCAP (Philips JUNCAP Device)

Symbol



Parameters

Name	Description	Units	Default
Model	Model instance name	None	JUNCAPM1
Ab †	diffusion area	m^2	1.0e-12
Ls †	length of sidewall of the diffusion area that is not under the gate	meter	1.0e-6
Lg †	length of sidewall of the diffusion area that is under the gate	meter	1.0e-6
Region	DC operating region; 0=off, 1=on, 2=rev, 3=sat	None	on
Temp	device operating temperature	°C	25
Trise	temperature rise above ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (refer to Note 1)	None	Nonlinear
Noise	noise generation option; yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

† Each instance parameter whose dimension contains a power of meter will be multiplied by the Scale to the same power. For example, a parameter with a dimension of *m* will be multiplied by $scale^{1}$ and a parameter with a dimension of m^{2} will be multiplied by $scale^{2}$. Note that only parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains *cm* instead of meter is not scaled.

- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation

time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device

DC Operating Point Parameters

The following table lists the DC operating point parameters that can be sent to the dataset.

Name	Description	Units
Id	Diode current	amperes
Power	DC power dissipated	watts
Rd	Series resistance	ohms
Cd	Junction capacitance	farads
Vd	Anode-cathode voltage	volts

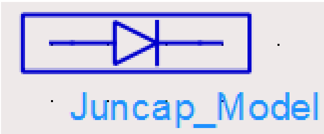
Additional Information

- Additional information about this device is available from the website: www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/source-code-library/juncap:JUNCAP
- This device has no default artwork associated with it.

Juncap Model (Philips JUNCAP Model)

Juncap_Model (Philips JUNCAP Model)

Symbol



The JUNCAP model is used to describe the behavior of diodes that are formed by the source, drain, or well-to-bulk junctions in MOS devices. The model is limited to the case of reverse biasing of these junctions. Similar to the MOS model, the current equations are formulated and ac effects are modeled via charge equations using the quasi-static approximation. In order to include the effects from differences in the sidewall, bottom and gate-edge junction profiles, these contributions are calculated separately in the JUNCAP model. Both the diffusion and the generation currents are treated in the model, each with its own temperature and voltage dependence. In the JUNCAP model a part of the total charge comes from the gate-edge junction very close to the surface. This charge is also included in the MOS-model charge equations, and is therefore counted twice. However, this results in only a very minor error.

Parameters

Name	Description	Units	Default
Tr (Tnom)	Temperature for the Reference Transistor	°C	25
Trise	temperature rise above ambient	°C	0
Vr	Reference Voltage	V	0.0
Jsgbr	Bottom Saturation Current Density due to Electron-Hole generation	A/m^2	1.0e-3
Jsdbr	Bottom Saturation Current Density due to Diffusion from Back Contact	A/m^2	1.0e-3

Name	Description	Units	Default
Jsgsr	Sidewall Saturation Current Density due to Electron-Hole generation	A/m	1.0e-3
Jsdsr	Sidewall Saturation Current Density due to Diffusion from Back Contact	A/m	1.0e-3
Jsggr	Gate-Edge Saturation Current Density due to Electron-Hole generation	A/m	1.0e-3
Jsdgr	Gate-Edge Saturation Current Density due to Diffusion from Back Contact	A/m	1.0e-3
Cjbr	Bottom Junction Capacitance	F/m^2	1.0e-12
Cjsr	Bottom Junction Capacitance	F/m	1.0e-12
Cjgr	Bottom Junction Capacitance	F/m	1.0e-12
Vdbr	Bottom Junction Capacitance	V	1.0
Vdsr	Bottom Junction Capacitance	V	1.0
Vdgr	Bottom Junction Capacitance	V	1.0
Pb	Bottom Junction Grading Coefficient	None	0.4
Ps	Bottom Junction Grading Coefficient	None	0.4
Pg	Bottom Junction Grading Coefficient	None	0.4
Nb	Emission Coefficient of the Bottom Forward Current	None	1.0
Ns	Emission Coefficient of the Bottom Forward Current	None	1.0
Ng	Emission Coefficient of the Bottom Forward Current	None	1.0
Gmin	P-N junction parallel conductance	None	1.0e-15
Imax	Explosion current	A	1.0

Name	Description	Units	Default
All Params	Data Access Component (DAC) Based Parameters	None	None

- Use AllParams with a DataAccessComponent (Data Access Component) to specify file-based parameters. Note that model parameters that are explicitly specified take precedence over those via AllParams.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelname Juncap [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by diode components to refer to the model. The third parameter indicates the type of model; for this model it is *Juncap*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example

```
model DSpar Juncap \
Jsbgr=3e-4 Cjbr=1e-4 Tr=25
```

NOTE Information about this model must be provided in a *model* file; refer to the Netlist Format.

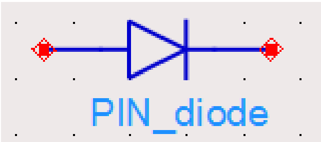
Additional Information

More information about the model can be obtained from:
http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/source-code-library/juncap:JUNCAP

PIN diode (PIN Diode)

PIN_diode (PIN Diode)

Symbol



Range of Usage

All parameters, except Trise and temperature coefficients Txxx, should be either positive or non-negative. Model_level can currently be 1 or 2. Out-of-range parameter values for Area, Temp, Tnom and W are reset to their default values. Parameters which are subject to temperature scaling are clipped at a small positive number or zero if, after scaling, their values become too small.

Parameters

Name	Description	Units	Default
Area	Area scaling factor	None	1.0
Temp	Device operating temperature	°C	25.0
Trise	Temperature rise above the circuit ambient (if Temp not specified)	°C	0.0
Tnom	Temperature at which device parameters were established	°C	25.0
Noise	Noise generation option: yes, no	None	yes
Model_level	Model level selector: 1=SPICE Cj model, 2=advanced Cj model	None	1
Is †, ††	Saturation Current	A	1.0e-14
N	Emission coefficient	None	1.0
B	PI-IN emission coefficient splitting factor	None	1.0
Ikf ††	High-injection knee current (0.0 means infinity)	A	infinity
Bv †	Reverse breakdown voltage (0.0 means infinity)	V	infinity
Ibv †	Current at reverse breakdown voltage	A	0.001
Rs †, †††	Diode ohmic resistance	Ohms	0.0

Rp †, †††	Junction parallel resistance	Ohms	1.0e9
Repi †, †††	Zero-bias resistance	Ohms	1.0e3
Rlim †, †††	Minimum series resistance	Ohms	1.0e-3
W	I-region width	m	1.0e-4
Wd	Depletion area width	m	1.0e-6
Tau	Ambipolar carrier lifetime	sec	1.0e-6
Iknee	Current dependent lifetime knee current (0.0 means infinity)	A	infinity
Rho	I-region resistivity	Ohm × m	0.0
Eps	I-region dielectric constant	None	11.9
Cj †, ††	Zero-bias capacitance	F	1.0e-15
Vj †	Junction potential	V	1.0
M †	Grading coefficient	None	0.0
Fc	Forward-bias depletion capacitance coefficient	None	0.5
Eg	Energy gap	eV	1.11
Xti	Temperature exponent for Is	None	3.0
Trs	Linear relative temperature coefficient for Rs	1/°C	0.0
Trs2	Quadratic relative temperature coefficient for Rs	$1/(°C)^2$	0.0
Trp	Linear relative temperature coefficient for Rp	1/°C	0.0
Trp2	Quadratic relative temperature coefficient for Rp	$1/(°C)^2$	0.0
Trepi	Linear relative temperature coefficient for Repi	1/°C	0.0
Trepi2	Quadratic relative temperature coefficient for Repi	$1/(°C)^2$	0.0
Trlim	Linear relative temperature coefficient for Rlim	1/°C	0.0
Trlim2	Quadratic relative temperature coefficient for Rlim	$1/(°C)^2$	0.0
Tm1	Linear relative temperature coefficient for M	1/°C	0.0
Tm2	Quadratic relative temperature coefficient for M	$1/(°C)^2$	0.0
Tbv	Temperature coefficient for Bv	V/°C	0.0
Kf	Flicker noise coefficient		0.0
Af	Flicker noise exponent	None	1.0
Ffe	Flicker noise frequency exponent	None	1.0
Cpack ††	Package parasitic capacitance	F	0.0

Lbond †††	Package parasitic inductance	H	0.0
Imax	Explosion current	A	1.0
_M	Number of devices in parallel	None	1
† Parameter value varies with the temperature based on Tnom and Temp. †† Parameter value scales with Area. ††† Parameter value scales inversely with Area.			

- The PIN diode device does not use a *model* card. All parameters are specified on each instance of the PIN diode device.
- For Model_level = 1 the standard SPICE diode equation is used to model the junction capacitance. Specifically, a linear extension is used for V_D > Fc × Vj.
- For Model_level = 2 the advanced model equations of [1] are implemented. However, for Transient simulations the frequency dependence of the junction capacitance could significantly affect the robustness of the simulation, and thus is disabled. This may create some discrepancies between Harmonic Balance and Transient simulation results.
- The device operating temperature *T* is either equal to the value of the parameter Temp, if it is specified, or defaults to the global (ambient) circuit temperature specified by the parameter Temp in the Options controller and modified by the value of Trise:
  _ T = circuit_ambient_temperature_ + Trise
  If Temp is not specified in the Options controller, the circuit ambient temperature defaults to 25°C.
- Tnom parameter, if not specified, defaults to the global value of Tnom as specified in the Options controller. If it is not specified in the Options controller, default is 25°C.
- Imax Parameter
  Imax specifies the P-N junction explosion current. The global value of Imax given in the Options controller is not used as the default value if the PIN diode parameter Imax is not specified. The default value remains as shown in the table.
- The parameter Rs is the series ohmic resistance of the diodes DPI and DIN shown in Equivalent Circuit. The overall PIN diode series resistance is not Rs, but rather a combination of Repi, Rlim and GRMOD, and is also affected by other parameters.
- Implementation of the PIN_diode model is based on [1-4]

Equations - Diode Current

The PIN diode main current equation follows that of the standard PN diode but comes as a result of two diodes connected in series: DPI and DIN, in addition to being processed by the controlled sources as shown in Equivalent Circuit. The two diodes share the following parameters:

> *Area, Temp, Tnom, Is, Rs, Ikf, Bv, Ibv, Trs, Trs2 and Tbv.*

but may have different emission coefficients as

$$N_{PI} = \frac{N}{1+B}, \quad N_{IN} = \frac{N \cdot B}{1+B}$$

if the model parameter B is different from 1.0.

The diode current is affected by the RC sub-circuit which is devised to model the impact of the charge storage in the I-region and its lifetime. The component values of the RC sub-circuit are defined as follows:

$$RP_i = 4i - 3 \; , \; CP_i = \frac{Tau}{4i-3} \; , \; RS_i = \frac{alpha}{4i-1}$$

where i = 1, 2, ... , 5,

$$alpha = \frac{W^2}{0.00048375 \cdot Tau}$$

and Tau and W are model parameters.

The main diode current IS2 is fed back to the main diode branch through a CCCS with a gain of 1. To establish the current in the main diode branch, its voltage Vpin is sensed by a VCVS and applied (with a gain of 1) directly to the diodes DPI and DIN. The current IS1 through the two diodes excites the RC sub-circuit via a CCVS with a trans-resistance of 1.

Finally, in addition to a limiting resistance Rlim and the zero-bias resistance Repi the diode current is affected by two nonlinear resistors, marked in the equivalent circuit as GRMOD and GE.
The current i_{GE} in GE is expressed in terms of its voltage v_{GE} as:

$$i_{GE} = 0.25 \cdot (v_{GE} + \sqrt{(v_{GE})^2 + 4\varepsilon^2})^2 / Iknee$$

where Iknee is a model parameter and Σ = 10^{-12}.

The GRMOD component is actually a voltage controlled resistance and its current i_{GRMOD} is expressed in terms of its voltage v_{GRMOD} and of the controlling voltage v_{rp1} as:

$$i_{GRMOD} = ((v_{RP1} + \sqrt{(v_{RP1})^2 + 4\varepsilon^2}) / (Wm)) \cdot v_{GRMOD}$$

where

$$Wm = \frac{10 \cdot W^2}{Tau}$$

and Tau and W are model parameters.

Equations - Diode Capacitance

The default setting of the parameter M (M = 0) makes the junction capacitance to be linear with its value specified by the parameter Cj.

For M > 0 and VD < Fc × Vj the standard SPICE nonlinear capacitance equation is used

$$C = \frac{Cj}{\left(1 - \frac{V_D}{Vj}\right)^M}$$

where VD is the voltage across the capacitance and Cj, Fc and Vj are model parameters.

The extension of this equation beyond Fc × Vj is controlled by the parameter Model_level.

For Model_level = 1 (default) and V_D > Fc × Vj the standard linear extension is used

$$C = \frac{Cj}{(1-Fc)^M} \cdot \left[1 + \frac{M}{(1-Fc)\cdot Vj} \cdot (V_D - Fc \cdot Vj)\right].$$

For Model_level = 2 and Fc × Vj < V_D < (2-Fc) × Vj the quadratic extension is used:

$$C = \frac{Cj}{(1-Fc)^M} \cdot \left[1 + \frac{M}{2} \cdot \left(1 - \left(\frac{V_D - Vj}{(1-Fc)\cdot Vj}\right)^2\right)\right]$$

which is followed by a decaying exponential extension for V_D > (2-Fc) × Vj, defined as follows.

$$C = \frac{Cj}{(1-Fc)^M} \cdot \exp\left(-\frac{M}{(1-Fc)\cdot Vj} \cdot (V_D - (2-Fc)\cdot Vj)\right)$$

Additionally, for Model_level = 2, a frequency dependence of Cj is incorporated into the capacitance equation using the following factor, if the model parameter Rho is specified and greater than zero. By default Rho = 0 and the frequency dependence of Cj does not take effect, i.e., the factor is set to 1.0.

$$Cj \Leftarrow Cj \cdot \frac{1 + \left(\frac{f}{f_r}\right)^2}{\left(\frac{Wd}{W}\right) + \left(\frac{f}{f_r}\right)^2}$$

where f_r is the dielectric relaxation frequency

$$f_r = \frac{1}{2\pi\rho\varepsilon_r\varepsilon_0}, \quad \rho = Rho, \quad \varepsilon_r = Eps$$

Rho, Eps, Wd and W are model parameters, and Σ0 is the permittivity of vacuum.

Other RLC Components

The parameters Rp, Repi, Rlim, Cpack and Lbond provide the component values for the respective components. Rp is the junction parallel (leakage) resistance. Repi is the zero-bias series diode resistance. Rlim establishes the minimum diode resistance. Cpack and Lbond are the package parasitic capacitance and inductance, respectively.

Temperature Scaling Relations

Temperature scaling is performed when the operating device temperature T (see Note 4) is different from Tnom. The temperature scaling relations used for the PIN diode are the same as for the PN diode with Tlev = 0 and Tlevc = 0. This includes scaling of the saturation current Is, the breakdown voltage Bv, the grading coefficient M, the junction potential Vj, the junction capacitance Cj, as well as the thermal voltage in the equation for the diode current. See Diode_Model (PN-Junction Diode Model) for more information.

Additionally, the resistances Rs, Rp, Repi and Rlim are scaled in the same way as the resistor component.

Dimensional Scaling Relations

If the parameter Area is different from 1.0 then the dimensional scaling is performed on several model parameters, as indicated in the parameter table for Area.

Noise Model

Thermal noise generated by resistors Rs, Rp, Repi and Rlim is characterized by the following spectral density:

$$\frac{\langle i^2 \rangle}{\Delta f} = \frac{4kT}{R}$$

where R=Rs, Rp, Rlim or Repi, respectively. Since the resistor Rs is included in both diodes DPI and DIN, there are correspondingly two noise sources.

Both diodes DPI and DIN are considered noisy (if the parameter Noise is set to "YES"). Shot noise and flicker noise (Kf, Af, Ffe) generated by the DC current flowing through the diodes is characterized by the following spectral density:

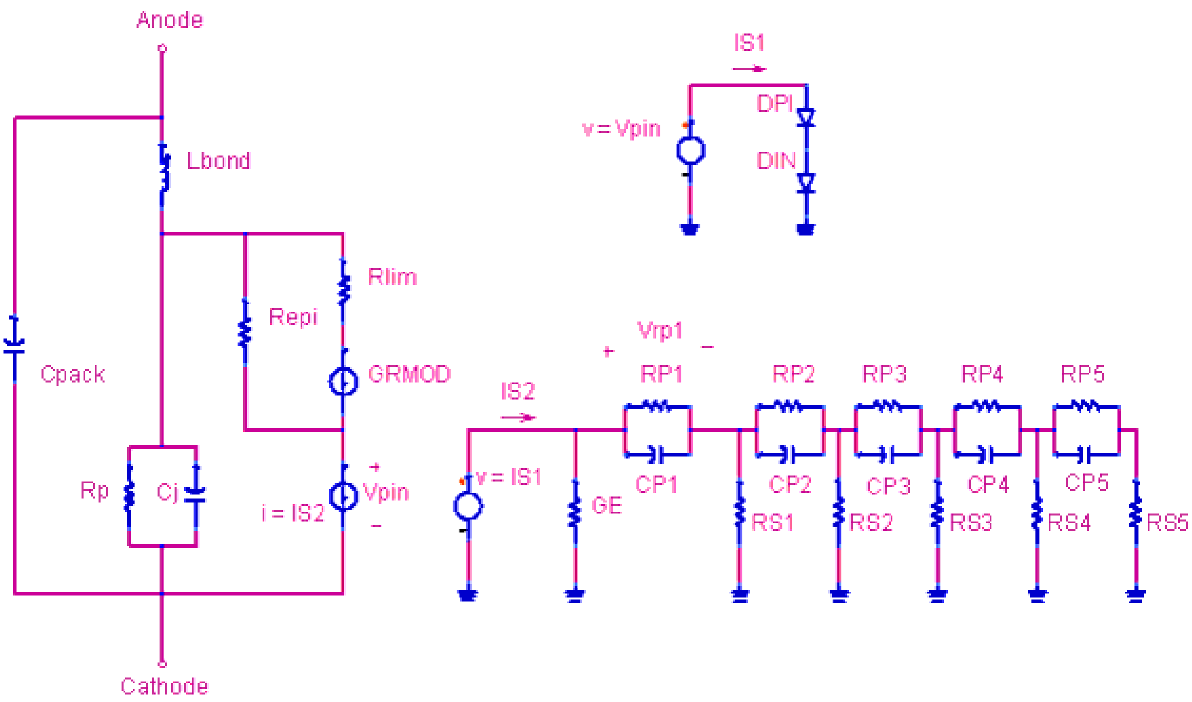
$$\frac{\langle i^2 \rangle}{\Delta f} = 2qI_D + Kf \cdot \frac{I_D^{Af}}{f^{Ffe}}$$

In the preceding expressions, k is Boltzmann's constant, T is the operating temperature in Kelvin, q is the electron charge, Kf, Af, and Ffe are model parameters, f is the simulation frequency, and Δ f is the noise bandwidth.

The RC sub-circuit is considered noiseless.

Additional Information

Equivalent Circuit



References

- J. Kyhl and M. Andersson, "An Advanced PIN-diode Model," Microwave Journal, September 2005, pp. 206-212.
- R.H. Caverly, N.V. Drozdovski, L.M. Drozdovskaia and M.J. Quinn, "SPICE Modeling of Microwave and RF Control Diodes," Proc. 43rd IEEE Midwest Symp., August 8-11, 2000.
- A.G.M. Strollo, "A New SPICE Model of Power P-I-N Diode Based on Asymptotic Waveform Evaluation," IEEE Transactions on Power Electronics, Vol. 12, No. 1, pp. 12-20, January 1997.

Devices and Models, GaAs

Devices and Models, GaAs

ADS provides the following industry standard non-linear FET-based models for amplifier design. There exists a direct link to IC-CAP for model extraction.

- ADS FET (ADS Root FET)
- ADS FET Model (ADS Root Model GaAsFET Model)
- Advanced Curtice2 Model (Advanced Curtice-Quadratic GaAsFET Model)
- Angelov FET (Angelov Nonlinear GaAsFET)
- Angelov Model (Angelov (Chalmers) Nonlinear GaAsFET Model)
- Curtice2 Model (Curtice-Quadratic GaAsFET Model)
- Curtice3 Model (Curtice-Cubic GaAsFET Model)
- EE FET3 (EEsof Scalable Nonlinear GaAsFet, Second Generation)
- EE FET3 Model (EEsof Scalable Nonlinear GaAsFet Model)
- EE HEMT1 (EEsof Scalable Nonlinear HEMT)
- EE HEMT1 Model (EEsof Scalable Nonlinear HEMT Model)
- GaAsFET (Nonlinear Gallium Arsenide FET)
- Materka Model (Materka GaAsFET Model)
- Mesfet Form (Symbolic MESFET Model)
- Modified Materka Model (Modified Materka GaAsFET Model)
- Statz Model (Statz Raytheon GaAsFET Model)
- Tajima Model (Tajima GaAsFET Model)
- TOM3 (TriQuint TOM3 Scalable Nonlinear FET)
- TOM3 Model (TriQuint TOM3 Scalable Nonlinear FET Model)
- TOM4 (TriQuint TOM4 Scalable Nonlinear FET)
- TOM4 Model (TriQuint TOM4 Scalable Nonlinear FET Model)
- TOM (TriQuint Scalable Nonlinear GaAsFET)
- TOM Model (TriQuint Scalable Nonlinear GaAsFET Model)
- TriQuintMaterka (TriQuint-Materka Nonlinear FET)
- TriQuintMaterka Model (TriQuint-Materka Nonlinear FET Model)

Bin Model

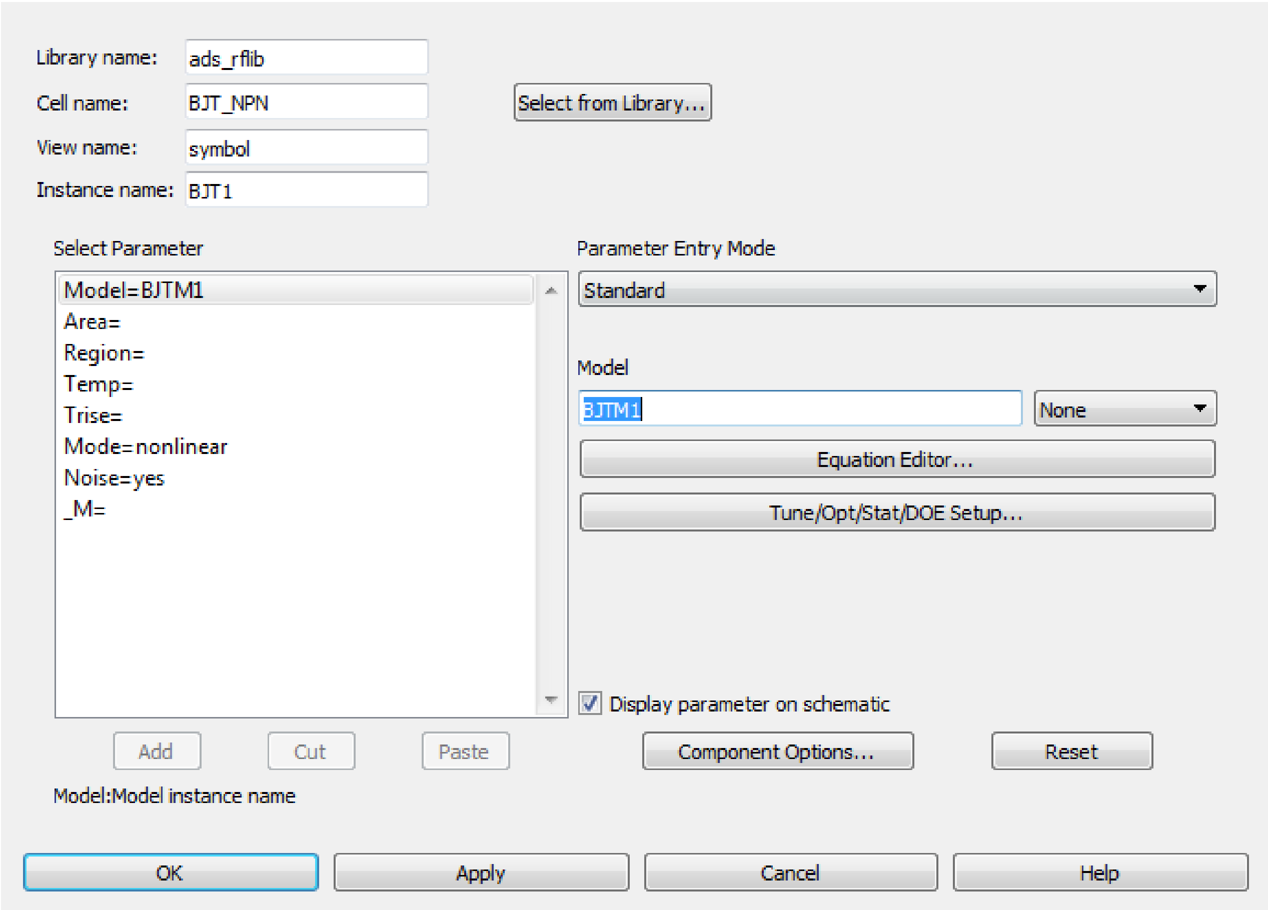
The BinModel in the GaAs library allows you to sweep a parameter (usually a geometry, such as gate length), then enable the simulator to automatically select between different model cards. This alleviates the problem that one scalable model typically doesn't work for all sizes of a device.

For information on the use of the binning feature, refer to "BinModel" in *Introduction to Circuit Components*.

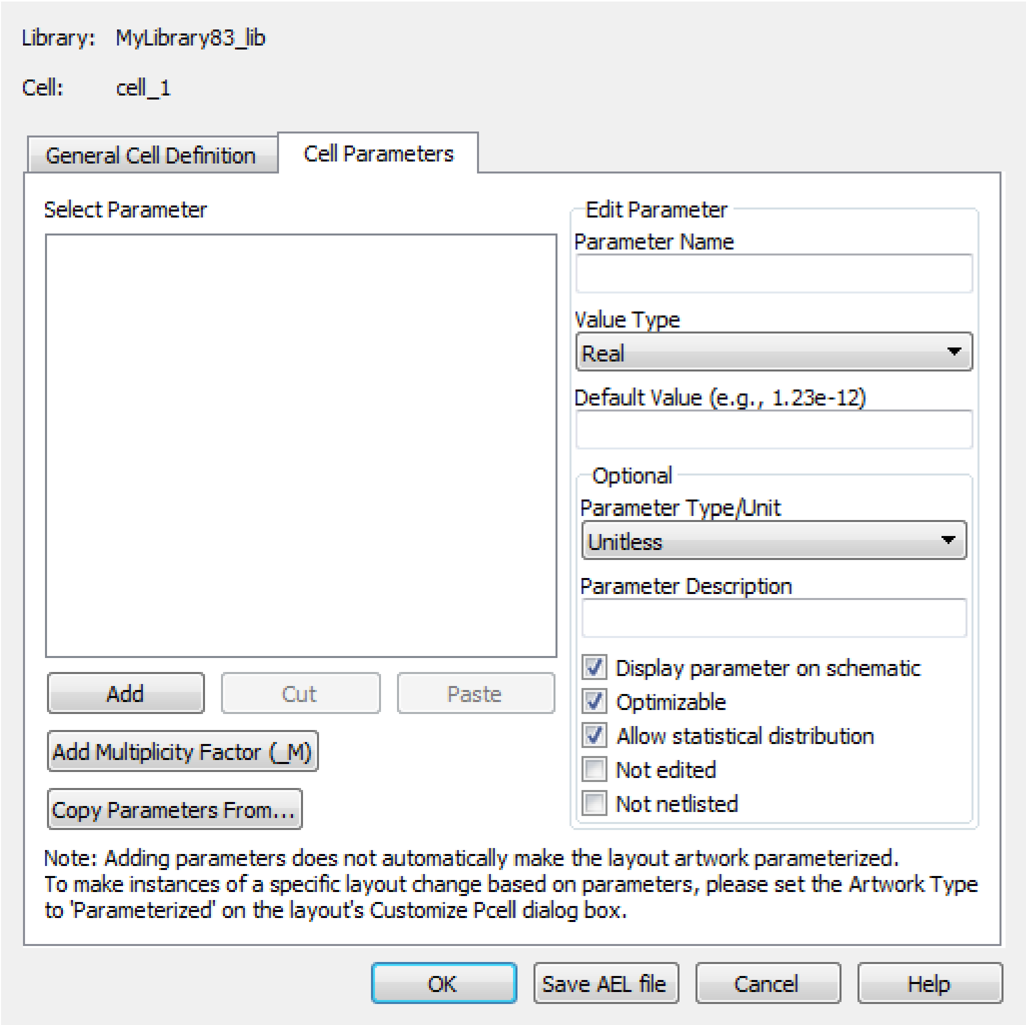
Multiplicity Parameter _M

The multiplicity feature provides a way to scale components or entire sub-circuits containing many components and sub-circuits. Given a component with a multiplicity value *M* , the simulator treats this component as if there were *M* such components all connected in parallel. Sub-circuits within sub-circuits will be appropriately scaled.

The _M parameter is available at the component level as shown here. (For components that do not explicitly have a Multiplicity parameter, the same functionality can be achieved by placing the component in a sub-circuit and using the sub-circuit's Multiplicity parameter, as described next.)



For sub-circuits, the parameter is enabled by selecting **File** > **Design Parameters** from the Schematic window. In the dialog box, select the **Parameters** tab. To add the Multiplicity parameter, choose **Add Multiplicity Factor_M**.



Netlist Syntax

Models for the ADS circuit simulator have the following syntax:

```
model modelname modeltype [param=value]*
```

where `model` is a keyword, `modelname` is the user-defined name for the model and `modeltype` is one of the predefined model types (e.g., Diode, BJT, MOSFET). After these three required fields comes zero or more `param=value` pairs. `param` is a model keyword and value is its user-assigned value. There is no required order for the `param=value` pairs. Model keywords that are not specified take on their default values. Refer to documentation for each model type to see the list of model parameters, their meanings and default values.

The model statement must be on a single line. Use the backslash "\" as a line continuation character. The instance and model parameter names are case sensitive. Most, but not all, model parameters have their first character capitalized and the rest are lower case. Scale factors (e.g., $p=10^{-12}$, $n=10^{-9}$, $u=10^{-6}$, $m=10^{-3}$, $k=10^{+3}$, $M=10^{+6}$) can be used with numbers for numeric values. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

A netlist translator is available for translating models and subcircuits from Pspice, Hspice, and Spectre syntax to the form used by the ADS Circuit Simulator. Refer to "Netlist Translator for SPICE and Spectre" for more information.

Parameter Aliases

For compatibility with other simulators, some models accept two or more different keywords for the same parameter. For example, the Diode model accepts both model keywords Is and Js for the saturation current. In the documentation, the parameter Name column lists the aliases in parentheses after the main parameter name. The main parameter name is the one that appears in the ADS dialog box for the model.

Tnom

All nonlinear device models have a parameter that specifies the temperature at which the model parameters were extracted. Normally called Tnom, some models may use Tref, Tr, or Tmeas. The default value for Tnom is specified on the Options item in the Tnom field. If Options.Tnom is not specified it defaults to 25°C. This is true for all nonlinear devices.

It is strongly suggested that the user explicitly set Tnom in each model and not depend on its default value. First, this provides a self-documenting model; other users of the device will not have to guess at what Tnom should be. Second, different users of the same model would get different results for the same circuit if they simulate with different values of Options.Tnom.

Temp and Trise

The ADS circuit simulation allows the user to directly specify the temperature of each individual device instance. This is done with the device instance parameter Temp which is the device temperature in degrees Celsius. If it is not specified, it defaults to the ambient temperature set with Options.Temp, which defaults to 25°C.

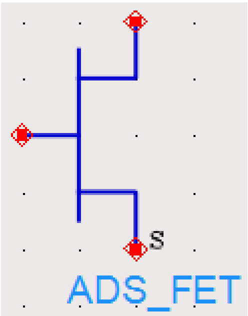
For compatibility with other simulators, many of the nonlinear devices allow the user to specify Trise for each device instance, which specifies actual device temperature as an increase from ambient. It defaults to zero. The Trise instance value is used only if the Temp instance value is not specified. If the user does not specify Trise on the instance, a default value for Trise can also be specified in the model. It defaults to zero. The following shows the logic of how the instance temperature is calculated if it is not explicitly specified.

```
if Instance.Temp is not specified
 if instance.Trise is not specified
   Instance.Temp = Options.Temp + Model.Trise
 else
   Instance.Temp = Options.Temp + Instance.Trise
```

ADS FET (ADS Root FET)

ADS_FET (ADS_Root FET)

Symbol



Parameters

Name	Description	Units	Default
Model	name of an ADS_FET model	None	ADSFETM1
Wtot	total gate width		1.0e-4
N	number of device gate fingers	None	1
_M	number of devices in parallel	None	1

- If Wtot or N is specified as *Rawfile value* or zero, the default gate width as specified in the model file is used. For other values, these values can be used to scale the extracted model for different geometries. Scaling remains valid for ratios up to 5:1.
- Wtot is the total gate width-not the width per finger; the parameter N is the number of fingers; therefore, the width per finger is Wtot/N.
- Currents and capacitances scale linearly with gate width:

$$I = I_0 \times \frac{Wtot}{W_0}$$

$$C = C_0 \times \frac{Wtot}{W_0}$$

Parasitic resistances scale as:

$$Rg = R_{G0} \times \frac{Wtot}{W_0}\left(\frac{N_0}{N}\right)^2$$

$$Rd = R_{D0} \times \frac{W_0}{Wtot}$$

$$Rs = R_{S0} \times \frac{W_0}{Wtot}$$

where Wtot and N are the user-specified values and W_0 and N_0 are the extracted values given in the ADS_FET_Model. The parasitic inductances do not scale.

- Care should be taken when using the transistor outside of the region at which the model measurements were taken. Extrapolation of the measured data may occur without warning during DC, harmonic balance, and time-domain analyses. This extrapolated data may produce unreliable results.
- ADS_FET currents can be measured with the standard current measurements, except that pins must be specified by number instead of name; for example, 1=G, 2=D, 3=S.
- The ADS_FET cannot be temperature scaled and is noiseless.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

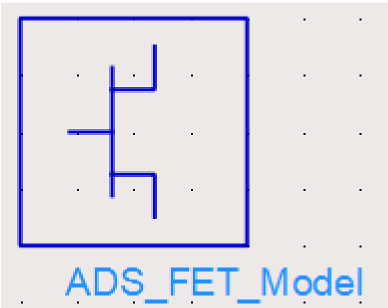
Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Ggs	Gate conductance (dIg/dVgs)	siemens
dIg_dVds	(dIg/dVds)	siemens

Name	Description	Units
dQd_dVds	(dQd/dVds)	farads
dQd_dVgs	(dQd/dVgs)	farads
dQg_dVds	(dQg/dVds)	farads
dQg_dVgs	(dQg/dVgs)	farads
Vgs	Gate-source voltage	volts
Vds	Gate-drain voltage	volts

ADS FET Model (ADS Root Model GaAsFET Model)

ADS_FET_Model (ADS Root Model GaAsFET Model)

Symbol



Parameters

Name	Description	Units	Default
File	name of file containing measured data	None	None
Rs	source resistance (overrides extracted value)	Ohm	None
Rg	gate resistance (overrides extracted value)	Ohm	None
Rd	drain resistance (overrides extracted value)	Ohm	None
Ls	source inductance (overrides extracted value)	H	None
Lg	gate inductance (overrides extracted value)	H	None
Ld	drain inductance (overrides extracted value)	H	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

- The default extension for the model file is*.raw*. This file should be in the same format as ADS Root model data.
- If Rs, Rg, Rd, Ls, Lg, or Ld is specified as *rawfile value* or zero, the default parasitic value is taken from the extracted values stored in the data file named by File parameter. Generally, *rawfile value* should be used.
- Because this model is measurement-based, extrapolation warning messages may occur if the Newton iteration exceeds the measurement range. If these messages occur frequently, check that the measurement data is within the simulation range.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). A nonlinear device model parameter value that is explicitly specified will override the value set by an AllParams association.

Additional Information

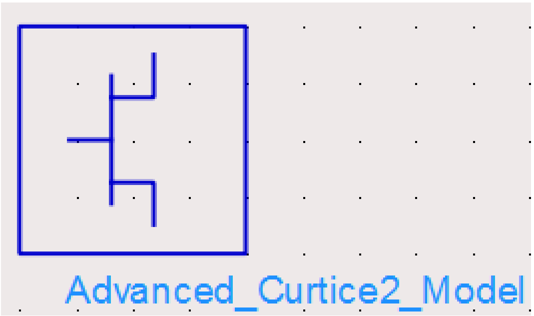
References

- D. Root, "Technology independent large signal non quasi static FET model by direct construction from automatically characterized device data," in *21st EuMC* , 1991, p. 927.
- D. E. Root, S. Fan, and J. Meyer, "Technology-independent large-signal FET models: A measurement-based approach to active device modeling," in *Proc. th ARMMS Conf., Bath, U.K.* , Sept. 1991, pp. 1-21.
- D. E. Root, M. Pirola, S. Fan, W. J. Anklam, and A. Cognata, "Measurement-based large-signal diode modeling system for circuit and device design," *IEEE Trans. Microwave Theory Tech.* , vol. 41, pp. 2211-2217, Dec. 1993.
- D. E. Root and B. Hughes, "Principles of nonlinear active device modeling for circuit simulation," in *32nd ARFTG Conf. Dig* ., Tempe, AZ, 1988, pp. 3-26.
- D. E. Root, S. Fan, and J. Meyer, "Technology-independent large-signal non quasi static FET models by direct extraction from automatically characterized device data," in *21st European Microwave Conf. Proc.* , Stuttgart, Germany, 1991, pp. 927-932.
- D. E. Root and S. Fan, "Experimental evaluation of large-signal modeling assumptions based on vector analysis of bias-dependent S-parameters data from MESFET's and HEMT's," in *IEEE MTT-S Int. Microwave Symp. Tech. Dig.* , 1992, pp. 927-932.

Advanced Curtice2 Model (Advanced Curtice-Quadratic GaAsFET Model)

Advanced_Curtice2_Model (Advanced Curtice-Quadratic GaAsFET Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NFET	N-channel model: yes or no	None	yes
PFET	P-channel model: yes or no	None	no
Idsmod	Ids model: 1=CQ 2=CC 3=Statz 4=Materka 5=Tajima 6=symbolic 7=TOM 8=Modified Materka	None	1
Vto †	threshold voltage	V	−2.0
Beta † , ††	transconductance	A/V^2	1.0e-4
Lambda	channel length modulation	1/V	0.0
Alpha	hyperbolic tangent function	1/V	2.0
Tau	transit time under gate	sec	0.0
Tnom	nominal ambient temperature at which these model parameters were derived	°C	25
Idstc	Ids temperature coefficient		0.0
Ucrit	critical field for mobility degradation	None	0
Vgexp	Vgs – Vto exponent	None	2

Gamds	effective pinch-off combined with Vds	None	-0.01
Vtotc	Vto temperature coefficient	V/°C	0.0
Betatce	BETA Exponential Temperature Coefficient	%/°C	0.0
Rgs †††	gate-source resistance	Ohm	0.0
Rf †††	gate-source effective forward- bias resistance	Ohm	infinity ‡
Gscap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Cgs † , ††	zero bias gate-source junction capacitance	F	0.0
Cgd † , ††	zero bias gate-drain junction capacitance	F	0.0
Gdcap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Fc	coefficient for forward bias depletion capacitance (diode model)	None	0.5
Rgd †††	gate drain resistance	Ohm	0.0
Rd †††	drain ohmic resistance	Ohm	fixed at 0.0
Rg	gate resistance	Ohm	fixed at 0.0
Rs †††	source ohmic resistance	Ohm	fixed at 0.0
Ld	drain inductance	H	fixed at 0.0
Lg	gate inductance	H	fixed at 0.0
Ls	source inductance	H	fixed at 0.0
Cds ††	drain-source capacitance	F	0.0
Rc †††	used with Crf to model frequency dependent output conductance	Ohm	infinity ‡
Crf ††	used with Rc to model frequency dependent output conductance	F	0.0
Gsfwd	0=none, 1=linear, 2=diode	None	linear
Gsrev	0=none, 1=linear, 2=diode	None	None
Gdfwd	0=none, 1=linear, 2=diode	None	None
Gdrev	0=none, 1=linear, 2=diode	None	linear
R1 †††	approximate breakdown resistance	Ohm	infinity ‡
R2 †††	resistance relating breakdown voltage to channel current	Ohm	infinity ‡
Vbi †	built-in gate potential	V	0.85

Vbr	gate-drain junction reverse bias breakdown voltage (gate-source junction reverse bias breakdown voltage with Vds < 0)	V	1e100
Vjr	breakdown junction potential	V	0.025
Is †, ††	gate junction saturation current (diode model)	A	1.0e-14
Ir	gate reverse saturation current	A	1.0e-14
Imax	explosion current	A	1.6
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 2)	A	defaults to Imax
Xti	temperature exponent for saturation current	None	3.0
Eg	energy gap for temperature effect on Is	eV	1.11
N	gate junction emission coefficient (diode model)	None	1
Fnc	flicker noise corner frequency	Hz	0.0
R	gate noise coefficient	None	0.5
P	drain noise coefficient	None	1.0
C	gate-drain noise correlation coefficient	None	0.9
Taumdl	use second order Bessel polynomial to model tau effect in transient simulation: yes or no	None	no
wVgfwd	gate junction forward bias warning	V	
wBvgs	gate-source reverse breakdown voltage warning	V	
wBvgd	gate-drain reverse breakdown voltage warning	V	
wBvds	drain-source breakdown voltage warning	V	
wIdsmax	maximum drain-source current warning	A	
wPmax	maximum power dissipation warning	W	
AllParams	DataAccessComponent for file-based model parameter values	None	None

† Parameter value varies with temperature based on model Tnom and device Temp. †† Parameter value scales with Area. ††† Parameter value scales inversely with Area. ‡ A value of 0.0 is interpreted as infinity.

- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- The P, R, and C parameters model drain and gate noise sources.

$$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTg_m\, P(1 + f_{NC}/f)$$

$$\frac{\langle i_g^2 \rangle}{\Delta f} = 4kT\, C_{gs}^{\ 2}\, \omega^2\, R/g_m$$

$$\frac{\langle i_g, i_d^* \rangle}{\Delta f} = 4kTj\, C_{gs}\, \omega \sqrt{PR}\, C$$

- Drain-Source Current
  Drain current in the Advanced Curtice quadratic model is based on the modification of the drain current equation in the Curtice quadratic model.
  The quadratic dependence of the drain current with respect to the gate voltage is calculated with the following expression in the region $V_{ds} \geq 0.0V$.

  > $I_{ds} = Beta_{NEW} \times (V_{gs} - Vto_{NEW})^{Vgexp} \times (1+Lambda \times V_{ds}) \times tanh(Alpha \times V_{ds})$

  where:

  > $Vto_{NEW} = Vto + Gainds \times Vds$
  >
  > $Beta_{NEW} = Beta/(1 + Ucrit \times (Vgs - Vto_{NEW}))$

  Assuming symmetry, in the reverse region, the drain and source swap roles and the expression becomes:

  > $I_{ds} = Beta_{NEW} \times (V_{gd} - Vto_{NEW})^{Vgexp} \times (1-Lambda \times V_{ds}) \times tanh(Alpha \times V_{ds})$

  where:

  > $I_{ds} = Beta_{NEW} \times (V_{gd} - Vto_{NEW})^{Vgexp} \times (1+Lambda \times V_{ds}) \times tanh(Alpha \times V_{ds})$.

  where:

  > $Vto_{NEW} = Vto + Gainds \times Vds$
  >
  > $Beta_{NEW} = Beta/(1 + Ucrit \times (Vgd - Vto_{NEW}))$

  The drain current is set to zero in either case if the junction voltage (V_{gs} or V_{gd}) drops below the threshold voltage Vto.
  If Ucrit is not equal to 0, the temperature coefficients Vtotc and Betatc are disabled.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). A nonlinear device model parameter value that is explicitly specified will override the value set by an AllParams association.

Additional Information

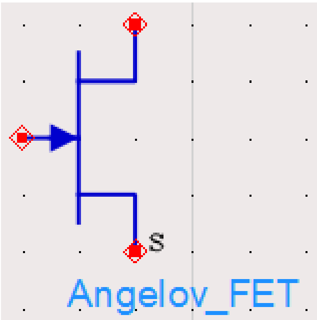
References

- A. Cappy, "Noise Modeling and Measurement Techniques," *IEEE Transactions on Microwave Theory and Techniques* , Vol. 36, No. 1, pp. 1-10, Jan. 1988.

Angelov FET (Angelov Nonlinear GaAsFET)

Angelov_FET (Angelov Nonlinear GaAsFET)

Symbol



Parameters

Name	Description	Units	Default
Model	name of an Angelov_Model	None	ANGELOVM1
Temp	device operating temperature	°C	25
Trise	temperature rise over ambient	None	0
Mode	simulation mode: Nonlinear, Linear, Standard (refer to note 1)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

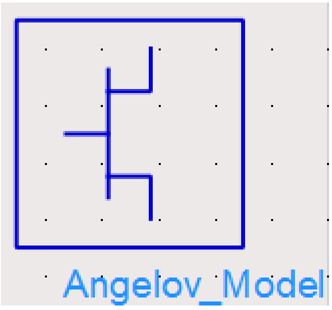
Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Ggs	Gate-source conductance	siemens
Ggd	Gate-drain conductance	siemens
Cgs	Gate-source capacitance	farads
Cgd	Gate-drain capacitance	farads
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts

- This device has no default artwork associated with it.

Angelov Model (Angelov (Chalmers) Nonlinear GaAsFET Model)

Angelov_Model (Angelov (Chalmers) Nonlinear GaAsFET Model)

Symbol



This model is based on the original Angelov (Chalmers) model described in [1] and [2], but includes the latest developments made by Prof. Itcho Angelov that have not been published. The original Angelov model is not symmetrical (which corresponds to setting Idsmod=0). ADS implementation of the Angelov model is enhanced by providing a symmetrical Ids equation which corresponds to setting Idsmod=1. It should be used when simulating switches or resistive mixers. Part of this work was published in [6].

Parameters

Following table lists the model parameters. The parameters must be specified in SI units.

Name	Description	Units	Default
Idsmod	Ids model flag: 0=original, 1=symmetric	None	0
Igmod	Igs/Igd model flag	None	0
Capmod	Capacitance model selector: 0=linear, 1=bias-dependent capacitances, 2=charge	None	2
Ipk0 †	Current for maximum transconductance	A	0.05
Vpks	Gate voltage for maximum transconductance	V	-0.2
Dvpks	Delta gate voltage at peak Gm	V	0.2
P1 †	Polynomial coefficient for channel current	None	1.0
P2	Polynomial coefficient for channel current	None	0.0

P3	Polynomial coefficient for channel current	None	0.0
Alphar	Saturation parameter	None	0.1
Alphas	Saturation parameter	None	1.0
Vkn ††	Knee voltage	V	0.8
Lambda	Channel length modulation parameter	None	0.0
Lambda1 ††	Channel length modulation parameter	None	0.0
Lvg ††	Coefficient for Lambda parameter	None	0.0
B1	Unsaturated coefficient for P1	None	0.0
B2	Unsaturated coefficient for P2	None	3.0
Lsb0 †	Soft breakdown model parameter	None	0.0
Vtr	Threshold voltage for breakdown	V	20.0
Vsb2	Surface breakdown model parameter	None	0.0
Cds	Drain-source capacitance	F	0.0
Cgspi	Gate-source pinch-off capacitance	F	0.0
Cgs0 †	Gate-source capacitance	F	0.0
Cgdpi	Gate-drain pinch-off capacitance	F	0.0
Cgd0 †	Gate-drain capacitance	F	0.0
Cgdpe	External gate-drain capacitance	F	0.0
P10	Polynomial coefficient for capacitance	None	0.0
P11	Polynomial coefficient for capacitance	None	1.0
P20	Polynomial coefficient for capacitance	None	0.0
P21	Polynomial coefficient for capacitance	None	0.2
P30	Polynomial coefficient for capacitance	None	0.0
P31	Polynomial coefficient for capacitance	None	0.2
P40	Polynomial coefficient for capacitance	None	0.0
P41	Polynomial coefficient for capacitance	None	1.0
P111	Polynomial coefficient for capacitance	None	0.0
Ij	Gate fwd saturation current	A	0.5e-3
Pg	Gate current parameter	None	15.0
Ne	Ideality factor	None	1.4
Vjg	Gate current parameter	V	0.7

Rg	Gate resistance	Ohm	0.0
Rd	Drain resistance	Ohm	0.0
Ri	Gate-source resistance	Ohm	0.0
Rs	Source resistance	Ohm	0.0
Rgd	Gate-drain resistance	Ohm	0.0
Lg	Gate inductance	H	0.0
Ld	Drain inductance	H	0.0
Ls	Source inductance	H	0.0
Tau	Internal time delay	sec	0.0
Rcmin	Minimum value of Rc resistance	Ohm	1.0e3
Rc†	R for frequency dependent output conductance	Ohm	10.0e3
Crf†	C for frequency dependent output conductance	F	0.0
Rcin	R for frequency dependent input conductance	Ohm	100.0e3
Crfin	C for frequency dependent input conductance	F	0.0
Rth	Thermal resistance	Ohm	0.0
Cth	Thermal capacitance	F	0.0
Tcipk0	Temperature coefficient of Ipk0 parameter	None	0.0
Tcp1	Temperature coefficient of P1 parameter	None	0.0
Tccgs0	Temperature coefficient of Cgs0 parameter	None	0.0
Tccgd0	Temperature coefficient of Cgd0 parameter	None	0.0
Tclsb0	Temperature coefficient of Lsb0 parameter	None	0.0
Tcrc	Temperature coefficient of Rc parameter	None	0.0
Tccrf	Temperature coefficient of Crf parameter	None	0.0
Tnom (Tamb)	Parameter measurement temperature	°C	25
Selft	Flag denoting self-heating	None	no
Noimod	Noise model selector	None	0
NoiseR	Gate noise coefficient	None	0.5
NoiseP	Drain noise coefficient	None	1.0
NoiseC	Gate-drain noise correlation coefficient	None	0.9
Fnc	Flicker-noise corner frequency	Hz	0.0
Kf	Flicker noise coefficient	None	0.0
Af	Flicker noise exponent	None	1.0

Ffe	Flicker noise frequency exponent	None	1.0
Tg	Gate equivalent temperature	°C	25
Td	Drain equivalent temperature coefficient	°C	25
Td1	Drain equivalent temperature coefficient		0.1
Tmn	Noise fitting coefficient	None	1.0
Klf	Flicker noise coefficient	None	0.0
Fgr	Generation-recombination frequency corner	Hz	0.0
Np	Flicker noise frequency exponent	None	1.0
Lw	effective gate noise width	mm	0.1
AllParams	DataAccessComponent for file-based model parameter values	None	None
† This parameter varies with temperature. †† This parameter is only used with Idsmod=1			

- The published Angelov model is capacitance based (which corresponds to setting Capmod=1). In general, the bias-dependent capacitor models are known to be less robust, which sometimes leads to non-convergence problems. Charge-based models are normally more robust. ADS implementation of the Angelov model is enhanced by providing a charge-based model, which corresponds to setting Capmod=2. Both of the models have been created by Prof. Angelov.
- If Rcmin is specified, the resistance Rc will be calculated based on the following nonlinear equation:

$$Rc = Rcmin + \frac{Rc}{(1 + \tanh(\psi))}$$

- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). A nonlinear device model parameter value that is explicitly specified will override the value set by an AllParams association.
- To use selfheating set `selft=1`, meaning that the temperature of the device is higher when the device is dissipating more power. `trise` is not used when self-heating is turned on (`selft=1`). Use `trise` parameter, if the temperature is known and a more accurate model is required at that temperature. If the model is characterized at different temperatures, the model should adapt to different temperatures.

Ids Equations

$$P1m = P1 \times (1 + B1 / \cosh^2(B2 \times Vds))$$

$$Vpkm = VPKS - DVPKS + DVPKS$$

$$\times \tanh(ALPHAS \times Vds) - VSB2 \times (Vdg - VTR)^2$$

$$\psi = P1m \times (Vgs - Vpkm) + P2 \times (Vgs - Vpkm)^2 + P3 \times (Vgs - Vpkm)^3$$

$$\alpha = ALPHAR + ALPHAS \times (1 + \tanh(\psi))$$

For the original model (Idsmod=0)

$$Ids = IPK0 \times (1 + \tanh(\psi)) \times \tanh(\alpha \times Vds)$$

$$\times (\ 1 + LAMBDA \times Vds + LSB0 \times \exp(Vdg - VTR))$$

For the symmetric model (Idsmod=1)

$$\psi_n = P1m \times (Vgd - Vpkm) + P2 \times (Vgd - Vpkm)^2 + P3 \times (Vgd - Vpkm)^3$$

$$\alpha_n = ALPHAR + ALPHAS \times (1 + \tanh(\psi_n))$$

$$\lambda_n = LAMBDA + LVG \times (1 + \tanh(\psi_n))$$

$$\lambda_p = LAMBDA + LVG \times (1 + \tanh(\psi))$$

$$\lambda_{n1} = LAMBDA1 + LVG \times (1 + \tanh(\psi_n))$$

$$\lambda_{p1} = LAMBDA1 + LVG \times (1 + \tanh(\psi))$$

$$Idsp = IPK0 \times (1 + \tanh(\psi)) \times (1 + \tanh(\alpha \times Vds))$$

$$\times \left(1 + \lambda_p \times \mathrm{Vds} \ + \lambda_{p1} \times \exp\left(\frac{Vds}{Vkn} - 1\right)\right)$$

$$Idsn = IPK0 \times (1 + \tanh(\psi_n)) \times (1 - \tanh(\alpha_n \times Vds))$$

$$\times \left(\ 1 - \lambda_n \times Vds - \lambda_{n1} \times \exp\left(\frac{Vds}{Vkn} - 1\right)\right)$$

$$Ids = 0.5 \times (Idsp - Idsn)$$

Igs, Igd Equations

For Igmod = 0

$$Igs = IJ \times (\exp(PG \times \tanh(2 \times (Vgsc - VJG))) - \exp(PG \times \tanh(-2 \times VJG)))$$

$$Igd = IJ \times (\exp(PG \times \tanh(2 \times (Vgdc - VJG))) - \exp(PG \times \tanh(-2 \times VJG)))$$

For Igmod = 1

$$Igs = IJ \times (\exp(PG \times \tanh(Vgsc - VJG)) - \exp(-PG \times VJG))$$

$$Igd = IJ \times (\exp(PG \times \tanh(Vgdc - VJG)) - \exp(-PG \times VJG))$$

If *PG* is not specified (left blank), but *NE* is specified then:

$$PG = 1 / (2 \times NE \times Vt)$$

where *Vt* = *K* × *Temp / q*

If both *PG* and *NE* are not specified then the default value for *NE* is used.
(*Vgsc* and *Vgdc* are the voltages directly across each current source in the *Equivalent Circuit* diagram).

Charge Equations

For Capmod = 0 (linear capacitance)
Cgs = CGSPI
Cgd = CGDPI
For Capmod = 1

$$Cgs = CGSPI + CGS0 \times (1 + \tanh(Phi1))(1 + \tanh(Phi2))$$

$$Cgd = CGDPI + CGD0 \times ((1 - P111 + \tanh(Phi3))(1 + \tanh(Phi4)) + 2 \times P111)$$

$$Phi1 = P10 + P11 \times Vgsc + P111 \times Vds$$

$$Phi2 = P20 + P21 \times Vds$$

$$Phi3 = P30 - P31 \times Vds$$

$$Phi4 = P40 + P41 \times Vgdc - P111 \times Vds$$

For Capmod = 2

$$Lc1 = 1n(\cosh(Phi1))$$

$$Lc10 = 1n(\cosh(P10 + P111 \times Vds))$$

$$Qgs = CGSPI \times Vgsc + CGS0$$

$$\times ((Phi1 + Lc1 - Qgs0) \times (1 - P111 + \tanh(Phi2)) / P11 + 2 \times P111 \times Vgsc)$$

$$Qgs0 = P10 + P111 \times Vds + Lc10$$

$$Lc4 = 1n(\cosh(Phi4))$$

$$Lc40 = 1n(\cosh(P40 - P111 \times Vds))$$

$$Qgd = CGDPI \times Vgdc + CGD0$$

$$\times ((Phi4 + Lc4 - Qgd0) \times (1 - P111 + \tanh(Phi3)) / P41 + 2 \times P111 \times Vgdc)$$

$$Qgd0 = P40 - P111 \times Vds + Lc40$$

$$Phi1 = P10 + P11 \times Vgsc + P111 \times Vds$$

$$Phi2 = P20 + P21 \times Vds$$

$$Phi3 = P30 - P31 \times Vds$$

$$Phi4 = P40 + P41 \times Vgdc - P111 \times Vds$$

Temperature Equations

$$Ipk0 = IPK0 \times (1 + TCIPK0 \times (Temp - Tnom))$$
$$P1 = P1 \times (1 + TCP1 \times (Temp - Tnom))$$
$$Lsb0 = LSB0 \times (1 + TCLSB0 \times (Temp - Tnom))$$
$$Cgs0 = CGS0 \times (1 + TCGS0 \times (Temp - Tnom))$$
$$Cgd0 = CGD0 \times (1 + TCGD0 \times (Temp - Tnom))$$
$$Rc = RC \times (1 + TCRC \times (Temp - Tnom))$$
$$Crf = CRF \times (1 + TCCRF \times (Temp - Tnom))$$

Ids Noise

Noimod = 0 (default value)

$$I_{dtn} = |I_{DS}| + |I_{GD}|$$

$$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTLw \sqrt{\frac{T'_D}{T}} I_{dtn} + Td1 \cdot I_{dtn}^2$$

$$T'_D = Td[1 + Tmn(1 + \tanh(\Psi)) \cdot |\tanh(\alpha V_{DS})| \cdot (1 + Lambda \cdot V_{DS})]$$

where Ψ
and α
are functions calculated for the Ids equation.

Noimod=1

Parameters NoiseP, NoiseR and NoiseC model the drain and gate noise sources, and their correlation.

$$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTg_m\, NoiseP$$

$$\frac{\langle i_g^2 \rangle}{\Delta f} = 4kT\, C_{gs}^2\, \omega^2\, NoiseR / g_m$$

$$\frac{\langle i_g, i_d^* \rangle}{\Delta f} = jNoiseC 4kT\, C_{gs}\, \omega \sqrt{NoiseP \cdot NoiseR}$$

Noimod=2 (supported for linear noise only)

If TMN is specified, Td (drain equivalent temperature) and Tg (gate equivalent temperature) are bias dependent:

$$Td = TD \times (1 + TMN \times (1 + \tanh[\psi]) \times ABS(\tanh[\alpha \times Vds] \times (1 + Lambda \times Vds)))$$

$$Tg = Temp \times (1 + (1 + \tanh[\psi]) \times ABS(\tanh[\alpha \times Vds] \times (1 + Lambda \times Vds)))$$

(ψ and α are functions calculated for the Ids equation)

Ids Flicker Noise Equations

NoiMod=0 (default value)

$$\frac{\langle i_{fl}^2 \rangle}{\Delta f} = 4kTLw\sqrt{\frac{T'_D}{T} I_{dtn} + Td1 \cdot I_{dtn}^2}\left[\frac{Klf}{f^{Np}} + \frac{Klf}{1 + f^2/(Fgr^2)}\right]$$

NoiMod=1 or NoiMod=2

$$\frac{\langle i_{fl}^2 \rangle}{\Delta f} = \frac{4kTg_m P \cdot Fnc}{f} + \frac{KfI_{DS}^{Af}}{f^{Ffe}}$$

Igs, Igd Shot Noise and Flicker Noise Equations

$$\frac{\langle i_{gs}^2 \rangle}{\Delta f} = 2qI_{GS} + \frac{KfI_{GS}^{Af}}{f^{Ffe}}$$

$$\frac{\langle i_{gd}^2 \rangle}{\Delta f} = 2qI_{GD} + \frac{KfI_{GD}^{Af}}{f^{Ffe}}$$

Thermal Noise Equations

Thermal noise of resistance Rgd, Rd, Rg and Rs:

$$\frac{\langle i^2 \rangle}{\Delta f} = 4kT/R$$

Thermal noise of resistance Ri:

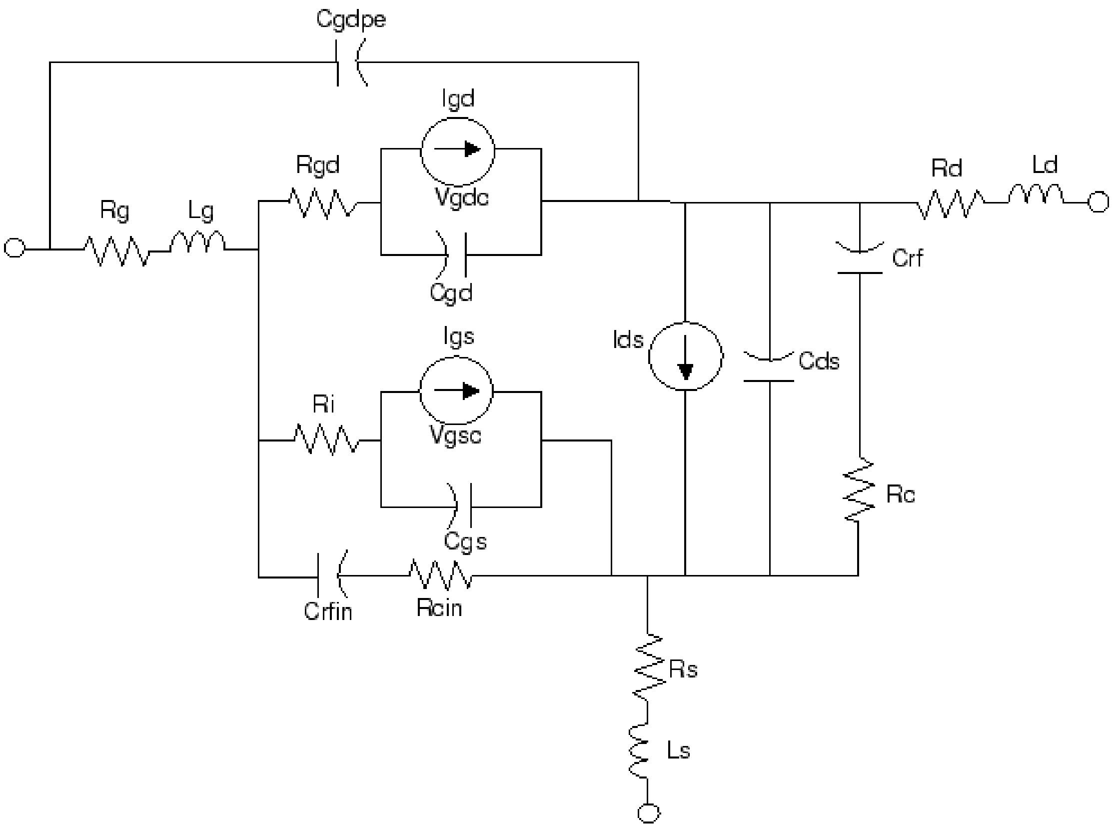
$$\frac{\langle i^2 \rangle}{\Delta f} = 4kTg'/Ri$$

$$Tg' = Tg([1 + (1 + \tanh(\Psi)) \cdot |\tanh(\alpha V_{DS})| \cdot (1 + Lambda \cdot V_{DS})])$$

where Ψ
and α
are functions calculated for the Ids equation.

Additional Information

Equivalent Circuit



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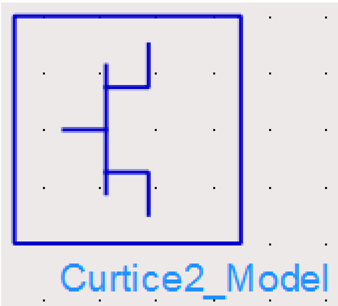
Curtice2 Model (Curtice-Quadratic GaAsFET Model)

Curtice2_Model (Curtice-Quadratic GaAsFET Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NFET	N-channel model type: yes or no	None	yes
PFET	P-channel model type: yes or no	None	no
Idsmod	Ids model: 1=CQ 2=CC 3=Statz 4=Materka 5=Tajima 6=symbolic 7=TOM 8=Modified Materka	None	1
Vto †	threshold voltage	V	-2.0
Beta †, ††	transconductance	A/V^2	1.0e-4
Lambda	channel length modulation	1/V	0.0
Alpha	hyperbolic tangent function	1/V	2.0
Tau	transit time under gate	sec	0.0
Tnom	nominal ambient temperature at which these model parameters were derived	°C	25
Idstc	Ids temperature coefficient		0.0
Vtotc	Vto temperature coefficient	V/°C	0.0
Betatce	BETA Exponential Temperature Coefficient	%/°C	0.0

Rin[†††]	channel resistance	Ohm	0.0
Rf[†††]	gate-source effective forward- bias resistance	Ohm	infinity[‡]
Gscap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Cgs[†,††]	zero bias gate-source junction capacitance	F	0.0
Cgd[†,††]	zero bias gate-drain junction capacitance	F	0.0
Rgd[†††]	gate drain resistance	Ohm	0.0
Gdcap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Fc	coefficient for forward bias depletion capacitance (diode model)	None	0.5
Rd[†††]	drain ohmic resistance	Ohm	fixed at 0.0
Rg	gate resistance	Ohm	fixed at 0.0
Rs[†††]	source ohmic resistance	Ohm	fixed at 0.0
Ld	drain inductance	H	fixed at 0.0
Lg	gate inductance	H	fixed at 0.0
Ls	source inductance	H	fixed at 0.0
Cds[††]	drain-source capacitance	F	0.0
Rc[†††]	used with Crf to model frequency dependent output conductance	Ohm	infinity[‡]
Crf[††]	used with Rc to model frequency dependent output conductance	F	0.0
Gsfwd	0=none, 1=linear, 2=diode	None	linear
Gsrev	0=none, 1=linear, 2=diode	None	None
Gdfwd	0=none, 1=linear, 2=diode	None	None
Gdrev	0=none, 1=linear, 2=diode	None	linear
R1[†††]	approximate breakdown resistance	Ohm	infinity[‡]
R2[†††]	resistance relating breakdown voltage to channel current	Ohm	infinity[‡]
Vbi[†]	built-in gate potential	V	0.85
Vbr	gate-drain junction reverse bias breakdown voltage (gate-source junction reverse bias breakdown voltage with Vds < 0)	V	1e100
Vjr	breakdown junction potential		0.025

Is †, ††	gate junction saturation current (diode model)	A	1.0e-14
Ir	gate reverse saturation current	A	1.0e-14
Imax	explosion current	A	1.6
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 2)	A	defaults to Imax
Xti	temperature exponent for saturation current	None	3.0
Eg	energy gap for temperature effect on Is	eV	1.11
N	gate junction emission coefficient (diode model)	None	1
Fnc	flicker noise corner frequency	Hz	0.0
R	gate noise coefficient	None	0.5
P	drain noise coefficient	None	1.0
C	gate-drain noise correlation coefficient	None	0.9
Taumdl	use second order Bessel polynomial to model tau effect in transient simulation: yes or no	None	no
Kf	Flicker Noise Coefficient	None	0.0
Af	Flicker Noise Exponent	None	1.0
wVgfwd	gate junction forward bias warning	V	
wBvgs	gate-source reverse breakdown voltage warning	V	
wBvgd	gate-drain reverse breakdown voltage warning	V	
wBvds	drain-source breakdown voltage warning	V	
wIdsmax	maximum drain-source current warning	A	
wPmax	maximum power dissipation warning	W	
AllParams	DataAccessComponent for file-based model parameter values	None	None
† Parameter value varies with temperature based on model Tnom and device Temp. †† Parameter value scales with Area. ††† Parameter value scales inversely with Area. ‡ A value of 0.0 is interpreted as infinity.			

- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). A nonlinear device model parameter value that is explicitly specified will override the value set by an AllParams association.

Equations/Discussion

Drain-Source Current

Drain current in the Curtice quadratic model is based on the work of W. R. Curtice [1].
The quadratic dependence of the drain current with respect to the gate voltage is calculated with the following expression in the region $V_{ds} \geq 0.0V$.

I_{ds} = Beta × $(V_{gs}$ - Vto$)^2$ × (1 + Lambda × V_{ds}) × tanh(Alpha × V_{ds}).

Assuming symmetry, in the reverse region, the drain and source swap roles and the expression becomes:

I_{ds} = Beta × $(V_{gd}$ - Vto$)^2$ × (1 - Lambda × V_{ds}) × tanh(Alpha × V_{ds}).

The drain current is set to zero in either case if the junction voltage (V_{gs} or V_{gd}) drops below the threshold voltage Vto.

Junction Charge (Capacitance)

Two options are available for modeling the junction capacitance of a device: model the junction as a linear component (a constant capacitance); model the junction using a diode depletion capacitance model. If a non-zero value of Cgs is specified and Gscap is set to 1 (linear), the gate-source junction will be modeled as a linear component. Similarly, specifying a non-zero value for Cgd and Gdcap = 1 result in a linear gate-drain model. A non-zero value for either Cgs or Cgd together with Gscap =2 (junction) or Gdcap = 2 will force the use of the diode depletion capacitance model for that particular junction. Note that each junction is modeled independent of the other; therefore, it is possible to model one junction as a linear component while the other is treated nonlinearly. The junction depletion charge and capacitance equations are summarized below.

Gate-source junction

For V_{gc} < Fc × Vbi

$$Q_{gs} = 2 \times V_{bi} \times Cgs\left[1 - \sqrt{1 - \frac{V_{gc}}{Vbi}}\right]$$

$$Capacitance_{gs} = \frac{\partial Q_{gs}}{\partial V_{gc}} = \frac{Cgs}{\sqrt{1 - \frac{V_{gc}}{Vbi}}}$$

For $V_{gc\{\ \}} \geq Fc \times Vbi$

$$Q_{gs} = 2 \times Vbi \times Cgs[1 - \sqrt{1 - Fc}] + \frac{Cgs}{(1 - Fc)^{3/2}}$$

$$\times \left[\left(1 - \frac{3 \times Fc}{2}\right) \times (V_{gc} - Fc \times Vbi) + \frac{V_{gc}^2 - (Fc \times Vbi)^2}{4 \times Vbi}\right]$$

$$Capacitance_{gs} = \frac{\partial Q_{gs}}{\partial V_{gc}} = \frac{Cgs}{(1 - Fc)^{3/2}} \times \left[1 - \frac{3 \times Fc}{2} + \frac{V_{gc}}{2 \times Vbi}\right]$$

Gate-drain junction

For $V_{gd} < Fc \times Vbi$

$$Q_{gd} = 2 \times Vbi \times Cgd \times \left[1 - \sqrt{1 - \frac{V_{gd}}{Vbi}}\right]$$

$$Capacitance_{gd} = \frac{\partial Q_{gd}}{\partial V_{gd}} = \frac{Cgd}{\sqrt{1 - \frac{V_{gd}}{Vbi}}}$$

For $V_{gd} \geq Fc \times Vbi$

$$Q_{gd} = 2 \times Vbi \times Cgd[1 - \sqrt{1 - Fc}] + \frac{Cgd}{(1 - Fc)^{3/2}}$$

$$\times \left[\left(1 - \frac{3 \times Fc}{2}\right) \times (V_{gd} - Fc \times Vbi) + \frac{V_{gd}^2 - (Fc \times Vbi)^2}{4 \times Vbi}\right]$$

$$Capacitance_{gd} = \frac{\partial Q_{gd}}{\partial V_{gd}} = \frac{Cgd}{(1 - Fc)^{3/2}} \times \left[1 - \frac{3 \times Fc}{2} + \frac{V_{gd}}{2 \times Vbi}\right]$$

Gate forward conduction and breakdown

Keysight's implementation of the Curtice quadratic model provides a few options for modeling gate conduction current between the gate-source and gate-drain junctions. The simplest model is that proposed by Curtice for his cubic polynomial model (see Curtice3). This model assumes an *effective value* of forward bias resistance Rf and an approximate breakdown resistance R1. With model parameters Gsfwd = 1 (linear) and Rf reset to non-zero, gate-source forward conduction current is given by:

I_{gs} = (V_{gs} - *Vbi*)/Rf when V_{gs} > Vbi

> *= 0 when $V_{gs} \leq$ Vbi.*

If Gsfwd = 2 (diode), the preceding expression for I_{gs} is replaced with the following diode expression:

$$I_{gs} = Is \times \left[exp\left(\frac{V_{gs}}{N \times v_t} \right) - 1 \right]$$

Similarly, with parameter Gdfwd = 1 (linear) and Rf set to non-zero, gate-drain forward conduction current is given by:
I_{gd} = (V_{gd} - Vbi)/Rf when V_{gd} > Vbi

> *= 0 when $V_{gd} \leq$ Vbi.*

If Gdfwd is set to 2 (diode), the preceding expression for Igd is replaced with a diode expression:

$$I_{gd} = Is \times \left[exp\left(\frac{V_{gd}}{N \times v_t} \right) - 1 \right]$$

The reverse breakdown current (I_{dg}) is given by the following expression if R1 is set non-zero and Gdrev = 1 (linear):
I_{gd} = V_{dg} - V_b)/R1 when $V_{dg} \geq V_b$ and $V_b > 0$

> *= 0 when $V_{dg} < V_b$ or $V_b \leq 0$*

V_b = Vbr + R2 × I_{ds}
If Gdrev is set to 2, the preceding Igd expression is replaced with a diode expression:

$$I_{gd} = -Ir \times \left[exp\left(\frac{Vdg - Vb}{Vjr} \right) - 1 \right]$$

With Gsrev -= 1 (linear) and R1 set to non-zero, the gate-source reverse breakdown current Igs is given by the following expression:
I_{gs} = (V_{sg} - Vb)/R1 when $V_{sg} \geq$ Vbi and Vb > 0

= 0 when V_{sg} £ Vbi or Vb ≤ 0
If Gsrev is set to 2, the preceding Igs expression is replaced with a diode expression.

$$I_{gs} = -Ir \times \left[exp\left(\frac{Vsg - Vb}{Vjr} \right) - 1 \right]$$

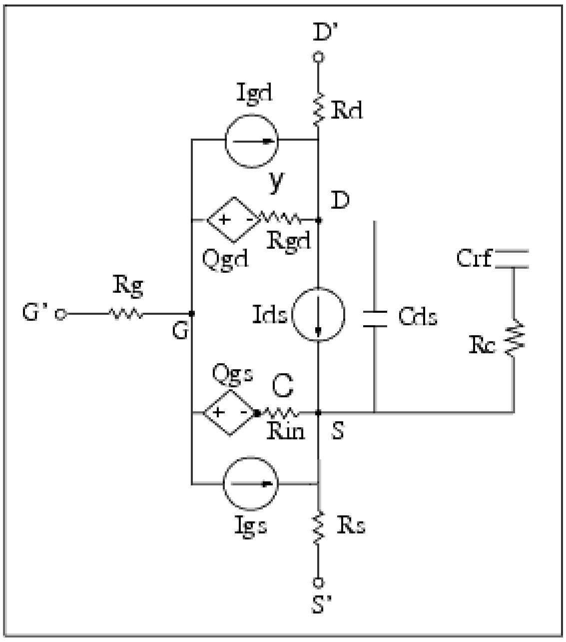
When the diode equations are both enabled, the DC model is symmetric with respect to the drain and source terminals. The AC model will also be symmetric if, in addition to the latter, Cgs=Cgd.

Time delay

This implementation models the delay as an ideal time delay. In the time domain, the drain source current for the ideal delay is given by:
$I_{ds}(t) = I_{ds}(V_j(t - Tau), V_{ds}(t))$
where $V_j = V_{gs}$ or $V_j = V_{gd}$ (depending on whether V_{ds} is positive or negative). In the frequency domain, only the transconductance is impacted by this delay and the familiar expression for transconductance is obtained
$y_m = g_m \times \exp(-j \times \omega \times Tau)$

High-frequency output conductance

The series-RC network in Curtice2_Model Schematic is comprised of the parameters Crf and Rc and is included to provide a correction to the AC output conductance at a specific bias condition. At a frequency high enough such that CRF is an effective short, the output conductance of the device can be increased by the factor 1/Rc. (For more on this, see Reference [2].)



Curtice2_Model Schematic

Temperature Scaling

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device item Temp parameter. (Temperatures in the following equations are in Kelvin.)

The saturation current Is scales as:

$$Is^{NEW} = Is \times exp\left[\left(\frac{Temp}{Tnom} - 1\right)\frac{q \times Eg}{k \times N \times Temp} + \frac{Xti}{N} \times ln\left(\frac{Temp}{Tnom}\right)\right]$$

The gate depletion capacitances Cgs and Cgd vary as:

$$Cgs^{NEW} = Cgs\left[\frac{1 + 0.5[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + 0.5[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Tnom}]}\right]$$

$$Cgd^{NEW} = Cgd\left[\frac{1 + 0.5[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + 0.5[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Tnom}]}\right]$$

where γ is a function of the junction potential and the energy gap variation with temperature.

The gate junction potential Vbi varies as:

$$Vbi^{NEW} = \frac{Temp}{Tnom} \times Vbi + \frac{2k \times Temp}{q} 1n\left(\frac{n_i^{Tnom}}{n_i^{Temp}}\right)$$

where n_i is the intrinsic carrier concentration for silicon, calculated at the appropriate temperature.

The threshold voltage Vto varies as:

$$Vto^{NEW} = Vto + Vtotc(Temp - Tnom)$$

The transconductance Beta varies as:

$$Beta^{NEW} = Beta \times 1.01^{Betatce(Temp - Tnom)}$$

If Betatc = 0 and Idstc ≠ 0

$Ids^{NEW} = Ids \times (1 + Idstc \times (Temp - Tnom))$

Noise Model

Thermal noise generated by resistors Rg, Rs, and Rd is characterized by the following spectral density:

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

Parameters P, R, and C model drain and gate noise sources.

$$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTg_m\ P + 4kTg_m\ PFnc\ /f + Kf\ Ids^{Af}\ /f^{Ffe}$$

$$\frac{\langle i_g^2 \rangle}{\Delta f} = 4kT\ C_{gs}^{\ 2}\ \omega^2\ R/g_m$$

$$\frac{\langle i_g, i_d^* \rangle}{\Delta f} = 4kTj\ C_{gs}\ \omega\sqrt{PR}\ C$$

For Series IV compatibility, set P=2/3, R=0, C=0, and Fnc=0; copy Kf, Af, and Ffe from the Series IV model.

Additional Information

References

- W. R. Curtice, "A MESFET model for use in the design of GaAs integrated circuits," *IEEE Trans Microwave Theory Tech* , vol. MTT-28, pp. 448-456, May 1980.
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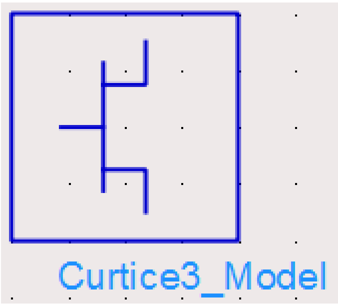
- P. Antognetti and G. Massobrio, *Semiconductor device modeling with SPICE* , New York: McGraw-Hill, Second Edition 1993.
- A. Cappy, "Noise Modeling and Measurement Techniques," *IEEE Transactions on Microwave Theory and Techniques* , Vol. 36, No. 1, pp. 1-10, Jan. 1988.

Curtice3 Model (Curtice-Cubic GaAsFET Model)

Curtice3_Model (Curtice-Cubic GaAsFET Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NFET	N-channel model type: yes or no	None	yes
PFET	P-channel model type: yes or no	None	no
Idsmod	Ids model: 1=CQ 2=CC 3=Statz 4=Materka 5=Tajima 6=symbolic 7=TOM 8=Modified Materka	None	2
Beta2	Coefficient for pinch-off change with respect to Vds	1/V	0.0
Rds0 †††	DC D-S resistance at Vgs=0	Ohm	0
Vout0	output voltage (Vds) at which A0, A1, A2, A3 were evaluated	V	0
Vdsdc	Vds at Rds0 measured bias	V	0
Tau	transit time under gate	sec	0.0
Gamma	current saturation	1/V	2.0
Tnom	nominal ambient temperature at which these model parameters were derived	°C	25
Idstc	Ids temperature coefficient	None	0
A0 †, ††	cubic polynomial Ids equation coefficient 1	A	0

A1 [†], [††]	cubic polynomial Ids equation coefficient 2	A/V	0
A2 [†], [††]	cubic polynomial Ids equation coefficient 3	A/V^2	0
A3 [†], [††]	cubic polynomial Ids equation coefficient 4	A/V^3	0
Vtotc	VTO temperature coefficient	V/°C	0.0
Betatce	BETA Exponential Temperature Coefficient	%/°C	0.0
Rin [†††]	channel resistance	Ohm	0.0
Rf [†††]	gate-source effective forward-bias resistance	Ohm	infinity [‡]
Fc	forward-bias depletion capacitance coefficient (diode model)	None	0.5
Gscap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Cgs [††]	zero-bias gate-source capacitance	F	0.0
Cgd [††]	zero-bias gate-drain capacitance	F	0.0
Rgd [†††]	gate drain resistance	Ohm	0.0
Gdcap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Rd [††]	drain ohmic resistance	Ohm	fixed at 0
Rg	gate resistance	Ohm	fixed at 0
Rs [†††]	source ohmic resistance	Ohm	fixed at 0
Ld	drain inductance	H	fixed at 0.0
Lg	gate inductance	H	fixed at 0.0
Ls	source inductance	H	fixed at 0.0
Cds [††]	drain-source capacitance	F	0.0
Crf [††]	with Rds, models frequency dependent output conductance	F	0.0
Rds [†††]	additional output resistance for RF operation	Ohm	0.0
Gsfwd	0=none, 1=linear, 2=diode	None	linear
Gsrev	0=none, 1=linear, 2=diode	None	None
Gdfwd	0=none, 1=linear, 2=diode	None	None
Gdrev	0=none, 1=linear, 2=diode	None	linear
R1 [†††]	approximate breakdown resistance	Ohm	infinity [‡]
R2 [†††]	resistance relating breakdown voltage to channel current	Ohm	fixed at infinity [‡]

Vbi †	built-in gate potential	V	0.85
Vbr	gate-drain junction reverse bias breakdown voltage (gate- source junction reverse bias breakdown voltage with Vds < 0)	V	1e100
Vjr	breakdown junction potential		0.025
Is † ††	gate junction saturation current (diode model)	A	1.0e-14
Ir	gate reverse saturation current	A	1.0e-14
Xti	Saturation Current Temperature Exponent	None	3.0
Eg	energy gap for temperature effect on Is	None	1.11
N	gate junction emission coefficient (diode model)	None	1
A5	time delay proportionality constant for Vds	None	fixed at 0.0
Imax	explosion current	A	1.6
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 3)	A	defaults to Imax
Taumdl	Use 2nd order Bessel polynomial to model tau effect in transient: yes or no	None	no
Fnc	flicker noise corner frequency	Hz	0.0
R	gate noise coefficient	None	0.5
P	drain noise coefficient	None	1.0
C	gate-drain noise correlation coefficient	None	0.9
Vto	(not used in this model)	None	None
wVgfwd	gate junction forward bias (warning)	V	None
wBvgs	gate-source reverse breakdown voltage (warning)	V	None
wBvgd	gate-drain reverse breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
Kf	flicker noise coefficient	None	0.0
Af	flicker noise exponent	None	1.0
Ffe	flicker noise frequency exponent	None	1.0
AllParams	DataAccessComponent for file-based model parameter values	None	None
† Parameter value varies with temperature based on model Tnom and device Temp. †† Parameter value scales with Area. ††† Parameter value scales inversely with Area. ‡ A value of 0.0 is interpreted as infinity.			

- The Curtice cubic model is based on the work of Curtice and Ettenberg. Curtice3_Model contains most of the features described in Curtice's original paper plus some additional features that may be turned off. The following subsections review the highlights of the model. Refer to Curtice's paper [1] for more information.
- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). A nonlinear device model parameter value that is explicitly specified will override the value set by an AllParams association.

Equations/Discussion

Drain-Source Current

Drain current in Curtice3_Model is calculated with the following expression:

$$I_{ds} = I_{dso} \times \tanh(Gamma \times V_{ds}),\ Tau_{NEW} = Tau + A5 \times Vds$$

where:

$$I_{dso} = [A0 + A1 \times V_1 + A2 \times V_1^2 + A3 \times V_1^3\ ] + (Vds - Vdsdc)/Rds0$$

$$V_1 = V_{gs}(t - Tau_{NEW}) \times (1 + Beta2 \times (Vout0 - V_{ds})),\ when\ V_{ds} \geq 0.0\ V$$

$$V_1 = V_{gd}(t - Tau_{NEW}) \times (1 + Beta2 \times (Vout0 + V_{ds})),\ when\ V_{ds} < 0.0\ V$$

The latter results in a symmetrical drain-source current that is continuous at V_{ds}=0.0 V. For values of V_1 below the internal calculated maximum pinchoff voltage Vpmax, which is the voltage at the local minimum of the function:

$$A0 + A1 \times n + A2 \times n^2 + A3 \times n^3$$

I_{dso} is replaced with the following expression:

$$I_{dso} = [A0 + A1 \times Vpmax + A2 \times Vpmax^2 + A3 \times Vpmax^3] + (Vds - Vdsdc)/Rds0$$

If the I_{dso} value is negative (for V_{ds} > 0.0V), current is set to 0.
This implementation models the delay as an ideal time delay.

NOTE: When Rds0 is defaulted to 0, the term (Vds – Vdsdc)/Rds0 is simply ignored and there is no divide by zero.

Junction Charge (Capacitance)

Two options are provided for modeling the junction capacitance of a device: to model the junction as a linear component (a constant capacitance); to model the junction using a diode depletion capacitance model. If a non-zero value of Cgs is specified and Gscap is set to 1 (linear), the gate-source junction will be modeled as a linear component. Similarly, specifying a non-zero value for Cgd and Gdcap=1 result in a linear gate-drain model. A non-zero value for either Cgs or Cgd together with Gscap=2 (junction) or Gdcap=2 will force the use of the diode depletion capacitance model for that particular junction. Note that each junction is modeled independent of the other; therefore, it is possible to model one junction as a linear component while the other is treated nonlinearly. The junction depletion charge and capacitance equations are summarized next.

Gate-Source Junction

For $V_{gc} < Fc \times Vbi$

$$Q_{gs} = 2 \times V_{bi} \times Cgs \times \left[1 - \sqrt{1 - \frac{V_{gc}}{Vbi}}\right]$$

$$Capacitance_{gs} = \frac{\partial Q_{gs}}{\partial V_{gc}} = \frac{Cgs}{\sqrt{1 - \frac{V_{gc}}{Vbi}}}$$

For $V_{gc} \geq Fc \times Vbi$

$$Q_{gs} = 2 \times V_{bi} \times Cgs \times [1 - \sqrt{1 - Fc}] + \frac{Cgs}{(1 - Fc)^{3/2}}$$

$$\times \left[\left(1 - \frac{3 \times Fc}{2}\right) \times (V_{gc} - Fc \times Vbi)\left(\frac{V_{gc}^2 - (Fc \times Vbi)^2}{4 \times Vbi}\right)\right]$$

$$Capacitance_{gs} = \frac{\partial Q_{gs}}{\partial V_{gc}} = \frac{Cgs}{(1 - Fc)^{3/2}} \times \left[1 - \frac{3 \times Fc}{2} + \frac{V_{gc}}{2 \times Vbi}\right]$$

Gate-Drain Junction

For V_{gd} < Fc × Vbi

$$Q_{gd} = 2 \times V_{bi} \times Cgd \times \left[1 - \sqrt{1 - \frac{V_{gd}}{Vbi}}\right]$$

$$Capacitance_{gd} = \frac{\partial Q_{gd}}{\partial V_{gd}} = \frac{Cgd}{\sqrt{1 - \frac{V_{gd}}{Vbi}}}$$

For V_{gd} ≥ Fc × Vbi

$$Q_{gd} = 2 \times V_{bi} \times Cgd \times \left([1 - \sqrt{1 - Fc}] + \frac{Cgd}{(1 - Fc)^{3/2}}\right)$$

$$\times \left(1 - \frac{3 \times Fc}{2}\right) \times \left(V_{gd} - F(c \times Vbi) + \frac{V_{gd}^2 - (Fbi)^2}{4 \times Vbi}\right)$$

$$Capacitance_{gd} = \frac{\partial Q_{gd}}{\partial V_{gd}} = \frac{Cgd}{(1 - Fc)^{3/2}} \times \left[1 - \frac{3 \times Fc}{2} + \frac{V_{gd}}{2 \times Vbi}\right]$$

Gate Forward Conduction and Breakdown

Keysight's implementation of the Curtice quadratic model provides a few options for modeling gate conduction current between the gate-source and gate-drain junctions. The simplest model is that proposed by Curtice for his cubic polynomial model (see Curtice3). This model assumes an *effective value* of forward bias resistance Rf and an approximate breakdown resistance R1. With model parameters Gsfwd = 1 (linear) and Rf reset to non-zero, gate-source forward conduction current is given by:
I_{gs} = (V_{gs} - Vbi)/Rf when V_{gs} > Vbi

= 0 when $V_{gs} \leq$ Vbi.

If Gsfwd = 2 (diode), the preceding expression for I_{gs} is replaced with the following diode expression:

$$I_{gs} = Is \times \left[exp\left(\frac{V_{gs}}{N \times v_t}\right) - 1\right]$$

Similarly, with parameter Gdfwd = 1 (linear) and Rf set to non-zero, gate-drain forward conduction current is given by:
I_{gd} = (V_{gd} - Vbi)/Rf when V_{gd} > Vbi

= 0 when $V_{gd} \leq Vbi$.

If Gdfwd is set to 2 (diode), the preceding expression for Igd is replaced with a diode expression:

$$I_{gd} = Is \times \left[exp\left(\frac{V_{gd}}{N \times v_t}\right) - 1\right]$$

The reverse breakdown current (I_{dg}) is given by the following expression if R1 is set non-zero and Gdrev = 1 (linear):

$I_{gd} = V_{dg} - V_b)/R1$ when $V_{dg} \geq V_b$ and $V_b > 0$

= 0 when $V_{dg} < V_b$ or $V_b \leq 0$

$V_b = Vbr + R2 \times I_{ds}$

If Gdrev is set to 2, the preceding Igd expression is replaced with a diode expression:

$$I_{gd} = -Ir \times \left[exp\left(\frac{Vdg - Vb}{Vjr}\right) - 1\right]$$

With Gsrev -= 1 (linear) and R1 set to non-zero, the gate-source reverse breakdown current Igs is given by the following expression:

$I_{gs} = (V_{sg} - Vb)/R1$ when $V_{sg} \geq Vbi$ and $Vb > 0$

= 0 when $V_{sg} \leq Vbi$ or $Vb \leq 0$

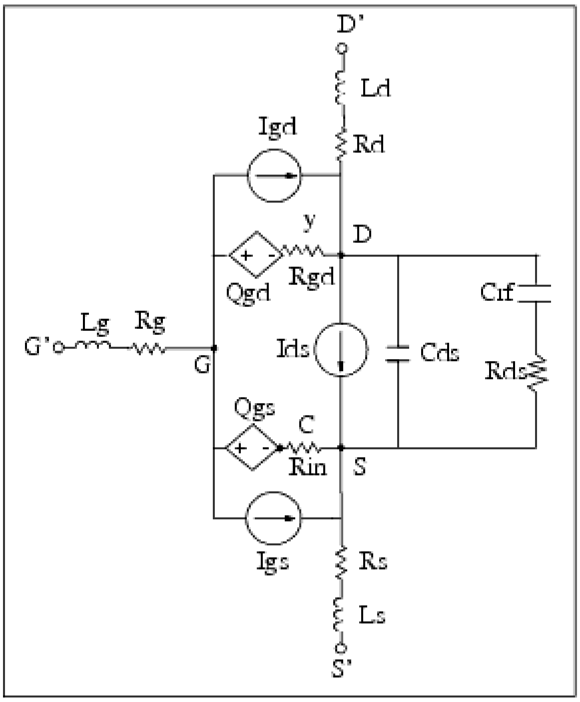
If Gsrev is set to 2, the preceding Igs expression is replaced with a diode expression.

$$I_{gs} = -Ir \times \left[exp\left(\frac{Vsg - Vb}{Vjr}\right) - 1\right]$$

When the diode equations are both enabled, the DC model is symmetric with respect to the drain and source terminals. The AC model will also be symmetric if, in addition to the latter, Cgs=Cgd.

High-Frequency Output Conductance

Curtice3_Model provides the user with two methods of modeling the high frequency output conductance. The series-RC network dispersion model (Curtice Cubic Model) is comprised of the parameters Crf and Rds and is included to provide a correction to the AC output conductance at a specific bias condition. At a frequency high enough such that Crf is an effective short, the output conductance of the device can be increased by the factor 1/Rds. (Also see [2]).



Curtice Cubic Model

Temperature Scaling

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device item Temp parameter. (Temperatures in the following equations are in Kelvin.)

The saturation current Is scales as:

$$Is^{NEW} = Is \times exp\left[\left(\frac{Temp}{Tnom} - 1\right)\frac{q \times Eg}{k \times N \times Temp} + \frac{Xti}{N} \times ln\left(\frac{Temp}{Tnom}\right)\right]$$

The gate depletion capacitances Cgso and Cgdo vary as:

$$Cgs^{NEW} = Cgs\left[\frac{1 + 0.5[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + 0.5[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Tnom}]}\right]$$

$$Cgd^{NEW} = Cgd\left[\frac{1 + 0.5[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + 0.5[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Tnom}]}\right]$$

where *y* is a function of junction potential and energy gap variation with temperature.
The gate junction potential Vbi varies as:

$$Vbi^{NEW} = \frac{Temp}{Tnom} \times Vbi + \frac{2k \times Temp}{q} 1n\left(\frac{n_i^{Tnom}}{n_i^{Temp}}\right)$$

where n_i is the intrinsic carrier concentration for silicon, calculated at the appropriate temperature.
The cubic polynomial coefficients A0, A1, A2, and A3 vary as:

$$\Delta = Vtotc(Temp - Tnom)$$

$$A0^{NEW} = (A0 - \Delta \times A1 + \Delta^2 \times A2 - \Delta^3 \times A3) \times 1.01^{Betatce(Temp - Tnom)}$$

$$A1^{NEW} = (A1 - 2\Delta \times A2 + 3\Delta^2 \times A3 - \Delta^3 \times A3) \times 1.01^{Betatce(Temp - Tnom)}$$

$$A2^{NEW} = (A2 - 3\Delta \times A3) \times 1.01^{Betatce(Temp - Tnom)}$$

$$A3^{NEW} = (A3) \times 1.01^{Betatce(Temp - Tnom)}$$

If Betatc = 0 and Idstc ≠ 0
Ids^{NEW} = Ids × (1 + Idstc × (Temp − Tnom))

Noise Model

Thermal noise generated by resistors Rg, Rs and Rd is characterized by the spectral density:

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

Parameters P, R, and C model drain and gate noise sources.

$$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTg_m\ P + 4kTg_m\ PFnc\ /f + Kf\ Ids^{Af}\ /f^{Ffe}$$

$$\frac{\langle i_g^2 \rangle}{\Delta f} = 4kT\ C_{gs}^{\ 2}\ \omega^2\ R/g_m$$

$$\frac{\langle i_g, i_d^* \rangle}{\Delta f} = 4kTj\ C_{gs}\ \omega\sqrt{PR}\ C$$

For Series IV compatibility, set P=2/3, R=0, C=0, and Fnc=0; copy Kf, Af, and Ffe from the Series IV model.

Calculation of Vto Parameter

The Vto parameter is not used in this model. Instead, it is calculated internally to avoid the discontinuous or non-physical characteristic in ids versus vgs if A0, A1, A2, A3 are not properly extracted.
For a given set of As, ADS will try to find the maximum cutoff voltage (Vpmax), which satisfies the following conditions:

> *f(Vpmax) = A0 + A1 × Vpmax + A2 × Vpmax^2 × 2 + A3 × Vpmax^3 × 3 ≤ 0*
> *first derivative of f(Vpmax) = 0 (inflection point)*
> *second derivative of f(Vpmax) > 0 (this is a minimum)*

If Vpmax cannot be found, a warning message is given *cubic model does not pinch off* .
During analysis, the following are calculated:

> *vc = vgs × (1 + Beta2 × (Vout0 - vds))*
> *ids = ((A0 + A1 × vc + A2 × vc×^{2} + A3 × vc×^{3}) + (vds − Vdsdc) / Rds0)*
> *× tanh(Gamma × vds)*

If ids < 0 then sets ids = 0.

If ids > 0 and Vc ≤ Vpmax then calculates ivc as follows:

ivc = (f(Vpmax) + (vds - Vdsdc) / Rds0) × tanh(Gamma × vds)
If ivc > 0 then sets ids = ivc and gives a warning message *Curtice cubic model does not pinch off, Ids truncated at minimum*.

> *else set ids = 0*

To ensure the model is physical and continuous, it is important to obtain a meaningful set of As that Vpmax can be found.

Additional Information

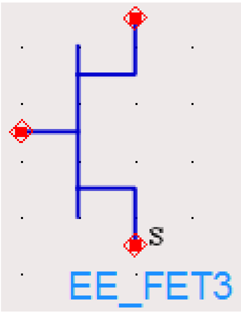
References

- W. R. Curtice and M. Ettenberg, "A nonlinear GaAsFET model for use in the design of output circuits for power amplifiers," *IEEE Trans of Microwave Theory Tech* , vol. MTT-33, pp. 1383-1394, Dec. 1985.
- C. Camacho-Penalosa and C.S. Aitchison, "Modelling frequency dependence of output impedance of a microwave MESFET at low frequencies," *Electron. Lett.,* Vol. 21, pp. 528-529, June 6, 1985.
- P. Antognetti and G. Massobrio, *Semiconductor device modeling with SPICE,* New York: McGraw-Hill, Second Edition 1993.
- A. Cappy, "Noise Modeling and Measurement Techniques," *IEEE Transactions on Microwave Theory and Techniques* , Vol. 36, No. 1, pp. 1-10, Jan. 1988.

EE FET3 (EEsof Scalable Nonlinear GaAsFet, Second Generation)

EE_FET3 (EEsof Scalable Nonlinear GaAsFet, Second Generation)

Symbol



Range of Usage

Ugw > 0
N > 0

Parameters

Name	Description	Units	Default
Model	name of an EE_FET3_Model	None	EEFET3M1
Ugw	unit gate width	None	0.0
N	number of gate fingers	None	1
Temp	device operating temperature	°C	25
Noise	noise generation option: yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

- Ugw and N are used for scaling device instance as described in the EE_FET3_Model information.
- The following table lists the DC operating point parameters that can be sent to the dataset.

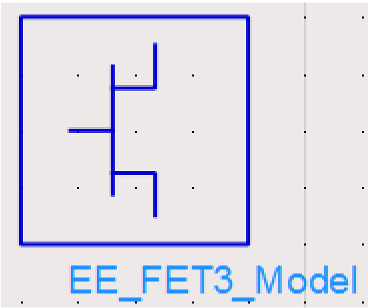
DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
GmAc	Forward transconductance (dIds/dVgs + dIdb/dVgs)	siemens
GdsAc	Output conductance (dIds/dVds + dIdb/dVgd)	siemens
Ggs	Gate-source conductance	siemens
Ggd	Gate-drain conductance	siemens
dIgd_dVgs	(dIgd/dVgs)	siemens
Cgc	Gate-source capacitance (dQgc/dVgc)	farads
dQgc_dVgy	(dQgc/dVgy)	farads
Cgy	Gate-drain capacitance (dQgy/dVgy)	farads
dQgy_dVgc	(dQgy/dVgc)	farads
Vgs	Gate-source voltage	volts
Vds	Gate-drain voltage	volts

EE FET3 Model (EEsof Scalable Nonlinear GaAsFet Model)

EE_FET3_Model (EEsof Scalable Nonlinear GaAsFet Model)

Symbol



Parameters

Name	Description	Units	Default
Vto	zero bias threshold	V	-1.5
Gamma	Transconductance	1/V	0.05
Vgo	gate-source voltage where transconductance is a maximum	V	0.0
Vdelt	controls linearization point for transconductance characteristic	V	0.0
Vch	gate-source voltage where Gamma no longer affects I-V curves	V	1.0
Gmmax	peak transconductance	S	70.0e-03
Vdso	Drain voltage where Vo dependence is nominal	V	2.0
Vsat	drain-source current saturation	V	1.0
Kapa	output conductance	S	1.0

Name	Description	Units	Default
Peff	channel to backside self-heating	W	2.0
Vtso	subthreshold onset voltage	V	-10.0
Is	gate junction reverse saturation current	A	1.0e-14
N	gate junction ideality factor	None	1.0
Ris	source end channel resistance	Ohm	0.0
Rid	drain end channel resistance	Ohm	0.0
Tau	gate transit time delay	sec	0.0
Cdso	drain-source inter-electrode capacitance	F	80.0e-15
Rdb	dispersion source output impedance	Ohm	1.0e+9
Cbs	trapping-state capacitance	F	1.6e-13
Vtoac	zero bias threshold (AC)	V	-1.5
Gammaac	Vds dependent threshold (AC)	1/V	0.05
Vdeltac	controls linearization point for transconductance characteristic (AC)	V	0.0
Gmmaxac	peak transconductance (AC)	S	60.0e-03
Kapaac	output conductance (AC)	S	0.0
Peffac	channel to backside self-heating (AC)	W	10.0
Vtsoac	subthreshold onset voltage (AC)	V	-10.0
Gdbm	additional d-b branch conductance at Vds = Vdsm	0.0	
Kdb	controls Vds dependence of additional d-b branch conductance.	None	0.0

Name	Description	Units	Default
Vdsm	voltage where additional d-b branch conductance becomes constant	V	1.0
C11o	maximum input capacitance for Vds=Vdso and Vdso>Deltds	F	0.3e-12
C11th	minimum (threshold) input capacitance for Vds=Vdso	F	0.03e-12
Vinfl	inflection point in C11-Vgs characteristic	V	-1.0
Deltgs	C11th to C110 transition voltage	V	0.5
Deltds	linear region to saturation region transition	V	1.0
Lambda	C11-Vds characteristic slope	1/V	1.0
C12sat	input transcapacitance for Vgs=Vinfl and Vds>Deltds	F	0.03e-12
Cgdsat	gate drain capacitance for Vds>Deltds	F	0.05e-12
Kbk	breakdown current coefficient at threshold	None	0.0
Vbr	drain-gate voltage where breakdown source begins conducting	V	15.0
Nbr	breakdown current exponent	None	2.0
Idsoc	open channel (maximum) value of Ids	A	100.0e-03
Rd	drain contact resistance	Ohm	1.0
Rs	source contact resistance	Ohm	1.0
Rg	gate metallization resistance	Ohm	1.0
Ugw	unit gate width of device	None	0.0
Ngf	number of device gate fingers	None	1.0
Tnom	Nominal ambient temperature	°C	25.0

Name	Description	Units	Default
Rgtc	linear temperature coefficient for RG	1/°C	0.0
Rdtc	linear temperature coefficient for RD	1/°C	0.0
Rstc	linear temperature coefficient for RS	1/°C	0.0
Vtotc	Vto temperature coefficient	V/°C	0.0
Gmmaxtc	Gmmax temperature coefficient	S/°C	0.0
Gammatc	Gamma temperature coefficient	None	0.0
Vinfltc	Vinfl temperature coefficient	V/°C	0.0
Vtoactc	Vtoac temperature coefficient	V/°C	0.0
Gmmaxactc	Gmmaxac temperature coefficient	S/°C	0.0
Gammaactc	Gammaac temperature coefficient	None	0.0
Xti	Temperature Exponent for Saturation Current	None	3.0
wVgfwd	gate junction forward bias (warning)	V	None
wBvgs	gate-source reverse breakdown voltage (warning)	V	None
wBvgd	gate-drain reverse breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

- To prevent numerical problems, the setting of some model parameters to 0 is trapped by the simulator. The parameter values are changed:

Rd = 10^{-4}
Rs = 10^{-4}
Rg = 10^{-4}
Ris = 10^{-4}
Rid = 10^{-4}
Vsat = 0.1
Peff = 10^{-6}
Peffac = 10^{-6}
Deltds = 0.1
Deltgs = 0.1
Idsoc = 0.1
Is = 10^{-50}

- Model parameters such as Ls, Ld, and Lg (as well as other package related parameters that are included as part of the output from the EEFET3 IC-CAP model file) are not used by the EE_FET3 device in the simulator. Only those parameters listed are part of the EE_FET3 device. Any extrinsic devices must be added externally by the user.

Equations/Discussion

EE_FET3 is an empirical analytic model that was developed by Keysight EEsof for the express purpose of fitting measured electrical behavior of GaAs FETs. The model represents a complete redesign of the previous generation model EEFET1-2 and includes the following features:

- Accurate isothermal drain-source current model fits virtually all processes.
- Self-heating correction for drain-source current.
- Improved charge model more accurately tracks measured capacitance values.
- Dispersion model that permits simultaneous fitting of high-frequency conductances and DC characteristics.
- Improved breakdown model describes gate-drain current as a function of both V_{gs} and V_{ds}.
- Well-behaved (non-polynomial) expressions permit accurate extrapolations outside of the measurement range used to extract the model.

The model equations were developed concurrently with parameter extraction techniques to ensure the model would contain only parameters that were extractable from measured data. Although the model is amenable to automated parameter extraction techniques, it was designed to consist of parameters that are easily estimated (visually) from measured data such as g_m -V_{gs} plots. The increased number of model parameters is commensurate with the improvement in accuracy as compared with other popular empirical models. Since the model equations are all well-behaved analytic expressions, EE_FET3 possesses no inherent limitations with respect to its usable power range. Keysight EEsof's IC-CAP program provides the user with the capability of extracting EEFET3 models from measured data.

Drain-Source Current

The drain-source current model in EE_FET3 is comprised of various analytic expressions that were developed through examination of g_m vs. bias plots on a wide class of devices from various manufacturers. The expressions below are given for V_{ds} > 0.0V although the model is equally valid for V_{ds} < 0.0V. The model assumes the device is symmetrical, and one need only replace V_{gs} with V_{gd} and V_{ds} with -V_{ds} in order to obtain the reverse region (V_{ds} < 0.0V) equations. The g_m, g_{ds} and I_{ds} equations take on four different forms depending on the value of V_{gs} relative to some of the model parameters. The I_{ds} expression is continuous through at least the second derivative everywhere.

if $V_{gs} \geq V_g$ and $V_{delt} \leq 0.0$

$$g_{mo} = Gmmax\{1 + Gamma(Vdso - V_{ds})\}$$

$$I_{dso} = Gmmax\left\{V_x(V_{gs}) - \frac{(Vgo + Vto)}{2} + Vch\right\}$$

$$g_{dso} = -Gmmax(Gamma(V_{gs} - Vch))$$

else if $V_{Delt} > 0.0$ and $V_{gs} > V_{gb}$

$$g_{mo} = g_{mm}(V_{gb}) + m_{g_{mm}} \times (V_{gs} - V_{gb})$$

$$I_{dso} = g_{mm}(V_{gb}) \times (V_{gs} - V_{gb}) + \frac{m_{g_{mm}}}{2}(V_{gs} - V_{gb})^2 + I_{dsm}(V_{gb})$$

$$g_{dso} = \frac{\partial(g_{mm}(V_{gb}))}{\partial V_{ds}}(V_{gs} - V_{gb}) + \frac{1}{2}(V_{gs} - V_{gb})^2 \times \frac{\partial m_{g_{mm}}}{\partial V_{ds}} - \frac{\partial V_{gb}}{\partial V_{ds}} g_{mo}$$

else if $V_{gs} \leq V_t$

$$g_{mo} = 0.0$$

$$I_{dso} = 0.0$$

$$g_{dso} = 0.0$$

else

$$g_{mo} = g_{mm}(V_{gs})$$

$$I_{dso} = I_{dsm}(V_{gs})$$

$$g_{dso} = -\frac{Gmmax}{2}Gamma(V_{gs} - Vch)$$

$$\times\left\{\cos\left[\pi\times\frac{V_x(V_{gs})-(Vgo-Vch)}{Vto-Vgo}\right]+1\right\}$$

where:

$$g_{mm}(V) = \frac{Gmmax}{2}[1+Gamma(Vdso-V_{ds})]$$

$$\times\left\{\cos\left[\pi\times\frac{V_x(V)-(Vgo-Vch)}{Vto-Vgo}\right]+1\right\}$$

$$I_{dsm}(V) = \frac{Gmmax}{2}\Big(((Vto-Vgo)/\pi)\sin\left[\pi\times\frac{V_x(V)-(Vgo-Vch)}{Vto-Vgo}\right]$$

$$+V_x(V)-(Vto-Vch))$$

$$V_x(V) = (V-Vch)[1+Gamma(Vdso-V_{ds})]$$

$$V_g = \frac{Vgo-Vch}{1+Gamma(Vdso-V_{ds})}+Vch$$

$$V_t = \frac{Vto-Vch}{1+Gamma(Vdso-V_{ds})}+Vch$$

$$V_{gb} = \frac{(Vgo-Vdelt)-Vch}{1+Gamma(Vdso-V_{ds})}+Vch$$

$$m_{g_{mm}} = \left.\frac{\partial g_{mm}}{\partial V}\right|_{V=V_{gb}}$$

$$= -\frac{Gmmax\pi}{2(Vto-Vgo)}[1+Gamma(Vdso-V_{ds})]^2$$

$$\times\sin\left[-\pi\times\frac{Vdelt}{Vto-Vgo}\right]$$

$$g_{mm}(V_{gb}) = \frac{Gmmax}{2}[1+Gamma(Vdso-V_{ds})]$$

$$\times\left\{\cos\left[-\pi\times\frac{Vdelt}{Vto-Vgo}\right]+1\right\}$$

$$I_{dsm}(V_{gb}) = \frac{Gmmax}{2}\Big(((Vto-Vgo)/\pi)\sin\left[-\pi\times\frac{Vdelt}{Vto-Vgo}\right]$$

$$+(Vgo-Vdelt-Vto))$$

$$\frac{\partial(g_{mm}(V_{gb}))}{\partial V_{ds}} = -\frac{Gmmax}{2}Gamma\left\{\cos\left[-\pi\times\frac{Vdelt}{Vto-Vgo}\right]+1\right\}$$

$$\frac{\partial m_{g_{mm}}}{\partial V_{ds}} = \frac{Gmmax\pi}{(Vto-Vgo)}(Gamma)[1+Ganna(Vdso-V_{ds})]$$

$$\times\sin\left[-\pi\times\frac{Vdelt}{Vto-Vgo}\right]$$

$$\frac{\partial V_{gb}}{\partial V_{ds}} = \frac{(Vgo-Vdelt)-Vch}{[1+Gamma(Vdso-V_{ds})]^2}\times Gamma$$

The preceding relations for I_{dso}, g_{mo} and g_{dso} can now be substituted in the following equations that model the current saturation and output conductance. This portion of the model can be recognized from the work of Curtice [1].

$$g'_m = g_{mo}(1+Kapa\times V_{ds})\tanh\left(\frac{3V_{ds}}{Vsat}\right)$$

$$I'_{ds} = I_{dso}(1+Kapa\times V_{ds})\tanh\left(\frac{3V_{ds}}{V(sat)}\right)$$

$$g'_{ds} = \{g_{dso}(1+Kapa\times V_{ds})+I_{dso}Kapa\}\tanh\left(\frac{3V_{ds}}{Vsat}\right)$$

$$+I_{dso}\times\frac{3(1+Kapa\times V_{ds})}{Vsat}\operatorname{sech}^2\left(\frac{3V_{ds}}{Vsat}\right)$$

These expressions do an excellent job of fitting GaAs FET I-V characteristics in regions of low power dissipation; they will also fit pulsed (isothermal) I-V characteristics. In order to model negative conductance effects due to self-heating, the thermal model of Canfield was incorporated [2]. With this final enhancement, the DC expressions for I_{ds} and associated conductances become:

$$I_{ds} = \frac{I'_{ds}}{1 + \frac{P_{diss}}{Peff}}$$

$$g_m = \frac{g'_m}{\left[1 + \frac{P_{diss}}{Peff}\right]^2}$$

$$g_{ds} = \frac{g'_{ds} - \frac{I'^2_{ds}}{Peff}}{\left[1 + \frac{P_{diss}}{Peff}\right]^2}$$

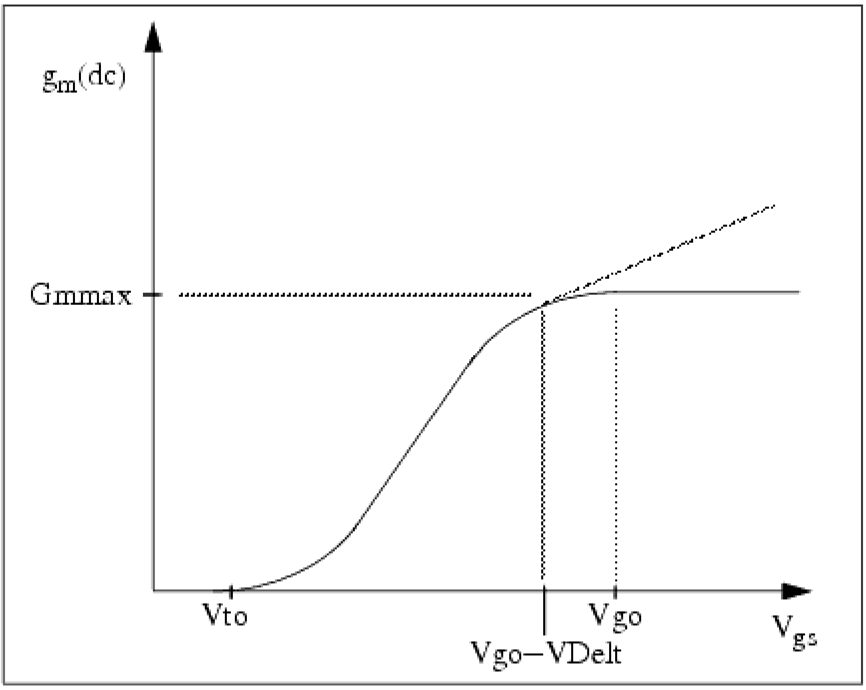
where:

$$P_{diss} = I'_{ds} V_{ds}$$

Qualitatively, operation of the drain-source model can be described as follows.
The V_{ds} dependence of the equations is dominated by the parameters Vsat, Gamma, Kapa, and Peff. Isothermal output conductance is controlled by Gamma and Kapa. The impact of Gamma on output conductance is more significant near threshold. At V_{gs}=Vch, the output conductance is controlled only by Kapa. The parameter Peff provides a correction to the isothermal model for modeling the self-heating effects manifested as a negative resistance on the I-V curves. The parameter Vsat represents the drain-source voltage at which the current saturates and output conductance becomes a constant (approximately).

The overall impact of Vch on the I-V characteristics is second order at best, and many different values of Vch will provide good fits to I-V plots. For most applications encountered, it is our experience that the default value of 1.0V is an adequate value for Vch. Similar to Vch, Vdso is a parameter that should be set rather than optimized. At V_{ds}=Vdso, the drain-source model collapses to a single voltage dependency in V_{gs}. It is recommended that the user set Vdso to a typical V_{ds} operating point in saturation. At this point, many of the parameters can be extracted right off a I_{ds} - V_{gs} plot for V_{ds}=Vdso or preferably, a g_m(DC)-V_{gs} plot at V_{ds}=Vdso.

When V_{ds}=Vdso and Peff is set large (to disable the self-heating model), the significance of the parameters Vto, Vgo, Vdelt, Gmmax are easily understood from a plot of g_m(DC)–V_{gs}. Gmmax is the peak constant transconductance of the model that occurs at V_{gs}=Vgo. The parameter Vto represents the gate-source voltage where g_m goes to zero. If Vdelt is set to a positive value, then it causes the transconductance to become linear at V_{gs} = Vgo–Vdelt with a slope equal to that of the underlying cosine function at this voltage. The parameter definitions are shown in the following illustration.



EEFET3 g_m -V $_{gs}$ Parameters

Dispersion Current (Idb)

Dispersion in a GaAs MESFET drain-source current is evidenced by the observation that the output conductance and transconductance beyond some transition frequency is higher than that inferred by the DC measurements. A physical explanation often attributed to this phenomenon is that the channel carriers are subject to being trapped in the channel-substrate and channel-surface interfaces. Under slowly varying signal conditions, the rate at which electrons are trapped in these sites is equal to the rate at which they are emitted back into the channel. Under rapidly varying signals, the traps cannot follow the applied signal and the *high-frequency* output conductance results.

The circuit used to model conductance dispersion consists of the devices Rdb, Cbs (these linear devices are also parameters) and the nonlinear source $I_{db}(V_{gs}, V_{ds})$. The model is a large-signal generalization of the dispersion model proposed by Golio et al. [3]. At DC, the drain-source current is just the current I_{ds}. At high frequency (well above transition frequency), drain source current will be equal to I_{ds}(high frequency) = I_{ds}(dc) + I_{db}. Linearization of the drain-source model yields the following expressions for y_{21} and y_{22} of the intrinsic EE_FET3 model.

$$y_{21} = g_{dsgs} + g_{dbgs} - \frac{g_{dbgs}}{1 + j\omega \times Cbs(Rdb)}$$

$$y_{22} = g_{dsds} + g_{dbds} + \frac{1}{Rdb} - \frac{\left(g_{dbds} + \frac{1}{Rdb}\right)}{1 + j\omega \times Cbs(Rdb)}$$

where:

$$g_{dsgs} = \frac{\partial I_{ds}}{\partial V_{gs}}$$

$$g_{dsds} = \frac{\partial I_{ds}}{\partial V_{ds}}$$

$$g_{dbgs} = \frac{\partial I_{db}}{\partial V_{gs}}$$

$$g_{dbds} = \frac{\partial I_{db}}{\partial V_{ds}}$$

Evaluating these expressions at the frequencies ω=0 and ω=infinity produces the following results for transconductance and output conductance:

for ω=0,

$$Re[y_{21}] = g_m = g_{dsgs}$$

$$Re[y_{22}] = g_{ds} = g_{dsds}$$

for ω=infinity,

$$Re[y_{21}] = g_m = g_{dsgs} + g_{dbgs}$$

$$Re[y_{22}] = g_{ds} = g_{dsds} + g_{dbds} + \frac{1}{Rdb}$$

Between these two extremes, the conductances make a smooth transition, the abruptness of which is governed by the time constant τ_{disp} = Rdb × Cbs. The frequency f_0 at which the conductances are midway between these two extremes is defined as:

$$f_0 = \frac{1}{2\pi\tau_{disp}}$$

The parameter Rdb should be set large enough so that its contribution to the output conductance is negligible. Unless the user is specifically interested in simulating the device near f_0, the default values of Rdb and Cbs will be adequate for most microwave applications.

The EE_FET3 I_{ds} model can be extracted to fit either DC or AC characteristics. In order to simultaneously fit both DC I-V and AC conductances, EE_FET3 uses a simple scheme for modeling the I_{db} current source whereby different values of the same parameters can be used in the I_{ds} equations. The DC and AC drain-source currents can be expressed as follows:

$$I_{ds}^{dc}(Voltages, Parameters) = I_{ds}(Voltages, Gmmax, Vdelt, Vto, \mathrm{Gamma},$$

$$Kapa, Peff, Vtso, Vgo, Vch, Vdso, Vsat)$$

$$I_{ds}^{ac}(Voltages, Parameters) = I_{ds}(Voltages, Gmmaxac, Vdeltac, Vtoac,$$

$$Gammaac, Kappaac, Peffac, Vtsoac,$$

$$Vgo, Vch, Vdso, Vsat)$$

Parameters such as Vgo that do not have an AC counterpart (there is no Vgoac parameter) have been found to not vary significantly between extractions using DC measurements versus those using AC measurements. The difference between the AC and DC values of I_{ds}, plus an additional term that is a function of V_{ds} only, gives the value of I_{db} for the dispersion model

$$I_{db}(V_{gs}, V_{ds}) = I_{ds}^{ac}(V_{gs}, V_{ds}) - I_{ds}^{dc}(V_{gs}, V_{ds}) + I_{dbp}(V_{ds})$$

where I_{dbp} and its associated conductance are given by:

for V_{ds} > Vdsm and $Kdb \neq 0$:

$$I_{dbp} = \sqrt{\frac{Gdbm}{Kdb}}\tan^{-1}((V_{ds} - Vdsm)\sqrt{Kdb(Gdbm)})$$

$$+ Gdbm(Vdsm)$$

$$g_{dbp} = \frac{Gdbm}{(Kdb(Gdbm(V_{ds} - Vdsm)^2 + 1))}$$

for V_{ds} < -Vdsm and $Kdb \neq 0$:

$$I_{dbp} = \sqrt{\frac{Gdbm}{Kdb}} \tan^{-1}((V_{ds} + Vdsm)\sqrt{Kdb(Gdbm)})$$

$$-Gdbm \times Vdsm$$

$$g_{dbp} = \frac{Gdbm}{(Kdb(Gdbm(V_{ds} + Vdsm)^2 + 1))}$$

for $-Vdsm \leq V_{ds} \leq Vdsm$

or $Kdb = 0$:

$$I_{dbp} = Gdbm \times V_{ds}$$

$$g_{dbp} = Gdbm$$

By setting the 7 high-frequency parameters equal to their DC counterparts, the dispersion model reduces to I_{db}=I_{dbp}. Examination of the I_{dbp} expression reveals that the additional setting of Gdbm to 0 disables the dispersion model entirely. The I_{dbp} current is a function of V_{ds} only, and will impact output conductance only. However, the current function I_{ds}^{ac} will impact g_m and g_{ds}.

Therefore, the model is primarily to use g_m data as a means for tuning I_{ds}^{ac}.
Once this *fitting* is accomplished, Gdbm, Kdb and Vdsm can be tuned to optimize the g_{ds} fit.

Gate Charge Model

The EE_FET3 gate charge model was developed through careful examination of extracted device capacitances over bias. The model consists of simple closed form charge expressions whose derivatives fit observed bias dependencies in capacitance data. This capacitances data can be obtained directly from measured Y-parameter data.

$$C_{11} = \frac{im[y_{11}]}{\omega} = \frac{\partial q_g}{\partial V_{gs}}$$

$$C_{12} = \frac{im[y_{12}]}{\omega} = \frac{\partial q_g}{\partial V_{ds}}$$

The capacitance data is remarkably self-consistent. In other words, a single q_g function's derivatives will fit both C_{11} data and C_{12} data. The EE_FET3 gate charge expression is:

$$q_g(V_j, V_o) = \left[\frac{(C11o - C11th)}{2} g(V_j) + C11th(V_j - Vinfl)\right]$$

$$\times [1 + Lambda(V_o - Vdso)] - C11sat \times V_o$$

where:

$$g(V_j) = V_j - Vinfl + \frac{Deltgs}{3}\log\left(\cosh\left(\frac{3}{Deltgs}(V_j - Vinfl)\right)\right)$$

This expression is valid for both positive and negative V_{ds}. Symmetry is forced through the following smoothing functions proposed by Statz [4]:

$$V_j = \frac{1}{2}\left(2V_{gs} - V_{ds} + \sqrt{V_{ds}^2 + Deltds^2}\right)$$

$$V_o = \sqrt{V_{ds}^2 + Deltds^2}$$

Differentiating the gate charge expression wrt V_{gs} yields the following expression for the gate capacitance C_{11}:

$$C_{11}(V_j, V_o) = \left[\frac{(C11o - C11th)}{2} \times g'(V_j) + C11th\right]$$

$$\times [1 + Lambda(V_o - Vdso)]$$

where:

$$g'(V_j) = \frac{dg(V_j)}{dV_j} = 1 + \tanh\left[\frac{3}{Deltds}(V_j - Vinfl)\right]$$

The gate transcapacitance C_{12} is defined as:

$$C_{12}(V_j, V_o) = \frac{\partial q_g}{\partial V_{ds}} = \frac{\partial q_g}{\partial V_j}\frac{\partial V_j}{\partial V_{ds}} + \frac{\partial q_g}{\partial V_o}\frac{\partial V_o}{\partial V_{ds}}$$

$$= C_{11}(V_j, V_o) \times \frac{1}{2}\left[\frac{V_{ds}}{\sqrt{V_{ds}^2 + Deltds^2}} - 1\right]$$

$$+ [[g'(V_j) + C11th(V_j - Vinfl)] \times Lambda(-C12sat)]$$

$$\times \frac{V_{ds}}{\sqrt{V_{ds}^2 + Deltds^2}}$$

The EE_FET3 topology requires that the gate charge be subdivided between the respective charge sources q_{gc} and q_{gy}. Although simulation could be performed directly from the nodal gate charge q_g, division of the charge into branches permits the inclusion of the resistances Ris and Rid that model charging delay between the depletion region and the channel. EE_FET3 assumes the following form for the gate-drain charge in saturation:

$$q_{gy}(V_{gy}) = Cgdsat(V_{gy} + q_{gyo})$$

which gives rise to a constant gate-drain capacitance in saturation. The gate-source charge q_{gc} can now be obtained by subtracting the latter from the gate charge equation. Smoothing functions can then be applied to these expressions in saturation in order to extend the model's applicable bias range to all V_{ds} values.

These smoothing functions force symmetry on the q_{gy} and q_{gc} charges such that

$$q_{gy} = q_{gc} = \frac{q_g}{2}$$

at $V_{gc} = V_{gy}$. Under large negative V_{ds} (saturation at the source end of the device), q_{gy} and q_{gc} swap roles:

$$q_{gc}(V_{gc}) = Cgdsat(V_{gc} + q_{gco})$$

The following continuous charge equations satisfy these constraints and are specified in terms of the gate charge.

$$q_{gy}(V_{gc}, V_{gy}) = \{q_g(V_{gc}, V_{gc} - V_{gy}) - Cgdsat \times V_{gc}\} \times f_2$$

$$+ Cgdsa \times V_{gy} \times f_1$$

$$q_{gc}(V_{gc}, V_{gy}) = \{q_g(V_{gc}, V_{gc} - V_{gy}) - C(gdsat \times V_{gy})\} \times f_1$$

$$+ Cgdsat \times V_{gc} \times f_2$$

where f_1 and f_2 are smoothing functions defined by

$$f_1 = \frac{1}{2}\left[1 + \tanh\left(\frac{3}{Deltds}(V_{gc} - V_{gy})\right)\right]$$

and

$$f_2 = \frac{1}{2}\left[1 - \tanh\left(\frac{3}{Deltds}(V_{gc} - V_{gy})\right)\right]$$

The capacitances associated with these *branch* charge sources can be obtained through differentiation of the q_{gc} and q_{gy} equations and by application of the chain rule to capacitances C_{11} and C_{12}. The gate charge derivatives re-formulated in terms of V_{gc} and V_{gy} are:

$$C_{ggy} = \frac{\partial q_g}{\partial V_{gy}} = -C_{12}(V_{gc}, V_{gc} - V_{gy})$$

$$C_{ggc} = \frac{\partial q_g}{\partial V_{gc}} = C_{11}(V_{gc}, V_{gc} - V_{gy}) + C_{12}(V_{gc}, V_{gc} - V_{gy})$$

The branch charge derivatives are:

$$C_{gygy} = \frac{\partial q_{gy}}{\partial V_{gy}} = \{q_g(V_{gc}, V_{gc} - V_{gy}) - Cgdsat \times V_{gc}\} \times \frac{\partial f_2}{\partial V_{gy}}$$

$$+ f_2 \times C_{ggy} + Cgdsat \times \left[V_{gy} \times \frac{\partial f_1}{\partial V_{gy}} + f_1\right]$$

$$C_{gygc} = \frac{\partial q_{gy}}{\partial V_{gc}} = \{q_g(V_{gc}, V_{gc} - V_{gy}) - Cgdsat \times V_{gc}\} \times \frac{\partial f_2}{\partial V_{gc}}$$

$$+ f_2 \times [C_{ggc} - Cgdsat] + Cgdsat \times V_{gy} \times \frac{\partial f_1}{\partial V_{gc}}$$

$$C_{gcgc} = \frac{\partial q_{gc}}{\partial V_{gc}} = \{q_g(V_{gc}, V_{gc} - V_{gy}) - Cgdsat \times V_{gy}\} \times \frac{\partial f_1}{\partial V_{gc}}$$

$$+ f_1 \times C_{ggc} + Cgdsat \times \left[V_{gc} \times \frac{\partial f_2}{\partial V_{gc}} + f_2\right]$$

$$C_{gcgy} = \frac{\partial q_{gc}}{\partial V_{gy}} = \{q_g(V_{gc}, V_{gc} - V_{gy}) - C(gdsat \times V_{gy})\} \times \frac{\partial f_1}{\partial V_{gy}}$$

$$+ f_1 \times [C_{ggy} - Cgdsat] + Cgdsat \times V_{gc} \times \frac{\partial f_2}{\partial V_{gy}}$$

where:

$$\frac{\partial f_1}{\partial V_{gc}} = \frac{3}{2 \times Deltds} \operatorname{sech}^2\left(\frac{3(V_{gc} - V_{gy})}{Deltds}\right)$$

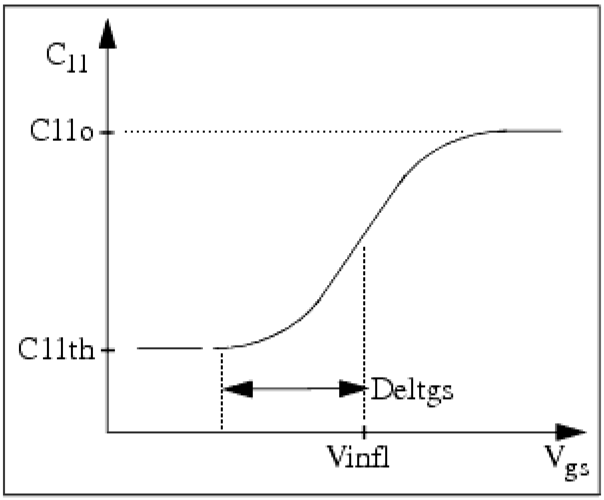
$$\frac{\partial f_1}{\partial V_{gy}} = -\frac{\partial f_1}{\partial V_{gc}}$$

$$\frac{\partial f_2}{\partial V_{gc}} = -\frac{\partial f_1}{\partial V_{gc}}$$

$$\frac{\partial f_2}{\partial V_{gy}} = \frac{\partial f_1}{\partial V_{gc}}$$

When V_{ds}=Vdso and Vdso > Deltds, the gate capacitance C_{11} reduces to a single voltage dependency in V_{gs}. Similar to the I_{ds} model then, the majority of the important gate charge parameters can be estimated from a single trace of a plot. In this case, the plot of interest is C_{11}–V_{gs} at V_{ds} = Vdso.

The parameter definitions are shown in the following illustration. The parameter Deltds models the gate capacitance transition from the linear region of the device into saturation. Lambda models the slope of the C_{11}–V_{ds} characteristic in saturation. C12sat is used to fit the gate transcapacitance (C_{12}) in saturation.



EE_FET3 C_{11}-V_{gs} Parameters

Output Charge and Delay

EE_FET3 uses a constant output capacitance specified with the parameter Cdso. This gives rise to a drain-source charge term of the form

$$q_{ds}(V_{ds}) = Cdso \times V_{ds}$$

The drain-source current previously described in this section is delayed with the parameter Tau according to the following equation:

$$I_{ds}(t) = I_{ds}(V_{gs}(t - Tau), V_{ds}(t))$$

In the frequency domain, only the transconductance is impacted by this delay and the familiar expression for transconductance is obtained:

$y_m = g_m \times \exp(-j \times \omega \times Tau)$

Gate Forward Conduction and Breakdown

Forward conduction in the gate junction is modeled using a standard 2-parameter diode expression. The current for this gate-source current is:

$$I_{gs}(V_{gs}) = Is \times \left[e^{\frac{qV_{gs}}{nkT}} - 1 \right]$$

where q is the charge on an electron, k is Boltzmann's constant and T is the junction temperature.

The EE_FET3 breakdown model was developed from measured DC breakdown data and includes the voltage dependency of both gate-drain and gate-source junctions. EE_FET3 models breakdown for V_{ds}>0V only, breakdown in the V_{ds}<0V region is not handled. The model consists of 4 parameters that are easily optimized to measured data. The breakdown current is given by:

for $-V_{gd} > Vbr$

$$I_{gd}(V_{gd}, V_{gs}) = -Kbk\left(\left[1 - \frac{Ids(V_{gs}, V_{ds})}{I(dsoc)}\right] \times (-V_{gd} - Vbr)^{Nbr}\right)$$

for $-V_{gd} \le V_{br}$

$$I_{gd}(V_{gd}, V_{gs}) = 0$$

Idsoc should be set to the maximum value attainable by I_{ds} to preclude the possibility of the gate-drain current flowing in the wrong direction.

Scaling Relations

Scaling of EE_FET3 model parameters is accomplished through the use of the model parameters Ugw and Ngf and device parameters Ugw and N. From these four parameters, the following scaling relations can be defined:

$$sf = \frac{Ugw^{new} \times N}{Ugw(Ngf)}$$

$$sfg = \frac{Ugw \times N}{Ugw^{new} \times Ngf}$$

where Ugw^{new} represents the device parameter Ugw, the new unit gate width.
Scaling will be disabled if any of the 4 scaling parameters are set to 0. The new EE_FET3 parameters are calculated internally by the simulator according to these equations:

$$Ris^{new} = \frac{Ris}{sf}$$

$$Rid^{new} = \frac{Rid}{sf}$$

$$Gmmax^{new} = Gmmax(sf)$$

$$Gmmaxac^{new} = Gmmaxac(sf)$$

$$Peff^{new} = Peff \times sf$$

$$Peffac^{new} = Peffac(sf)$$

$$Rdb^{new} = \frac{Rdb}{sf}$$

$$Gdbm^{new} = Gdbm(sf)$$

$$Kdb^{new} = \frac{Kdb}{sf}$$

$$Is^{new} = Is \times sf$$

$$Kbk^{new} = Kbk(sf)$$

$$Idsoc^{new} = Idsoc(sf)$$

$$Rg^{new} = \frac{Rg}{sfg}$$

$$Rd^{new} = \frac{Rd}{sf}$$

$$Rs^{new} = \frac{Rs}{sf}$$

$$Cbs^{new} = Cbs \times sf$$

$$C11o^{new} = C11o \times sf$$

$$C11th^{new} = C11th \times sf$$

$$C12sat^{new} = C12sat \times sf$$

$$Cgdsat^{new} = Cgdsat \times sf$$

$$Cdso^{new} = Cdso \times sf$$

Temperature Scaling

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device item Temp parameter. (Temperatures in the following equations are in Kelvin.)

The saturation current Is scales as:

$$Is^{NEW} = Is \times exp\left[\left(\frac{Temp}{Tnom} - 1\right)\frac{q \times Eg}{k \times N \times Temp} + \frac{Xti}{N} \times ln\left(\frac{Temp}{Tnom}\right)\right]$$

where:

E_g = 1.11

The threshold voltage Vto varies as:

$$Vto^{NEW} = Vto + Vtotc(Temp - Tnom)$$

Following are additional equations for the temperature scaling parameters:

$$RG^{NEW} = Rg[1 + Rgtc(Temp - Tnom)]$$

$$RD^{NEW} = Rd[1 + Rdtc(Temp - Tnom)]$$

$$RS^{NEW} = Rs[1 + Rstc(Temp - Tnom)]$$

$$VTOAC^{NEW} = Vtoac + Vtoactc(Temp - Tnom)$$

$$VTSO^{NEW} = Vtso + Vtotc(Temp - Tnom)$$

$$VTSOAC^{NEW} = Vtsoac + Vtoactc(Temp - Tnom)$$

$$GAMMA^{NEW} = GAMMA\left(\left[\frac{Temp}{Tnom}\right]^{GAMMATC}\right)$$

$$GAMMAAC^{NEW} = GAMMAAC\left(\left[\frac{Temp}{Tnom}\right]^{GAMMAACTC}\right)$$

$$GMMAX^{NEW} = GMMAX + GMMAXTC(Temp - Tnom)$$

$$GMMAXAC^{NEW} = GMMAXAC + GMMAXACTC(Temp - Tnom)$$

$$VINFL^{NEW} = Vinfl + Vinfltc(Temp - Tnom)$$

Noise Model

Thermal noise generated by resistors Rg, Rs, Rd, Ris, Rid, and Rdb is characterized by the following spectral density.

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

Channel noise generated by the DC transconductance gm is characterized by the following spectral density:

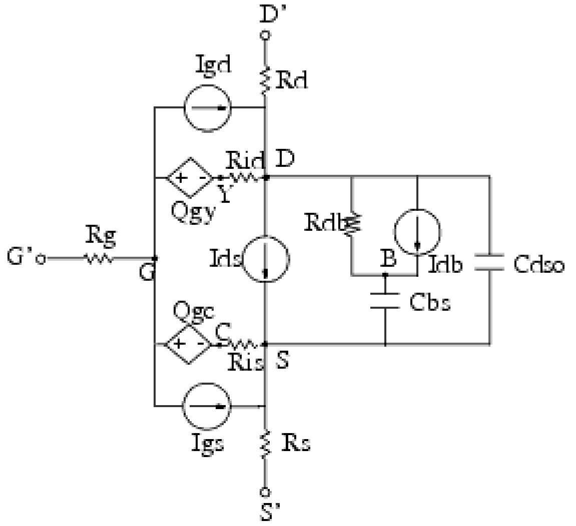
$$\frac{<i_{ds}^2>}{\Delta f} = \frac{8kTg_m}{3}$$

In these expressions, *k* is Boltzmann's constant, *T* is the operating temperature in Kelvin, *q* is the electron charge, and Δ *f* is the noise bandwidth.

Flicker noise for this device is not modeled in this version of the simulator. However, the bias-dependent noise sources I_NoiseBD and V_NoiseBD can be connected external to the device to model flicker noise.

Additional Information

Equivalent Circuit



Device Operating Point Data

This model generates device operating point data during a DC simulation. The procedure for viewing device operating point data for a component is in *Using Circuit Simulators*. Data displayed for EE_FET3_Model (and EE_HEMT1_model) is:

Id	0.167708
Ig	-9.99941e-0
Is	-0.167708
Power	0.838539
Gm	0.119883
Gds	0.0109841
GmAc	0.0487499
GdsAc	0.00342116
Ggs	2.31388e-017

Ggd	0
dIgd_dVgs	0
Cgc	1.40818e-012
dQgc_dVgy	-2.28547e-013
Cgy	5e-014
dQgy_dVgc	-4.57459e-025
Vgs	-0.25
Vds	5

Conductance Model

The detailed operating point analysis returns information on the internal calculations of EEfet3. Since the model accounts for dynamic affects found in conductance and transconductance of GaAs devices, both DC and AC operation are reported for Gm and Gds.

- Gm, Gds DC transconductance, output conductance
- GmAc, GdsAC High-frequency transconductance and output conductance
- dIgd_dVgs Transconductance effects of the gate-drain voltage.

References

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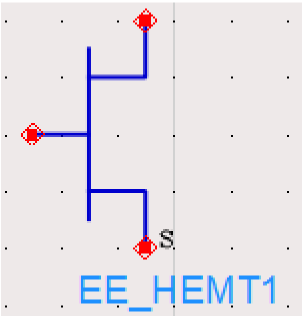
2. P. C. Canfield, "Modeling of frequency and temperature effects in GaAs MESFETs" *IEEE Journal of Solid-State Circuits,* Vol. 25, pp. 299-306,Feb. 1990.
3. J.M. Golio, M. Miller, G. Maracus, D. Johnson, "Frequency dependent electrical characteristics of GaAs MESFETs," *IEEE Trans. Elec. Devices* , vol. ED-37, pp. 1217-1227, May 1990.
4. H. Statz, P. Newman, I. Smith, R. Pucel, H. Haus, "GaAs FET device and circuit simulation in SPICE," *IEEE Trans. Elec. Devices* , vol. ED-34, pp. 160-169, Feb. 1987.

EE HEMT1 (EEsof Scalable Nonlinear HEMT)

EE_HEMT1 (EEsof Scalable Nonlinear HEMT)

Symbol



Range of Usage

Ugw > 0
N > 0

Parameters

Name	Description	Units	Default
Model	name of an EE_HEMT1_Model	None	EEHEMTM1
Ugw	new unit gate width	None	0.0
N	new number of gate fingers	None	1.0
Noise	noise generation option: yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

- Ugw and N are used for scaling device instance; refer to EE_HEMT1_Model (EEsof Scalable Nonlinear HEMT Model).
- The following table lists the DC operating point parameters that can be sent to the dataset.

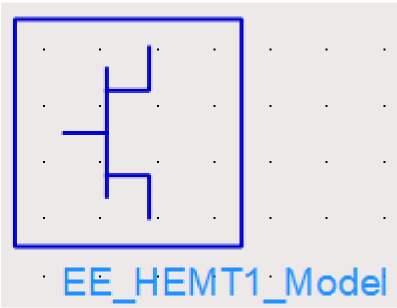
DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
GmAc	Forward transconductance (dIds/dVgs + dIdb/dVgs)	siemens
GdsAc	Output conductance (dIds/dVds + dIdb/dVgd)	siemens
Ggs	Gate-source conductance	siemens
Ggd	Gate-drain conductance	siemens
dIgd_dVgs	(dIgd/dVgs)	siemens
Cgc	Gate-source capacitance (dQgc/dVgc)	farads
dQgc_dVgy	(dQgc/dVgy)	farads
Cgy	Gate-drain capacitance (dQgy/dVgy)	farads
dQgy_dVgc	(dQgy/dVgc)	farads
Vgs	Gate-source voltage	volts
Vds	Gate-drain voltage	volts

EE HEMT1 Model (EEsof Scalable Nonlinear HEMT Model)

EE_HEMT1_Model (EEsof Scalable Nonlinear HEMT Model)

Symbol



EE_HEMT1 is an empirical analytic model that was developed by Keysight EEsof for the express purpose of fitting measured electrical behavior of HEMTs. The model includes the following features:

- Accurate isothermal drain-source current model fits virtually all processes
- Flexible transconductance formulation permits accurate fitting of g_m compression found in HEMTs
- Self-heating correction for drain-source current
- Charge model that accurately tracks measured capacitance values
- Dispersion model that permits simultaneous fitting of high-frequency conductances and DC characteristics
- Accurate breakdown model describes gate-drain current as a function of both V_{gs} and V_{ds}.
- Well-behaved (non-polynomial) expressions permit accurate extrapolations outside of the measurement range used to extract the model.

Parameters

Name	Description	Units	Default
Vto	zero bias threshold	V	-1.5
Gamma	Transconductance parameter	1/V	0.05
Vgo	gate-source voltage where transconductance is a maximum	V	0.0

Name	Description	Units	Default
Vdelt	Parameter which controls linearization point	V	0.0
Vch	gate-source voltage where Gamma no longer affects I-V curves	V	1.0
Gmmax	peak transconductance	S	70.0e-03
Vdso	Drain voltage where Vo dependence is nominal	V	2.0
Vsat	drain-source current saturation	V	1.0
Kapa	output conductance	S	1.0
Peff	channel to backside self-heating	W	2.0
Vtso	subthreshold onset voltage	V	-10.0
Is	gate junction reverse saturation current	A	1.0e-14
N	gate junction ideality factor	None	1.0
Ris	source end channel resistance	Ohm	0.0
Rid	drain end channel resistance	Ohm	0.0
Tau	gate transit time delay	sec	0.0
Cdso	drain-source inter-electrode capacitance	F	80.0e-15
Rdb	dispersion source output impedance	Ohm	1.0e+9
Cbs	trapping-state capacitance	F	1.6e-13
Vtoac	zero bias threshold (AC)	V	-1.5
Gammaac	Transconductance parameter (AC)	1/V	0.05
Vdeltac	Parameter which controls linearization point (AC)	V	0.0

Name	Description	Units	Default
Gmmaxac	peak transconductance (AC)	S	60.0e-03
Kapaac	output conductance (AC)	S	0.0
Peffac	channel to backside self-heating (AC)	W	10.0
Vtsoac	subthreshold onset voltage (AC)	V	-10.0
Gdbm	additional d-b branch conductance at Vds = VDSM		0.0
Kdb	Dependence of d-b branch conductance with Vds	None	0.0
Vdsm	voltage where additional d-b branch conductance becomes constant		1.0
C11o	maximum input capacitance for Vds=Vdso and Vdso>Deltds	F	0.3e-12
C11th	minimum (threshold) input capacitance for Vds=Vdso	F	0.03e-12
Vinfl	inflection point in C11-Vgs characteristic	V	1.0
Deltgs	C11th to C11o transition voltage	V	0.5
Deltds	linear region to saturation region transition	V	1.0
Lambda	C11-Vds characteristic slope	1/V	1.0
C12sat	input transcapacitance for Vgs=Vinfl and Vds>Deltds	F	0.03e-12
Cgdsat	gate drain capacitance for Vds>Deltds	F	0.05e-12
Kbk	breakdown current coefficient at threshold	None	0.0
Vbr	Breakdown onset voltage	V	15.0
Nbr	breakdown current exponent	None	2.0
Idsoc	open channel (maximum) value of Ids	A	100.0e-03

Name	Description	Units	Default
Rd	drain contact resistance	Ohm	1.0
Rs	source contact resistance	Ohm	1.0
Rg	gate metallization resistance	Ohm	1.0
Ugw	unit gate width of device		0.0
Ngf	number of device gate fingers	None	1.0
Vco	voltage where transconductance compression begins for Vds=Vdso	V	10.0
Vba	transconductance compression tail-off	V	1.0
Vbc	transconductance roll-off to tail-off transition voltage	V	1.0
Mu	Vo dependent transconductance compression	None	1.0
Deltgm	slope of transconductance compression characteristic	None	0.0
Deltgmac	slope of transconductance compression characteristic (AC)	None	0.0
Alpha	transconductance saturation to compression transition	V	1.0e-03
Tnom	Nominal ambient temperature	°C	25
Rgtc	linear temperature coefficient for RG	1/°C	0.0
Rdtc	linear temperature coefficient for RD	1/°C	0.0
Rstc	linear temperature coefficient for RS	1/°C	0.0
Vtotc	Vto temperature coefficient	V/°C	0.0
Gmmaxtc	Gmmax temperature coefficient	S/°C	0.0
Gammatc	Gamma temperature coefficient	None	0.0

Name	Description	Units	Default
Vinfltc	Vinfl temperature coefficient	V/°C	0.0
Vtoactc	Vtoac temperature coefficient	V/°C	0.0
Gmmaxactc	Gmmaxac temperature coefficient	S/°C	0.0
Gammaactc	Gammaac temperature coefficient	None	0.0
Xti	Temperature Exponent for Saturation Curren	None	3.0
Kmod	library model number	None	1
Kver	version number	None	1
wVgfwd	gate junction forward bias (warning)	V	None
wBvgs	gate-source reverse breakdown voltage (warning)	V	None
wBvgd	gate-drain reverse breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

- Model parameters such as Ls, Ld, and Lg (as well as other package related parameters that are included as part of the output from the EE_HEMT1 IC-CAP model file) are not used by the EE_HEMT1 component in the simulator. Only those parameters listed are part of the EE_HEMT1 component. Any extrinsic components must be added externally by the user.
- To prevent numerical problems, the setting of some model parameters to 0 is trapped by the simulator. Parameter values are changed internally as follows:
  Rd = 10^{-4}
  Rs = 10^{-4}
  Rg = 10^{-4}
  Ris = 10^{-4}
  Rid = 10^{-4}
  Vsat = 0.1

Peff = 10^{-6}
Peffac = 10^{-6}
Deltds = 0.1
Deltgs = 0.1
Idsoc = 0.1
Is = 10^{-50}

- When g_m is computed from operating point details, the result does not include the effects of parasitic resistance such as R_g or R_s. This generates a different result from the g_m that is computed using I_{ds} and V_{gs}.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). A nonlinear device model parameter value that is explicitly specified will override the value set by an AllParams association.

Equations/Discussion

The model equations were developed concurrently with parameter extraction techniques to ensure the model would contain only parameters that were extractable from measured data. Although the model is amenable to automated parameter extraction techniques, it was designed to consist of parameters that are easily estimated (visually) from measured data such as g_m-V_{gs} plots. The increased number of model parameters is commensurate with the improvement in accuracy as compared with other popular empirical models. Since the model equations are all well behaved analytic expressions, EE_HEMT1 possesses no inherent limitations with respect to its usable power range. With the parameters Vdelt and Vdeltac set to zero, EE_FET3 becomes a subset of EE_HEMT1. The linear transconductance region modeled with the parameter Vdelt in EE_FET3 is omitted from EE_HEMT1 and replaced with a series of parameters designed to model transconductance compression. Keysight EEsof's IC-CAP program provides the user with the capability of extracting EE_HEMT1 models from measured data.

Drain-Source Current

The drain-source current model in EE_HEMT1 is comprised of various analytic expressions that were developed through examination of g_m versus bias plots on a wide class of devices from various manufacturers. The expressions below are given for V_{ds} > 0.0V although the model is equally valid for V_{ds} < 0.0V. The model assumes the device is symmetrical, and one need only replace V_{gs} with V_{gd} and V_{ds} with $-V_{ds}$ in order to obtain the reverse region (V_{ds} < 0.0V) equations. The g_m, g_{ds} and I_{ds} equations take on four different forms depending on the value of V_{gs} relative to some of the model parameters. The I_{ds} expression is continuous through at least the second derivative everywhere.

$$V_{ts} = \frac{Vtso - Vch}{1 + Gamma(Vdso - Vds)} + Vch$$

if V_{gs} < Vts and Vtso > Vto
V_{gs} = Vts
if $V_{gs} \geq V_g$

$$g_{mo} = Gmmax\{1 + Gamma(Vdso - V_{ds})\}$$

$$I_{dso} = Gmmax\left\{V_x(V_{gs}) - \frac{(Vgo + Vto)}{2} + Vch\right\}$$

$$g_{dso} = -Gmmax \times Gamma(V_{gs} - Vch)$$

else if $V_{gs} \leq V_t$

$$g_{mo} = 0.0$$

$$I_{dso} = 0.0$$

$$g_{dso} = 0.0$$

else

$$g_{mo} = g_{mm}(V_{gs})$$

$$I_{dso} = I_{dsm}(V_{gs})$$

$$g_{dso} = -\frac{Gmmax}{2}Gamma(V_{gs} - Vch)$$

$$\times \left\{\cos\left[\pi \times \frac{V_x(V_{gs}) - (Vgo - Vch)}{Vto - Vgo}\right] + 1\right\}$$

where:

$$g_{mm}(V) = \frac{Gmmax}{2}[1 + Gamma(Vdso - V_{ds})]$$

$$\times \left\{\cos\left[\pi \times \frac{V_x(V) - (Vgo - Vch)}{Vto - Vgo}\right] + 1\right\}$$

$$I_{dsm}(V) = \frac{Gmmax}{2}\Bigg(((Vto - Vgo)/\pi)\sin\left[\pi \times \frac{V_x(V) - (Vgo - Vch)}{Vto - Vgo}\right]$$

$$+V_x(V) - (Vto - Vch))$$

$$V_x(V) = (V - Vch)[1 + Gamma(Vdso - V_{ds})]$$

$$V_g = \frac{Vgo - Vch}{1 + Gamma(Vdso - V_{ds})} + Vch$$

$$V_t = \frac{Vto - Vch}{1 + Gamma(Vdso - V_{ds})} + Vch$$

.

The following voltages define regions of operation that are used in the g_m compression terms:

$$V_c = Vco + Mu \times (Vdso - V_{ds})$$

$$V_b = Vbc + V_c$$

$$V_a = V_b - Vba$$

For $V_{gs} > V_c$, the basic I_{dso}, g_{mo} and g_{dso} relations are modified as follows:
for $V_{gs} < V_b$,

$$g_{mo}^{comp} = g_{mo} - g_{mv}(V_{gs}, V_{ds})$$

$$I_{dso}^{comp} = I_{dso} - I_{dsv}(V_{gs}, V_{ds})$$

$$g_{dso}^{comp} = g_{dso} - g_{dsv}(V_{gs}, V_{ds})$$

for $V_{gs} \geq V_b$ and $b \neq -1$,

$$g_{mo}^{comp} = g_{mo} - [a(V_{gs} - V_a)^b + g_{moff}]$$

$$I_{dso}^{comp} = I_{dso} - \frac{a}{b+1}[(V_{gs} - V_a)^{b+1} - Vba^{b+1}] - g_{moff} \times (V_{gs} - V_b)$$

$$-I_{dsv}(V_b, V_{ds})$$

$$g_{dso}^{comp} = g_{dso} - Mu[a(V_{gs} - V_a)^b + g_{moff}] - g_{dsv}(V_b, V_{ds})$$

for $V_{gs} \geq V_b$ and $b = -1$,

$$g_{mo}^{comp} = g_{mo} - [a(V_{gs} - V_a)^b + g_{moff}]$$

$$I_{dso}^{comp} = I_{dso} - a[\log(V_{gs} - V_a) - \log(Vba)] - g_{moff} \times (V_{gs} - V_b)$$

$$-I_{dsv}(V_b, V_{ds})$$

$$g_{dso}^{comp} = g_{dso} - \frac{Mu \times a}{(V_{gs} - V_a)} - Mu \times g_{moff} - g_{dsv}(V_b, V_{ds})$$

where:

$$a = \frac{g_{mv}(V_b, V_{ds}) - g_{moff}}{Vba^b}$$

$$b = \frac{s_{vb} \times Vba}{g_{mv}(V_b, V_{ds}) - g_{moff}}$$

$$s_{vb} = Deltgm \times \frac{Vbc}{\sqrt{Alpha^2 + Vbc^2}}$$

$$g_{mv}(V, V_{ds}) = Deltgm \times \left[\sqrt{Alpha^2 + (V - V_c)^2} - Alpha\right]$$

$$I_{dsv}(V - V_{ds}) = Deltgm\left(\frac{1}{2}\left((V - V_c)\sqrt{Alpha^2 + (V - V_c)^2} + Alpha^2 * log\left[\frac{(V - V_c) + \sqrt{Alpha^2 + (V - V_c)^2}}{Alpha}\right]\right) - Alpha * (V - V_c)\right)$$

$$g_{dsv}(V, V_{ds}) =$$

$$Deltgm \times Mu\left(\frac{1}{2}\left(\frac{2(V - V_c)^2 + Alpha^2}{\sqrt{Alpha^2 + (V - V_c)^2}} + \frac{Alpha^2}{(V - V_c) + \sqrt{Alpha^2 + (V - V_c)^2}} \times \left[1 + \frac{(V - V_c)}{\sqrt{Alpha^2 + (V - V_c)^2}}\right]\right) - Alpha\right)$$

where $g_{moff} = g_{mo}(Vco, Vdso)$ means replace *Vgs* by *Vco*, *Vds* by *Vdso*; i.e.,

if *Vco* > *Vgo*

$g_{moff} = Gmmax$

else if *Vco* < *Vto*

$g_{moff} = 0$

else

$$gmoff = \frac{Gmmax}{2}\left[\cos\left(\pi \times \frac{Vco - Vgo}{Vto - Vgo}\right) + 1\right]$$

If junction voltage drops below the onset of subthreshold (*Vts*), current and conductances are modified to decay exponentially from their value at *Vgs* = *Vts* .

if *Idso* ≠ 0 and *Vgs* < *Vts* and *Vtso* > *Vto* and *gmo* / *Idso* > 0

$$\arg = -\left(\frac{gmo}{Idso}\right) \times (Vts - Vgs)$$

$$Idso = Idso \times \exp(\arg)$$

$$gmo = gmo \times \exp(\arg)$$

$$gdso = gdso \times \exp(\arg)$$

where:

$Idso, gmo$ are $Idso^{comp}, gmo^{comp}$ if $Vgs > Vc$

To prevent g_m from becoming negative at high gate-source biases, it is advisable to use the parameter Deltgm under the following value:

$$Deltgm < \frac{g_{moff}}{\sqrt{Alpha^2 + Vbc^2} - Alpha}$$

The preceding relations for I_{dso}^{comp} , g_{mo}^{comp} and g_{dso}^{comp} can now be substituted in the following equations that model current saturation and output conductance. This portion of the model can be recognized from the work of Curtice [1].

$$g'_m = g_{mo}^{comp}(1 + Kapa \times V_{ds})\tanh\left(\frac{3V_{ds}}{Vsat}\right)$$

$$I'_{ds} = I_{dso}^{comp}(1 + Kapa \times V_{ds})\tanh\left(\frac{3V_{ds}}{Vsat}\right)$$

$$g'_{ds} = \left\{g_{dso}^{comp}(1 + Kapa \times V_{ds}) + I_{dso}^{comp} Kapa\right\}\tanh\left(\frac{3V_{ds}}{Vsat}\right)$$

$$+ I_{dso}^{comp} \times \frac{3(1 + Kapa \times V_{ds})}{Vsat}\operatorname{sech}^2\left(\frac{3V_{ds}}{Vsat}\right)$$

These expressions do an excellent job of fitting HEMT I-V characteristics in regions of low power dissipation. They will also fit pulsed (isothermal) I-V characteristics. To model negative conductance effects due to self-heating, the thermal model of Canfield was incorporated [2]. With this final enhancement, the DC expressions for I_{ds} and its associated conductances become:

$$I_{ds} = \frac{I'_{ds}}{1 + \dfrac{P_{diss}}{Peff}}$$

$$g_m = \frac{g'_m}{\left[1 + \dfrac{P_{diss}}{Peff}\right]^2}$$

$$g_{ds} = \frac{g'_{ds} - \dfrac{I'^2_{ds}}{Peff}}{\left[1 + \dfrac{P_{diss}}{Peff}\right]^2}$$

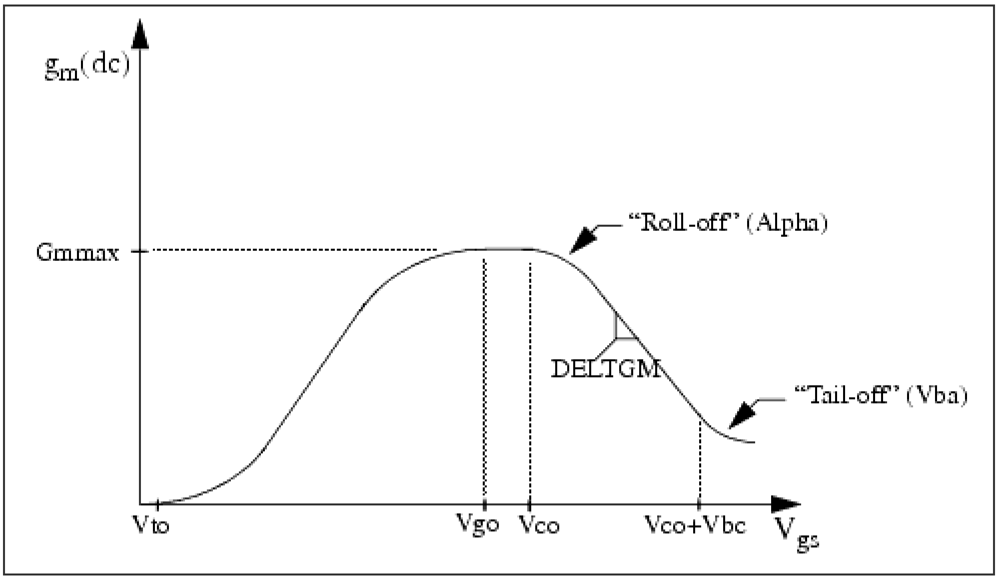
where:

$$P_{diss} = I'_{ds}V_{ds}$$

Qualitatively, the operation of the drain-source model can be described as follows.
The V_{ds} dependence of the equations is dominated by the parameters Vsat, Gamma, Kapa, and Peff. Isothermal output conductance is controlled by Gamma and Kapa. The impact of Gamma on output conductance is more significant near threshold. At V_{gs} =Vch, the output conductance is controlled only by Kapa. Peff provides a correction to the isothermal model for modeling the self-heating effects manifested as a negative resistance on the I-V curves. Vsat represents the drain-source voltage at which the current saturates and output conductance becomes a constant (approximately). Mu also impacts the I-V curves in the g_m compression region, but its effect is second order. In most cases, the g_m fit is more sensitive to the parameter Mu.

The overall impact of Vch on the I-V characteristics is second order at best, and many different values of Vch will provide good fits to I-V plots. For most applications encountered, the default value of 1.0V is an adequate value for Vch. Similar to Vch, Vdso is a parameter that should be set rather than optimized. At V_{ds}=Vdso, the drain-source model collapses to a single voltage dependency in V_{gs}. It is recommended that the user set Vdso to a typical V_{ds} operating point in saturation. At this point, many of the parameters can be extracted from a I_{ds}-V_{gs} plot for V_{ds}=Vdso or, preferably, a g_m(dc)-V_{gs} plot at V_{ds}=Vdso.

When V_{ds}=Vdso and Peff is set large (to disable the self-heating model), the significance of Vto, Vgo, Gmmax, Vco, Vba, Vbc, Deltgm and Alpha are easily understood from a plot of g_m(dc)-V_{gs}. Gmmax is the peak transconductance of the model that occurs at V_{gs}=Vgo. Vto represents the gate-source voltage where g_m goes to zero. Transconductance compression begins at V_{gs}=Vco. Alpha controls the abruptness of this transition while Deltgm controls the slope of the g_m characteristic in compression. At V_{gs}=Vco+Vbc, the linear g_m slope begins to tail-off and asymtotically approach zero. The shape of this *tail-off* region is controlled by Vba. The parameter definitions are illustrated in EE_HEMT1 gm–Vgs Parameters.



EE_HEMT1 g_m–V_{gs} Parameters

Dispersion Current (Idb)

Dispersion in a GaAs MESFET or HEMT drain-source current is evidenced by the observation that the output conductance and transconductance beyond some transition frequency is higher than that inferred by the DC measurements. A physical explanation often attributed to this phenomenon is that the channel carriers are subject to being trapped in the channel-substrate and channel-surface interfaces. Under slowly varying signal conditions, the rate at which electrons are trapped in these sites is equal to the rate at which they are emitted back into the channel. Under rapidly varying signals, the traps cannot follow the applied signal and the *high-frequency* output conductance results.

The circuit used to model conductance dispersion consists of the Rdb, Cbs (these linear components are also parameters) and the nonlinear source $I_{db}(V_{gs}, V_{ds})$. The model is a large-signal generalization of the dispersion model proposed by Golio et al. [3]. At DC, the drain-source current is just the current I_{ds}. At high frequency (well above the transition frequency), the drain source current will be equal to I_{ds}(high frequency) = I_{ds}(dc) + I_{db}. Linearization of the drain-source model yields the following expressions for y_{21} and y_{22} of the intrinsic EE_HEMT1 model:

$$y_{21} = g_{dsgs} + g_{dbgs} - \frac{g_{dbgs}}{1 + j\omega \times Cbs(Rdb)}$$

$$y_{22} = g_{dsds} + g_{dbds} + \frac{1}{Rdb} - \frac{\left(g_{dbds} + \frac{1}{Rdb}\right)}{1 + j\omega \times Cbs(Rdb)}$$

where:

$$g_{dsgs} = \frac{\partial I_{ds}}{\partial V_{gs}}$$

$$g_{dsds} = \frac{\partial I_{ds}}{\partial V_{ds}}$$

$$g_{dbgs} = \frac{\partial I_{db}}{\partial V_{gs}}$$

$$g_{dbds} = \frac{\partial I_{db}}{\partial V_{ds}}$$

Evaluating these expressions at the frequencies ω=0 and ω=infinity, produces the following results for transconductance and output conductance:
for ω = 0,

$$Re[y_{21}] = g_m = g_{dsgs}$$

$$Re[y_{22}] = g_{ds} = g_{dsds}$$

for ω = infinity,

$$Re[y_{21}] = g_m = g_{dsgs} + g_{dbgs}$$

$$Re[y_{22}] = g_{ds} = g_{dsds} + g_{dbds} + \frac{1}{Rdb}$$

Between these two extremes, the conductances make a smooth transition, the abruptness of which is governed by the time constant τdisp = Rdb × Cbs. The frequency f_0 at which the conductances are midway between these two extremes is defined as:

$$f_0 = \frac{1}{2\pi\tau_{disp}}$$

The parameter Rdb should be set large enough so that its contribution to the output conductance is negligible. Unless the user is specifically interested in simulating the device near f_0, the default values of Rdb and Cbs will be adequate for most microwave applications.

The EE_HEMT1 I_{ds} model can be extracted to fit either DC or AC characteristics. In order to simultaneously fit both DC I-V characteristics and AC conductances, EE_HEMT1 uses a simple scheme for modeling the I_{db} current source whereby different values of the same parameters can be used in the I_{ds} equations. The DC and AC drain-source currents can be expressed as follows:

$$I_{ds}^{dc}(\text{Voltages, Parameters}) = I_{ds}$$

(Voltages, Gmmax, Vdelt, Vto, Gamma, Kapa, Peff, Vtso, Deltgm, Vgo, Vch, Vdso, Vsat)

$$I_{ds}^{ac}(\text{Voltages, Parameters}) = I_{ds}$$

(Voltages, Gmmaxac, Vdeltac, Vto, Gammaac, Kapaac, Peffac, Vtsoac, Deltgmac, Vgo, Vch, Vdso, Vsat)

Parameters such as Vgo that do not have an AC counterpart (there is no Vgoac parameter) have been found not to vary significantly between extractions utilizing DC measurements versus those using AC measurements. The difference between the AC and DC values of Ids, plus an additional term that is a function of Vds only, gives the value of Idb for the dispersion model:

$$I_{db}(V_{gs}, V_{ds}) = I_{ds}^{ac}(V_{gs}, V_{ds}) - I_{ds}^{dc}(V_{gs}, V_{ds}) + I_{dbp}(V_{ds})$$

where I_{dbp} and its associated conductance are given by:
for $V_{ds} > Vdsm$ and $Kdb \neq 0$:

$$I_{dbp} = \sqrt{\frac{Gdbm}{Kdb}}\tan^{-1}((V_{ds} - Vdsm)\sqrt{Kdb(Gdbm)} + Gdbm \times Vdsm)$$

$$g_{dbp} = \frac{Gdbm}{(Kdb(Gdbm(V_{ds} - Vdsm)^2 + 1))}$$

for $V_{ds} \leq Vdsm$ and $Kdb \neq 0$:

$$I_{dbp} = \sqrt{\frac{Gdbm}{Kdb}}\tan^{-1}((V_{ds} + Vdsm)\sqrt{Kdb(Gdbm)}) - Gdsm \times Vdsn$$

$$g_{dbp} = \frac{(Gdbm)}{(Kdb(Gdbm(V_{ds} + Vdsm)^2 + 1))}$$

for $-Vdsm \leq V_{ds} \leq Vdsm$ or $Kdb = 0$:

$$I_{dsm} = Gdbm \times V_{ds}$$

$$g_{dbm} = Gdbm$$

By setting the eight high-frequency parameters equal to their DC counterparts, the dispersion model reduces to $I_{db} = I_{dbp}$. Examination of the I_{dbp} expression reveals that the additional setting of

Gdbm to zero disables the dispersion model entirely. Since the I_{dbp} current is a function of V_{ds} only, it will impact output conductance only. However, the current function:

$$I_{ds}^{AC}$$

will impact both g_m and g_{ds}. For this reason, the model is primarily intended to utilize g_m data as a means for tuning:

$$I_{ds}^{AC}$$

Once this *fitting* is accomplished, the parameters Gdbm, Kdb and Vdsm can be tuned to optimize the g_{ds} fit.

Gate Charge Model

The EE_HEMT1 gate charge model was developed through careful examination of extracted device capacitances over bias. The model consists of simple closed form charge expressions whose derivatives fit observed bias dependencies in capacitance data. This capacitance data can be obtained directly from measured Y-parameter data:

$$C_{11} = \frac{im[y_{11}]}{\omega} = \frac{\partial q_g}{\partial V_{gs}}$$

$$C_{12} = \frac{im[y_{12}]}{\omega} = \frac{\partial q_g}{\partial V_{ds}}$$

The capacitance data is remarkably self-consistent. In other words, a single q_g function's derivatives will fit both *C* 11 data and *C* 12 data. The EE_HEMT1 gate charge expression is:

$$q_g(V_j, V_o) = \left[\frac{C11o - C11th}{2} g(V_j) + C11th(V_j - Vinfl)\right]$$

$$\times[1 + Lambda(V_o - Vdso)] - C12sat \times V_o$$

where:

$$g(V_j) = V_j - Vinfl + \frac{Deltgs}{3}\ln\left(\cosh\left(\frac{3}{Deltgs}(V_j - Vinfl)\right)\right)$$

This expression is valid for both positive and negative V_{ds}. Symmetry is forced through the following smoothing functions proposed by Statz [4]:

$$V_j = \frac{1}{2}\left(2V_{gs} - V_{ds} + \sqrt{V_{ds}^2 + Deltds^2}\right)$$

$$V_o = \sqrt{V_{ds}^2 + Deltds^2}$$

Differentiating the gate charge expression wrt V_{gs} yields the following expression for the gate capacitance C 11:

$$C_{11}(V_j, V_o) = \left[\frac{C11o - C11th}{2} g'(V_j) + C11th\right] \times [1 + Lambda(V_o - Vdso)]$$

where:

$$g'(V_j) = \frac{dg(V_j)}{dV_j} = 1 + \tanh\left[\frac{3}{Deltgs}(V_j - Vinfl)\right]$$

The gate transcapacitance C_{12} is defined as:

$$C_{12}(V_j, V_o) = \frac{\partial q_g}{\partial V_{ds}} = \frac{\partial q_g}{\partial V_j}\frac{\partial V_j}{\partial V_{ds}} + \frac{\partial q_g}{\partial V_o}\frac{\partial V_o}{\partial V_{ds}}$$

$$= C_{11}(V_j, V_o) \times \frac{1}{2}\left[\frac{V_{ds}}{\sqrt{V_{ds}^2 + Deltds^2}} - 1\right]$$

$$+ \left[\frac{C11o - C11th}{2} g(V_j - Vinfl)\right]$$

$$\times Lambda - C12sat \times \frac{V_{ds}}{\sqrt{V_{ds}^2 + Deltds^2}}$$

The EE_HEMT1 topology requires that the gate charge be subdivided between the respective charge sources q gc and q gy. Although simulation could be performed directly from the nodal gate charge q_g, division of the charge into branches permits the inclusion of the resistances Ris and Rid that model charging delay between the depletion region and the channel. EE_HEMT1 assumes the following form for the gate-drain charge in saturation:

$$q_{gy}(V_{gy}) = Cgdsat \times (V_{gy} + q_{gyo})$$

which gives rise to a constant gate-drain capacitance in saturation.

The gate-source charge q_{gc} can now be obtained by subtracting the latter from the gate charge equation. Smoothing functions can then be applied to these expressions in saturation in order to extend the model's applicable bias range to all V_{ds} values. These smoothing functions force symmetry on the q_{gy} and q_{gc} charges such that:

$$q_{gy} = q_{gc} = \frac{q_g}{2}$$

at V gc = V gy. Under large negative V_{ds} (saturation at the source end of the device), q_{gy} and q_{gc} swap roles, i.e:

$$q_{gc}(V_{gc}) = Cgdsat \times (V_{gc} + q_{gco})$$

The following continuous charge equations satisfy these constraints and are specified in terms of the gate charge:

$$q_{gy}(V_{gc}, V_{gy}) = \{q_g(V_{gc}, V_{gc} - V_{gy}) - Cgdsat \times V_{gc}\} \times f_2$$

$$+ Cgdsat \times V_{gy} \times tf_1$$

$$q_{gc}(V_{gc}, V_{gy}) = \{q_g(V_{gc}, V_{gc} - V_{gy}) - Cgdsat \times V_{gy}\} \times f_1$$

$$+ C(Ggdsat) \times V_{gc} \times f_2$$

where f_1 and f_2 are smoothing functions defined by:

$$f_1 = \frac{1}{2}\left[1 + \tanh\left(\frac{3}{Deltds}(V_{gc} - V_{gy})\right)\right]$$

and

$$f_2 = \frac{1}{2}\left[1 - \tanh\left(\frac{3}{Deltds}(V_{gc} - V_{gy})\right)\right]$$

The capacitances associated with these *branch* charge sources can be obtained through differentiation of the q_{gc} and q_{gy} equations and by application of the chain rule to the capacitances C11 and C12. The gate charge derivatives re-formulated in terms of V_{gc} and V_{gy} are:

$$C_{ggy} = \frac{\partial q_g}{\partial V_{gy}} = -C_{12}(V_{gc}, V_{gc} - V_{gy})$$

$$C_{ggc} = \frac{\partial q_g}{\partial V_{gc}} = C_{11}(V_{gc}, V_{gc} - V_{gy}) + C_{12}(V_{gc}, V_{gc} - V_{gy})$$

The branch charge derivatives are:

$$C_{gygy} = \frac{\partial q_{gy}}{\partial V_{gy}} = \{q_g(V_{gc}, V_{gc} - V_{gy}) - Cgdsat \times V_{gc}\} \times \frac{\partial f_2}{\partial V_{gy}}$$

$$+ f_2 \times C_{ggy} + Cgdsat \times \left[V_{gy} \times \frac{\partial f_1}{\partial V_{gy}} + f_1\right]$$

$$C_{gygc} = \frac{\partial q_{gy}}{\partial V_{gc}} = \{q_g(V_{gc}, V_{gc} - V_{gy}) - Cgdsat \times V_{gc}\} \times \frac{\partial f_2}{\partial V_{gc}}$$

$$+ f_2 \times [C_{ggc} - Cgdsat] + Cgdsat \times V_{gy} \times \frac{\partial f_1}{\partial V_{gc}}$$

$$C_{gcgc} = \frac{\partial q_{gc}}{\partial V_{gc}} = \{q_g(V_{gc}, V_{gc} - V_{gy}) - Cgdsat \times V_{gy}\} \times \frac{\partial f_1}{\partial V_{gc}}$$

$$+ f_1 \times C_{ggc} + Cdsat \times \left[V_{gc} \times \frac{\partial f_2}{\partial V_{gc}} + f_2\right]$$

$$C_{gcgy} = \frac{\partial q_{gc}}{\partial V_{gy}} = \{q_g(V_{gc}, V_{gc} - V_{gy}) - Cgdsat \times V_{gy}\} \times \frac{\partial f_1}{\partial V_{gy}}$$

$$+ f_1 \times [C_{ggy} - Cgdsat] + Cgdsat \times V_{gc} \times \frac{\partial f_2}{\partial V_{gy}}$$

where:

$$\frac{\partial f_1}{\partial V_{gc}} = \frac{3}{2 \times Deltds} \mathrm{sech}^2\left(\frac{3(V_{gc} - V_{gy})}{Deltds}\right)$$

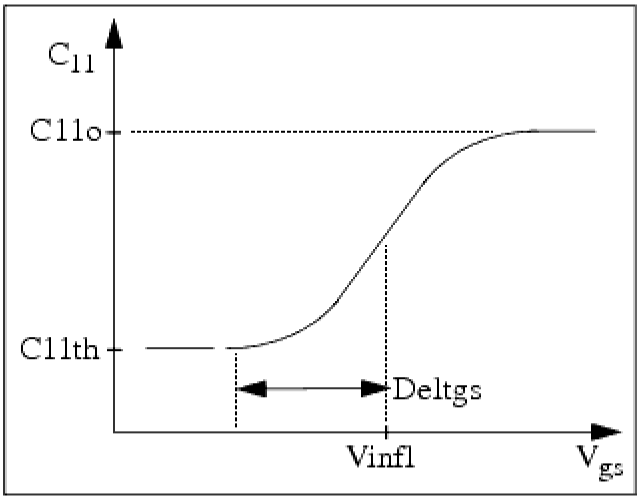
$$\frac{\partial f_1}{\partial V_{gy}} = -\frac{\partial f_1}{\partial V_{gc}}$$

$$\frac{\partial f_2}{\partial V_{gc}} = -\frac{\partial f_1}{\partial V_{gc}}$$

$$\frac{\partial f_2}{\partial V_{gy}} = \frac{\partial f_1}{\partial V_{gc}}$$

When V_{ds}=Vdso and Vdso>>Deltds, the gate capacitance $C11$ reduces to a single voltage dependency in V_{gs}. Similar to the I_{ds} model, the majority of the important gate charge parameters can then be estimated from a single trace of a plot. In this case, the plot of interest is $C11$-V_{gs} at V_{ds} = Vdso. The parameter definitions are shown in the following illustration, "EE_HEMT1 C11-Vgs Parameters".

The parameter Deltds models the gate capacitance transition from the linear region of the device into saturation. Lambda models the slope of the $C11$-V_{ds} characteristic in saturation. C12sat is used to fit the gate transcapacitance ($C12$) in saturation.



EE_HEMT1 C_{11}-V_{gs} Parameters

Output Charge and Delay

EE_HEMT1 uses a constant output capacitance specified with the parameter Cdso. This gives rise to a drain-source charge term of the form:

$$q_{ds}(V_{ds}) = Cdso \times V_{ds}$$

The drain-source current described previously, is delayed with the parameter TAU according to the following equation:

$$I_{ds}(t) = I_{ds}(V_{gs}(t - Tau), V_{ds}(t))$$

In the frequency domain, only the transconductance is impacted by this delay and the familiar expression for transconductance is obtained:

$y_m = g_m \times exp(-j \times \omega \times Tau)$

Gate Forward Conduction and Breakdown

Forward conduction in the gate junction is modeled using a standard 2-parameter diode expression. The current for this gate-source current is:

$$I_{gs}(V_{gs}) = IS \times \left[e^{\frac{qV_{gs}}{nkT}} - 1 \right]$$

where q is the charge on an electron, k is Boltzmann's constant, and T is the junction temperature.

The EE_HEMT1 breakdown model was developed from measured DC breakdown data and includes the voltage dependency of both gate-drain and gate-source junctions. EE_HEMT1 models breakdown for Vds > 0V only, breakdown in the Vds < 0V region is not handled. The model consists of four parameters that are easily optimized to measured data. The breakdown current is given by:

for $-V_{gd} > Vbr$

$$I_{gd}(V_{gd}, V_{gs}) = -Kbk\left[1 - \frac{Ids(V_{gs}, V_{ds})}{Idsoc}\right] \times (-V_{gd} - Vbr)^{Nbr}$$

for $-V_{gd} \leq Vbr$

$$I_{gd}(V_{gd}, V_{gs}) = 0$$

Care must be exercised in setting Idsoc. This parameter should be set to the maximum value attainable by I_{ds}. This precludes the possibility of the gate-drain current flowing in the wrong direction.

Scaling Relations

Scaling of EE_HEMT1 model parameters is accomplished through model parameters Ugw and Ngf and device parameters Ugw (same name as the model parameter) and N. From these four parameters, the following scaling relations can be defined:

$$sf = \frac{Ugw^{new} \times N}{Ugw \times Ngf}$$

$$sfg = \frac{Ugw \times N}{Ugw^{new} \times Ngf}$$

where Ugw^{new} represents the device parameter Ugw, the new unit gate width.

Scaling will be disabled if any of the four scaling parameters are set to 0. The new EE_HEMT1 parameters are calculated internally by the simulator according to the following equations:

$$Ris^{new} = \frac{Ris}{sf}$$

$$Rid^{new} = \frac{Rid}{sf}$$

$$Gmmax^{new} = Gmmax \times sf$$

$$Gmmaxac^{new} = Gmmaxac \times sf$$

$$Deltgm^{new} = Deltgm \times sf$$

$$Deltgmac^{new} = Deltgmac \times sf$$

$$Peff^{new} = Peff \times sf$$

$$Peffac^{new} = Peffac \times sf$$

$$Rdb^{new} = \frac{Rdb}{sf}$$

$$Gdbm^{new} = Gdbm \times sf$$

$$Kdb^{new} = \frac{Kdb}{sf}$$

$$Is^{new} = Is \times sf$$

$$Kbk^{new} = Kbk \times sf$$

$$Idsoc^{new} = Idsocs \times sf$$

$$Rg^{new} = \frac{Rg}{sfg}$$

$$Rd^{new} = \frac{Rd}{sf}$$

$$Rs^{new} = \frac{Rs}{sf}$$

$$Cbs^{new} = Cbs \times sf$$

$$C11o^{new} = C11o \times sf$$

$$C11th^{new} = C11th \times sf$$
$$C12sat^{new} = C12sat \times sf$$
$$Cgdsat^{new} = Cgdsat \times sf$$
$$Cdso^{new} = Cdso \times sf$$

Noise Model

Thermal noise generated by resistors Rg, Rs, Rd, Ris, Rid, and Rdb is characterized by the following spectral density.

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

Channel noise generated by the DC transconductance g_m is characterized by the following spectral density:

$$\frac{<i_{ds}^2>}{\Delta f} = \frac{8kTg_m}{3}$$

In the preceding expressions, *k* is Boltzmann's constant, *T* is the operating temperature in Kelvin, *q* is the electron charge, and Δ *f* is the noise bandwidth.

Flicker noise for this device is not modeled in this version of the simulator. However, the bias-dependent noise sources I_NoiseBD and V_NoiseBD can be connected external to the device to model flicker noise.

Temperature Scaling

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device item Temp parameter. (Temperatures in the following equations are in Kelvin.)
The saturation current Is scales as:

$$Is^{NEW} = Is \times exp\left[\left(\frac{Temp}{Tnom} - 1\right)\frac{q \times Eg}{k \times N \times Temp} + \frac{Xti}{N} \times ln\left(\frac{Temp}{Tnom}\right)\right]$$

where

$E_g = 1.11$

The threshold voltage Vto varies as:

$$Vto^{NEW} = Vto + Vtotc(Temp - Tnom)$$

Following are additional equations for the temperature scaling parameters:

$$RG^{NEW} = Rg[1 + Rgtc(Temp - Tnom)]$$

$$RD^{NEW} = Rd[1 + Rdtc(Temp - Tnom)]$$

$$RS^{NEW} = Rs[1 + Rstc(Temp - Tnom)]$$

$$VTOAC^{NEW} = Vtoac + Vtoactc(Temp - Tnom)$$

$$VTSO^{NEW} = Vtso + Vtotc(Temp - Tnom)$$

$$VTSOAC^{NEW} = Vtsoac + Vtoactc(Temp - Tnom)$$

$$GAMMA^{NEW} = GAMMA\left(\left\lceil\frac{Temp}{Tnom}\right\rceil^{GAMMATC}\right)$$

$$GAMMAAC^{NEW} = GAMMAAC\left(\left\lceil\frac{Temp}{Tnom}\right\rceil^{GAMMAACTC}\right)$$

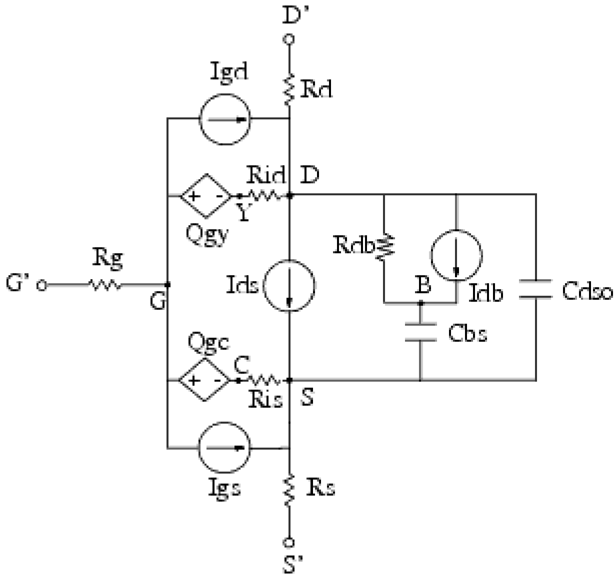
$$GMMAX^{NEW} = GMMAX + GMMAXTC(Temp - Tnom)$$

$$GMMAXAC^{NEW} = GMMAXAC + GMMAXACTC(Temp - Tnom)$$

$$VINFL^{NEW} = Vinfl + Vinfltc(Temp - Tnom)$$

Additional Information

Equivalent Circuit



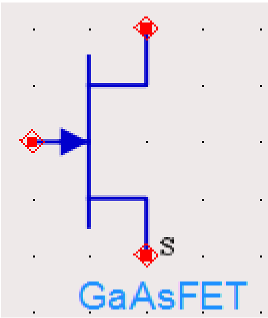
References

- W. R. Curtice, "A MESFET model for use in the design of GaAs integrated circuits," *IEEE Transactions of Microwave Theory and Techniques,* Vol. MTT-28, pp. 448-456, May 1980.
- P. C. Canfield, "Modeling of frequency and temperature effects in GaAs MESFETs" *IEEE Journal of Solid-State Circuits,* Vol. 25, pp. 299-306, Feb. 1990.
- J. M. Golio, M. Miller, G. Maracus, D. Johnson, "Frequency dependent electrical characteristics of GaAs MESFETs," *IEEE Trans. Elec. Devices* , vol. ED-37, pp. 1217-1227, May 1990.
- H. Statz, P. Newman, I. Smith, R. Pucel, H. Haus. "GaAs FET device and circuit simulation in SPICE," *IEEE Trans. Elec. Devices,* vol. ED-34, pp. 160-169, Feb. 1987.

GaAsFET (Nonlinear Gallium Arsenide FET)

GaAsFET (Nonlinear Gallium Arsenide FET)

Symbol



Range of Usage

Area > 0

Parameters

Name	Description	Units	Default
Model	name of a GaAsFET model	None	MESFETM1
Area	scaling factor that scales certain parameter values of the associated model item	None	1.0
Temp	device operating temperature	°C	25
Trise	temperature rise over ambient	°C	0
Noise	noise generation option: yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

- Advanced_Curtice2_Model, Curtice2_Model, Curtice3_Model, Materka_Model, Modified_Materka_Model, Statz_Model, and Tajima_Model are the nonlinear model items that define the GaAsFET.
- The Area parameter permits changes to a specific semiconductor because semiconductors may share the same model.
  - Parameters scaled proportionally to Area: A0, A1, A2, A3, Beta, Cgs, Cgd, Cgs, Cds, Is.
  - Resistive parameters scaled inversely proportional to Area: Rd, Rg, Rs. For example, Model = Curtice2 and Area=3 use the following calculations:
    Rd/3: Cgs × 3 Beta × 3
    Rg/3: Cgdo × 3
    Rs/3: Cds × 3
    These calculations have the same effect as placing three devices in parallel to simulate a larger device and are much more efficient.

- The Temp parameter specifies the physical (operating) temperature of the device. If this is different than the temperature at which the model parameters are valid or extracted (specified by the Tnom parameter of the associated model item) certain model parameters are scaled such that the device is simulated at its operating temperature. Refer to the appropriate model to see which parameter values are scaled.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Ggs	Gate to source conductance	siemens
Ggd	Gate to drain conductance	siemens
dIgs_dVgd	(dIgs/dVgd)	siemens
dIgd_dVgs	(dIgd/dVgs)	siemens

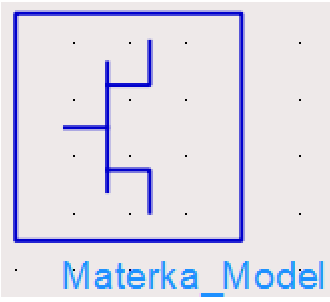
Name	Description	Units
dIds_dVgb	Backgate transconductance (dIds/dVgb)	siemens
Cgs	Gate-source capacitance	farads
Cgd	Gate-drain capacitance	farads
Cds	Drain-source capacitance	farads
dQgs_dVgd	(dQgs/dVgd)	farads
dQgd_dVgs	(dQgd/dVgs)	farads
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts

- This device has no default artwork associated with it.

Materka Model (Materka GaAsFET Model)

Materka_Model (Materka GaAsFET Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NFET	N-channel model type: yes or no	None	yes
PFET	P-channel model type: yes or no	None	no
Idsmod	Ids model: 1=CQ 2=CC 3=Statz 4=Materka 5=Tajima 6=symbolic 7=TOM 8=Modified Materka	None	4
Idss	saturation drain current	A	0
Vto †	Value of V1 below which Ids = Ids(V1=VTO,Vds)	V	-2.0
Alpha	hyperbolic tangent function	V	2.0
Beta2	coefficient for pinch-off change with respect to Vds	1/V	0
Tau	transit time under gate	sec	0
Lambda	channel length modulation	1/V	0.0
Rin	channel resistance	Ohm	0.0
Fc	coefficient for forward bias depletion capacitance (diode model)	None	0.5
Gscap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Cgs	zero bias gate-source junction capacitance	F	0.0

Gdcap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Cgd	zero bias gate-drain junction capacitance	F	0.0
Rd	drain ohmic resistance	Ohm	fixed at 0
Rg	gate resistance	Ohm	fixed at 0
Rs	source resistance	Ohm	fixed at 0
Ld	drain inductance	H	fixed at 0.0
Lg	gate inductance	H	fixed at 0.0
Ls	source inductance	H	fixed at 0.0
Cds	Drain-source cap.	F	0.0
Gsfwd	0-none, 1=linear, 2=diode	None	linear
Gsrev	0-none, 1=linear, 2=diode	None	None
Gdfwd	0-none, 1=linear, 2=diode	None	None
Gdrev	0-none, 1=linear, 2=diode	None	linear
Vbi †	built-in gate potential	V	0.85
Vjr	Breakdown junction potential	V	0.025
Is	gate junction reverse saturation current (diode model)	A	1.0e-14
Ir	gate reverse saturation current	A	1.0e-14
Imax	explosion current	A	1.6
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 2)	A	defaults to Imax
N	gate junction ideality factor (diode model)	None	1
Vbr	gate junction reverse bias breakdown voltage	V	1e100
Fnc	flicker noise corner frequency	Hz	0.0
R	gate noise coefficient	None	0.5
P	drain noise coefficient	None	1
C	gate-drain noise correlation coefficient	None	0.9
Taumdl	Use 2nd order Bessel polynomial to model tau effect in transient: yes or no	None	no
Tnom	nominal ambient temperature at which these model parameters were derived	°C	25
wVgfwd	gate junction forward bias (warning)	V	None

wBvgs	gate-source reverse breakdown voltage (warning)	V	None
wBvgd	gate-drain reverse breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None
† Parameter value varies with temperature based on model Tnom and device Temp.			

- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Drain current in the Materka_Model is calculated with the following expression:

  > *Vp = Vto + Beta2 × Vds*
  >
  > *if (Vfc - Vp ≤ 0 or Vp ≥ 0)*

  else

  > *TI = ABS (Alpha × Vds)*
  >
  > *TanhF = tanh (TI/(Vgc − Vp))*

  $$Ids = Idss \times \left(\frac{Vgc}{V_P} - 1\right)^2 \times TanhF \times (1 + Lambda \times Vds)$$

- The P, R, and C parameters model drain and gate noise sources.

  $$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTg_m P\left(1 + f_{NC}/f\right)$$

  $$\frac{\langle i_g^2 \rangle}{\Delta f} = 4kTC_{gs}^2 \omega^2 R / g_m$$

  $$\frac{\langle i_g, i_d^* \rangle}{\Delta f} = 4kTjC_{gs}\omega\sqrt{PRC}$$

- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). A nonlinear device model parameter value that is explicitly specified will override the value set by an AllParams association.

Additional Information

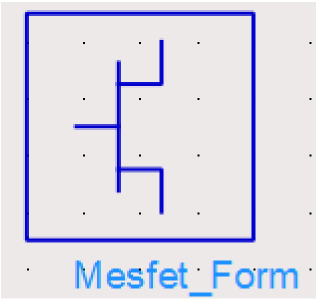
References

- A. Cappy, "Noise Modeling and Measurement Techniques," *IEEE Transactions on Microwave Theory and Techniques* , Vol. 36, No. 1, pp. 1-10, Jan. 1988.

Mesfet Form (Symbolic MESFET Model)

Mesfet_Form (Symbolic MESFET Model)

Symbol



Parameters

Name	Description	Units	Default
NFET	N-channel model type: yes or no	None	yes
PFET	P-channel model type: yes or no	None	no
Idsmod	Ids model: 1=CQ 2=CC 3=Statz 4=Materka 5=Tajima 6=symbolic 7=TOM 8=Modified Materka	None	6
Ids	user-defined equation for drain-source current	None	see Note 1
Qgs	user-defined equation for gate-source charge	None	see Note 1
Qgd	user-defined equation for gate-drain charge	None	see Note1
Igd	user-defined equation for gate-drain current	None	see Note 1
Igs	user-defined equation for gate-source current	None	see Note 1
Beta	transconductance	A/V^2	1.0e-4
Lambda	channel length modulation parameter	1/V	0.0
Alpha	current saturation	1/V	2.0
B	doping tail extending	None	0.3

Tnom	nominal ambient temperature	°C	25
Idstc	IDS temperature coefficient	None	0.0
Vbi	built-in gate potential	V	0.85
Tau	transit time under gate	sec	0.0
Rds0	dc drain-source resistance at Vgs = 0	Ohm	0
Betatce	BETA exponential temperature coefficient	%/°C	0.0
Delta1	capacitance transition voltage	V	0.3
Delta2	capacitance threshold transition voltage	V	0.2
Gscap	0=none, 1=linear, 2 = junction, 3 = Statz Charge, 4 = Symbolic, 5 = Statz Cap	None	linear
Gdcap	0=none, 1=linear, 2 = junction, 3 = Statz Charge, 4 = Symbolic, 5 = Statz Cap	None	linear
Cgs	zero-bias G-S junction cap	F	0.0
Cgd	zero-bias G-D junction cap	F	0.0
Rgs	G-S resistance	Ohm	0.0
Rgd	gate drain resistance	Ohm	0.0
Rf	G-S effective forward-bias resistance	Ohm	infinity†
Tqm	temperature coefficient for triquint junction capacitance	None	0.2
Vmax	maximum junction voltage before capacitance limiting		0.5
Fc	coefficient for forward-bias depletion cap	None	0.5
Rd	drain ohmic resistance	Ohm	fixed at 0
Rg	gate resistance	Ohm	fixed at 0
Rs	source ohmic resistance	Ohm	fixed at 0
Ld	drain inductance	H	fixed at 0.0
Lg	gate inductance	H	fixed at 0.0
Ls	source inductance	H	fixed at 0.0
Cds	drain-source cap	F	0.0
Crf	used with RC to model frequency-dependent output conductance	F	10^{100}
Rc	used with CRC to model frequency-dependent output conductance	Ohm	infinity†
Gsfwd	0=none, 1=linear, 2=diode	None	linear
Gdfwd	0=none, 1=linear, 2=diode	None	None

Gsrev	0=none, 1=linear, 2=diode, 3=custom	None	None
Gdrev	gate junction forward bias warning	None	linear
Vjr	breakdown junction potential		0.025
Is	gate-junction saturation current	A	1.0e-14
Ir	gate rev saturation current	A	1.0e-14
Imax	expression current	A	1.6
Xti	saturation current temperature exponent	None	3.0
N	gate junction emission coefficient	None	1
Eg	energy tap for temperature effect on IS	None	1.1.1
Vbr†	gate junction reverse bias breakdown voltage	V	1e100
Vtotc	VTO temperature coefficient	V/°C	0.0
Rin	channel resistance	Ohm	0.0
Taumdl	use 2nd order Bessel polynomial to model tau effect in transient: yes or no	None	no
Fnc	flicker noise corner frequency	Hz	0.0
R	gate noise coefficient	None	0.5
C	gate-drain noise correlation coefficient	None	0.9
P	drain noise coefficient	None	1.0
wVgfwd	gate junction forward bias (warning	V	None
wBvgs	gate-source reverse breakdown voltage (warning)	V	None
wBvgd	gate-drain reverse breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None
† Value of 0.0 is interpreted as infinity.			

- Equations for default settings:
  Ids = (100mA) × ((1+_v2))^2) × tanh(_v1)
  Qgs = (1pf) × (_v1) - (1pf) × ((_v2) -(_v1)) × (_v1)
  Qgd = (1prf) × (_v1) - ((v2) -(v1)) × (_v1)
  Igd = ramp ((10 + (_v1)) / 10)
  Igs = ramp ((10 + (_v1)) / 10)
- Imax and Imelt Parameters

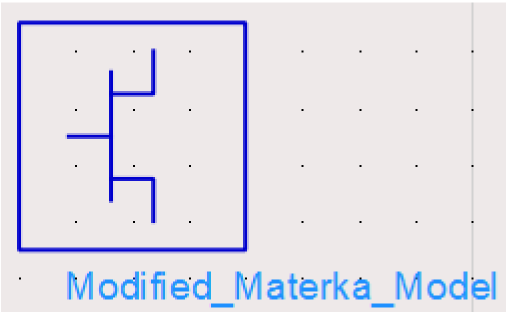
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.

If the *Imelt* value is less than the *Imelt* value, the *Imelt* value is increased to the *Imelt* value.
If *Imelt* is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if *Imax* is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model *Imelt* default value (which is the same as the model *Imelt* default value).

Modified Materka Model (Modified Materka GaAsFET Model)

Modified_Materka_Model (Modified Materka GaAsFET Model)

Symbol



Parameters

Name	Description	Units	Default
NFET	N-channel model type: yes or no	None	yes
PFET	P-channel model type: yes or no	None	no
Idsmod	Ids model: 1=CQ 2=CC 3=Statz 4=Materka 5=Tajima 6=symbolic 7=TOM 8=Modified Materka	None	8
Idss	saturation drain current	A	0
Vto	threshold voltage	V	-2.0
Beta2	coefficient for pinch-off change with respect to Vds	1/V	0
Ee	exponent defining dependence of saturation current	1/V	2.0
Ke	description of dependence on gate voltage	V	0.0

Name	Description	Units	Default
Kg	dependence on Vgs of drain slope in linear region	V	0.0
Sl	linear region slope of Vgs-0 drain characteristic	None	1.0
Ss	saturation region drain slope characteristic at vgs=0	None	0.0
Tau	transit time under gate	sec	0.0
Rgs	channel resistance	Ohm	0.0
Rgd	gate drain resistance	Ohm	0.0
Fc	coefficient for forward bias depletion capacitance (diode model)	None	0.5
Gscap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Cgs	zero bias gate-source junction capacitance	F	0.0
Gdcap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Cgd	zero bias gate-drain junction capacitance	F	0.0
Rd	drain ohmic resistance	Ohm	fixed at 0
Rg	gate resistance	Ohm	fixed at 0
Rs	source ohmic resistance	Ohm	fixed at 0
Ld	drain inductance	H	fixed at 0.0
Lg	gate inductance	H	fixed at 0.0
Ls	source inductance	H	fixed at 0.0
Cds	drain-source capacitance	F	fixed at 0.0
Gsfwd	0-none, 1=linear, 2=diode	None	linear

Name	Description	Units	Default
Gsrev	0-none, 1=linear, 2=diode	None	None
Gdfwd	0-none, 1=linear, 2=diode	None	None
Gdrev	0-none, 1=linear, 2=diode	None	linear
Vbi †	built-in gate potential	V	0.85
Vjr	Breakdown junction potential	V	0.025
Is	gate junction saturation current (diode model)	A	1.0e-14
Ir	gate reverse saturation current	A	1.0e-14
Imax	explosion current	A	1.6
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 3)	A	defaults to Imax
N	gate junction emission coefficient (diode model)	None	1
Fnc	flicker noise corner frequency	Hz	0.0
Lambda	channel length modulation	1/V	0.0
Vbr	reverse bias breakdown voltage	V	1e100
R	gate noise coefficient	None	0.5
P	drain noise coefficient	None	1
C	gate-drain noise correlation coefficient	None	0.9
Taumdl	Use 2nd order Bessel polynomial to model tau effect in transient simulation: yes or no	None	no
wVgfwd	gate junction forward bias warning	V	None

Name	Description	Units	Default
wBvgs	gate-source reverse breakdown voltage warning	V	None
wBvgd	gate-drain reverse breakdown voltage warning	V	None
wBvds	drain-source breakdown voltage warning	V	None
wIdsmax	maximum drain-source current warning	A	None
wPmax	maximum power dissipation warning	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

- Drain current in the Modified_Materka_Model is calculated as follows:

$$V_{psmooth} = 0.5 * \left(V_p - \sqrt{(V_p * V_p + 0.01)} \right)$$

$$V_{p\_eps} = V_{psmooth} + 0.075^2$$

$$DeltaV_{gc} = \left(V_{gc} - V_{p\_eps}\right)^2 + 0.075^2$$

$$V_{gcsmooth} = 0.5 * \left(\sqrt{DeltaV_{gc}} + V_{gc} - V_{p\_eps} \right) + V_{p\_eps}$$

$$Power0 = pow\left(\left(1 - \frac{V_{gcsmooth}}{V_{psmooth}} \right), ee + ke * V_{gcsmooth} \right)$$

$$F0 = 0.5 + 0.5 * \tanh\left(\frac{V_{gc} - V_{psmooth}}{0.075} \right)$$

$$xx = I_{dss} * \left(\frac{1 - K_g * V_{gc}}{SL} \right)$$

$$yy = 0.5 * (\sqrt{(xx - 0.01)^2 + 0.075^2) + xx - 0.01} + 0.01$$

$$GI = \tanh\left(\frac{V_{ds}}{yy} \right)$$

$$HI0 = 1.0 + Ss * \frac{V_{ds}}{I_{dss}}$$

$$HI = 0.5 * \left(\sqrt{(HI0^2 + 0.075^2)} + HI0 \right)$$

$$I_{ds} = I_{dss} * Power0 * F0 * GI * HI$$

- Imax and Imelt Parameters

  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is

specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).

- The P, R, and C parameters model drain and gate noise sources.

$$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTg_m\, P(1 + f_{NC}/f)$$

$$\frac{\langle i_g^2 \rangle}{\Delta f} = 4kT\, C_{gs}^2\, \omega^2\, R/g_m$$

$$\frac{\langle i_g, i_d^* \rangle}{\Delta f} = 4kTj\, C_{gs}\, \omega\sqrt{PR}\, C$$

- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). A nonlinear device model parameter value that is explicitly specified will override the value set by an AllParams association.

Additional Information

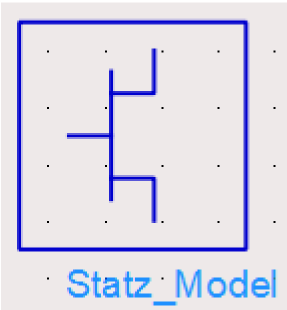
References

- A. Cappy, "Noise Modeling and Measurement Techniques," *IEEE Transactions on Microwave Theory and Techniques* , Vol. 36, No. 1, pp. 1-10, Jan. 1988.

Statz Model (Statz Raytheon GaAsFET Model)

Statz_Model (Statz Raytheon GaAsFET Model)

Symbol



Statz_Model implementation is based on the work of Statz et al [1].
In particular, the expressions for drain source current and gate charge are implemented exactly as published in [1]. The Statz model also includes a number of features that (although not described in the Statz article) are generally accepted to be important features of a GaAsFET model. These include a gate delay factor (Tau), an input charging resistance (Ri), gate junction forward conduction and breakdown.

Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NFET	N-channel type: yes or no	None	yes
PFET	P-channel type: yes or no	None	no
Idsmod	Ids model: 1=CQ 2=CC 3=Statz 4=Materka 5=Tajima 6=symbolic 7=TOM 8=Modified Materka	None	3
Vto ††	threshold voltage	V	-2.0
Beta †, ††	transconductance	A/V^2	1.0e-4
Lambda	output conductance	1/V	0.0

Alpha	current saturation	1/V	2.0
B	Doping tail extending parameter	None	0.3
Tnom	nominal ambient temperature	°C	25
Trise	Temperature rise over ambient	°C	None
Idstc	Ids temperature coefficient	None	0.0
Vbi ††	built-in gate potential	V	0.85
Tau	transit time under gate	sec	0.0
Betatce	drain current exponential temperature coefficient	%/°C	0.0
Delta1	capacitance saturation transition voltage	V	0.3
Delta2	capacitance threshold transition voltage	V	0.2
Gscap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Cgs †, ††	zero bias gate-source junction capacitance	F	0.0
Gdcap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Cgd †, ††	zero bias gate-drain junction capacitance	F	0.0
Rgd‡	gate drain resistance	Ohm	0.0
Tqm	junction capacitance temperature coefficient	None	0.2
Vmax	maximum junction voltage before capacitance limiting		0.5
Fc	coefficient for forward bias depletion capacitance (diode model)	None	0.5
Rd ‡	drain ohmic resistance	Ohm	fixed at 0
Rg	gate resistance	Ohm	fixed at 0
Rs ‡	source ohmic resistance	Ohm	fixed at 0
Ld	drain inductance	H	fixed at 0.0
Lg	gate inductance	H	fixed at 0.0
Ls	source inductance	H	fixed at 0.0
Cds †	drain-source capacitance	F	0.0
Crf †	used with Rc to model frequency dependent output conductance	F	0.0
Rc ‡	used with Crf to model frequency dependent output conductance	Ohm	infinity †††
Gsfwd	0-none, 1=linear, 2=diode	None	linear
Gsrev	0-none, 1=linear, 2=diode	None	none

Gdfwd	0-none, 1=linear, 2=diode	None	none
Gdrev	0-none, 1=linear, 2=diode	None	linear
Vjr	breakdown junction potential		0.025
Is †	gate junction saturation current (diode model)	A	1.0e-14
Ir †	gate reverse saturation current	A	1.0e-14
Imax	explosion current	A	1.6
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 3)	A	defaults to Imax
Xti	temperature exponent for saturation current	None	3.0
N	gate junction emission coefficient	None	1
Eg	energy gap for temperature effect on Is	None	1.11
Vbr	Gate junction reverse bias breakdown voltage	V	1e100
Vtotc	Vto temperature coefficient	V/°C	0.0
Rin ‡	channel resistance	Ohm	0.0
Taumdl	Use 2nd order Bessel polynomial to model tau effect in transient: yes or no	None	no
Fnc	flicker noise corner frequency	Hz	0.0
R	gate noise coefficient	None	0.5
C	gate-drain noise correlation coefficient	None	0.9
P	drain noise coefficient	None	1.0
wVgfwd	gate junction forward bias warning	V	None
wBvgs	gate-source reverse breakdown voltage warning	V	None
wBvgd	gate-drain reverse breakdown voltage warning	V	None
wBvds	drain-source breakdown voltage warning	V	None
wIdsmax	maximum drain-source current warning	A	None
wPmax	maximum power dissipation warning	W	None
Kf	flicker noise coefficient	None	0.0
Af	flicker noise exponent	None	1.0
Ffe	flicker noise frequency exponent	None	1.0
AllParams	DataAccessComponent for file-based model parameter values	None	None
† Parameter value scales with Area. †† Parameter value varies with temperature based on model Tnom and device Temp. ††† Value of 0.0 is interpreted as infinity. ‡ Parameter value scales inversely with Area.			

- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). A nonlinear device model parameter value that is explicitly specified will override the value set by an AllParams association.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname GaAs Idsmod=3[parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by GaAsFET components to refer to the model. The third parameter indicates the type of model; for this model it is *GaAs* . Idsmod=3 is a required parameter that is used to tell the simulator to use the Statz equations. Use either parameter NFET=yes or PFET=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example

```
model  gf1  GaAs Idsmod=3 \
  Vto=-2.5 Beta=1e-3 NFET=yes
```

Equations/Discussion

Drain-Source Current

Statz_Model DC drain-source current is given by these expressions:

For 0 < Vds < 3 / α

$$I_{ds} = \frac{\beta V_{gs} - Vto^2}{1 + \beta V_{gs} - Vto}\left[1 - \left[1 - \frac{\alpha V_{ds}}{3}\right]^3\right](1 + \lambda V_{ds})$$

where α is Alpha, β is Beta, Θ is B.
For Vds ≥ 3/α

$$I_{ds} = \frac{\beta(V_{gs} - Vto)^2}{1 + \beta(V_{gs} - Vto)}(1 + \lambda V_{ds})$$

The current is set to zero for V_{gs} < Vto.

where α is Alpha, β is Beta, Θ is B.

Gate Charge

You are provided with two options in modeling the junction capacitance of a device. The first is to model the junction as a linear component (a constant capacitance). The second is to model the junction using a diode depletion capacitance model. If a non-zero value of Cgs is specified and Gscap is set to 1 (linear), the gate-source junction will be modeled as a linear component. Similarly, specifying a non-zero value for Cgd and Gdcap = 1 result in a linear gate-drain model. A non-zero value for either Cgs or Cgd together with Gscap =2 (junction) or Gdcap = 2 will force the use of the diode depletion capacitance model for that particular junction. Note that each junction is modeled independent of the other; hence, it is possible to model one junction as a linear component while the other is treated nonlinearly. The junction depletion charge and capacitance equations are summarized below.
The gate charge in Statz_Model is given by,
for $V_{new} > V_{max}$,

$$Q_g = Cgs\left(2 \times Vbi\left(1 - \sqrt{1 - \frac{V_{max}}{Vbi}}\right) + \frac{V_{new} - V_{max}}{\sqrt{1 - \frac{V_{max}}{Vbi}}}\right) + Cgd \times V_{eff2}$$

for $V_{new} \le V_{max}$

$$Q_g = Cgs \times 2 \times Vbi\left(1 - \sqrt{1 - \frac{V_{new}}{Vbi}}\right) + Cgd \times V_{eff2}$$

where:

V_{max} = Min (Fc x Vbi, V_{max})

$$V_{new} = \frac{1}{2}\left(V_{eff1} + Vto + \sqrt{(V_{eff1} - Vto)^2 + Delta2^2}\right)$$

$$V_{eff1} = \frac{1}{2}\left\{V_{gc} + V_{gd} + \sqrt{(V_{gc} - V_{gd})^2 + Delta1^2}\right\}$$

and

$$V_{eff2} = \frac{1}{2}\left\{V_{gc} + V_{gd} - \sqrt{(V_{gc} - V_{gd})^2 + Delta1^2}\right\}$$

The inclusion of Ri requires that one of the controlling voltages be switched from V_{gs} to V_{gc}. This results in a symmetry between the d-c nodes instead of the d-s nodal symmetry described in the Statz paper (of course, if Ri is set to zero, the model reduces to the exact representation in the Statz paper).

To implement this model in a simulator, the gate charge must be partitioned between the g-c and g-d branches. Implementation of the Statz model partitions the gate charge according to the work of Divekar [2]. Under this partitioning scheme, the gate-source charge is given by:
if Delta1 is given and > 0

$$sqInvAlpha = Delta1^2$$

else if Alpha > 0

$$sqInvAlpha = \frac{1}{Alpha^2}$$

$$\sqrt{V_{gs}V_{gd}} = \sqrt{\left(\left(V_{gs} - V_{gd}\right) * \left(V_{gs} - V_{gd}\right) + sqInvAlpha\right)}$$

$$V_e = \frac{(V_{gs} + V_{gd} + \sqrt{V_{gs}V_{gd}})}{2}$$

$$V_{e2} = \frac{\left(\left(V_{gs} + V_{gd}\right) - \sqrt{V_{gs}V_{gd}}\right)}{2}$$

$$\sqrt{V_eV_{to}} = \sqrt{((V_e - V_{to})^2 + Delta^2)}$$

$$V_n = \frac{(V_e+V_{to}+\sqrt{V_eV_{to}})}{2}$$

$$k1 = \frac{1 + \frac{(V_e - V_{to})}{\sqrt{V_eV_{to}}}}{2}$$

$$k2 = \frac{1 + \frac{(V_{gs} - V_{gd})}{\sqrt{V_{gs}V_{gd}}}}{2}$$

$$k3 = \frac{1 - \frac{(V_{gs} - V_{gd})}{\sqrt{V_{gs}V_{gd}}}}{2}$$

if

$(F_c * V_jT < V_{max})$

$v_{max} = F_c * V_jT$

else

$v_{max} = V_{max}$

where, V_jT is the temperature adjusted V_{bi}
if

($v_n < v_{max}$)

$$\sqrt{V_n V_{bi}} = \sqrt{1 - \frac{V_n}{V_{jT}}}$$

$$Q_{gs} = 2 * C_{gs\_T} * V_{jT} * (1 - \sqrt{V_n V_{bi}})$$

otherwise,

$$\sqrt{V_n V_{bi}} = \sqrt{1 - \frac{V_{max}}{V_{jT}}}$$

$$Q_{gs} = C_{gs\_T} * (2 * V_{jT} * \left(1 - \sqrt{V_n V_{bi}}\right) + \frac{(V_n - V_{max})}{\sqrt{V_n V_{bi}}}$$

$$Q_{gd} = C_{gd\_T} * V_{e2}$$

Where C_{gs_T} and C_{gd_T} are the temperature adjusted C_{gs} and C_{gd}

The small-signal capacitances (equations 16 and 17 in the Statz paper) are related to the charge partial derivatives through the following expressions:

$$C_{gs} = \frac{\partial Q_{gs}}{\partial V_{gc}} + \frac{\partial Q_{gd}}{\partial V_{gc}}$$

$$C_{gd} = \frac{\partial Q_{gs}}{\partial V_{gd}} + \frac{\partial Q_{gd}}{\partial V_{gd}}$$

Although the drain-source current model and the gate-conduction model (next section) are well behaved for negative V_{ds} (as well as the zero crossing), the charge model may cause convergence problems in the region $V_{ds} < 0.0V$. The reason for this is that the charge partitioning is somewhat artificial in that Q_{gs} and Q_{gd} should *swap* roles for negative V_{ds} but don't. It is recommended that this model be used for positive V_{ds} only.

Gate forward conduction and breakdown

Implementation of Statz_Model places a diode model in both the gate-source and gate-drain junctions to model forward conduction current and reverse breakdown current. These currents are calculated with these expressions:

Gate-Source Current

for $V_{gs} > -10 \times N \times v_t$

$$I_{gs} = Is \times \left[exp\left(\frac{V_{gs}}{N \times v_t}\right) - 1\right]$$

for $-Vbr + 50 \times v_t < V_{gs} \le -10 \times N \times v_t$

$$I_{gs} = Is \times [exp(-10) - 1] + g_{gs} \times (V_{gs} - 10 \times N \times v_t)$$

where:

$$g_{gs} = Is \times \frac{exp(-10)}{N \times v_t}$$

for $V_{gs} \le -Vbr + 50 \times v_t$

$$I_{gs} = -Is \times \exp\left(\frac{-Vbr + V_{gs}}{N \times v_t}\right) + Is \times [exp(-10) - 1] + g_{gs} \times (V_{gs} - 10 \times N \times v_t)$$

Gate-Drain Current

for $V_{gd} > -10 \times N \times v_t$

$$I_{gd} = Is \times \left[exp\left(\frac{V_{gd}}{N \times v_t}\right) - 1\right]$$

for $-Vbr + 50 \times v_t < V_{gd} \le -10 \times N \times v_t$

$$I_{gd} = Is \times [exp(-10) - 1] + g_{gd} \times (V_{gd} - 10 \times N \times v_t)$$

where:

$$g_{gd} = Is \times \frac{exp-10}{N \times v_t}$$

for $V_{gd} \le -Vbr + 50 \times v_t$

$$I_{gd} = -Is \times \exp\left(\frac{-(Vbr + V_{gd})}{N \times v_t}\right) Is \times [exp(-10) - 1] + g_{gd} \times (V_{gd} - 10 \times N \times v_t)$$

Time Delay

Like Curtice2_Model and Curtice3 _Model, Statz_Model uses an ideal time delay to model transit time effects under the gate. In the time domain, the drain source current for the ideal delay is given by:

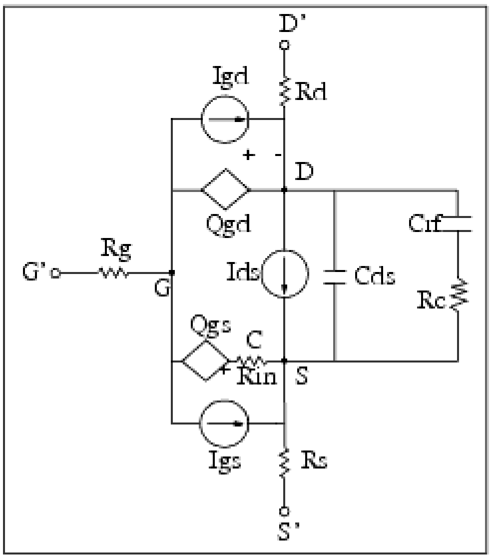
$I_{ds}(t) = I_{ds}(V_j(t\text{-}Tau), V_{ds}(t))$

where $V_j = V_{gs}$ or $V_j = V_{gd}$ (depending on whether V_{ds} is positive or negative). In the frequency domain, only the transconductance is impacted by this delay and the familiar expression for transconductance is obtained:

$y_m = g_m \times exp(-j \times \omega \times Tau)$

High-Frequency Output Conductance

The series-RC network, shown below, is comprised of the Crf and Rc parameters and is included to provide a correction to the AC output conductance at a specific bias condition. At a frequency high enough such that Crf is an effective short, the output conductance of the device can be increased by the factor 1/Rc. (Also see [3].)



Statz_Model Schematic

Temperature Scaling

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device item Temp parameter. (Temperatures in the following equations are in Kelvin.)

The saturation current Is scales as:

$$Is^{NEW} = Is \times exp\left[\left(\frac{Temp}{Tnom} - 1\right)\frac{q \times Eg}{k \times N \times Temp} + \frac{Xti}{N} \times ln\left(\frac{Temp}{Tnom}\right)\right]$$

The gate depletion capacitances Cgs and Cgd vary as:

$$Cgs^{NEW} = Cgs\left(1 + Tqm\left(4 \times 10^{-4}(Temp - Tnom) - \left(\frac{Vbi^{NEW}}{Vbi}\right) - 1\right)\right)$$

$$Cgd^{NEW} = Cgd\left(1 + Tqm\left(4 \times 10^{-4}(Temp - Tnom) - \left(\frac{Vbi^{NEW}}{Vbi}\right) - 1\right)\right)$$

Where VbiNEW is the temperature scaled value of Vbi at Temp.

The gate junction potential Vbi varies as:

$$Vbi^{NEW} = \frac{Temp}{Tnom} \times Vbi + \frac{2k \times Temp}{q} 1n\left(\frac{n_i^{Tnom}}{n_i^{Temp}}\right)$$

where n_i is the intrinsic carrier concentration for silicon, calculated at the appropriate temperature.

The threshold voltage Vto varies as:

$$Vto^{NEW} = Vto + Vtotc(Temp - Tnom)$$

The transconductance Beta varies as:

$$Beta^{NEW} = Beta \times 1.01^{Betatce(Temp - Tnom)}$$

Noise Model

Thermal noise generated by resistors Rg, Rs, Rd and Rin is characterized by the spectral density:

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

Parameters P, R, and C model drain and gate noise sources.

$$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTg_m\ P + 4kTg_m\ PFnc\ /f + Kf\ Ids^{Af}\ /f^{Ffe}$$

$$\frac{\langle i_g^2 \rangle}{\Delta f} = 4kT\ C_{gs}^2\ \omega^2\ R/g_m$$

$$\frac{\langle i_g, i_d^* \rangle}{\Delta f} = 4kTj\ C_{gs}\ \omega\sqrt{PR}\ C$$

For Series IV compatibility, set P=2/3, R=0, C=0, and Fnc=0; copy Kf, Af, and Ffe from the Series IV model.

Additional Model

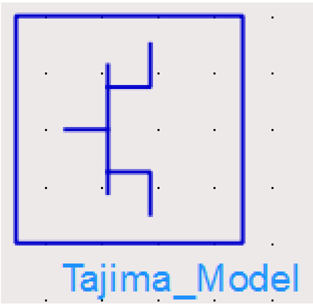
References

- H. Statz, P. Newman, I. Smith, R. Pucel and H. Haus. "GaAs FET device and circuit simulation in SPICE," *IEEE Trans, on Electron Devices,* vol. ED-34, pp. 160-169, Feb. 1987.
- D. Divekar, *Comments on `GaAs FET device and circuit simulation in SPICE, ' IEEE Transactions on Electron Devices,* Vol. ED-34, pp. 2564-2565, Dec. 1987.
- C. Camacho-Penalosa and C.S. Aitchison. "Modelling frequency dependence of output impedance of a microwave MESFET at low frequencies," *Electron. Lett.* , Vol. 21, pp. 528-529, June 6, 1985.
- P. Antognetti and G. Massobrio. *Semiconductor device modeling with SPICE,* New York: McGraw-Hill, Second Edition 1993.
- A. Cappy, "Noise Modeling and Measurement Techniques," *IEEE Transactions on Microwave Theory and Techniques,* Vol. 36, No. 1, pp. 1-10, Jan. 1988.

Tajima Model (Tajima GaAsFET Model)

Tajima_Model (Tajima GaAsFET Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NFET	N-channel model type: yes or no	None	yes
PFET	P-channel model type: yes or no	None	no
Idsmod	Ids model type: 1=CQ 2=CC 3=Statz 4=Materka 5=Tajima 6=symbolic 7=TOM 8=Modified Materka	None	5
Vdss	drain current saturation voltage	V	1.0
Vto	value of V1 below which Ids = Ids(V1=VT0,Vds)	V	-2.0
Beta2	coefficient for pinch-off change with respect to Vds	1/V	0
Ta	\`a' coefficient	None	2
Tb	\`b' coefficient	None	0.6
Tm	\`m' coefficient	None	3.0
Idss	saturation drain current	A	0
Rin ††	channel resistance	Ohm	0.0
Fc	coefficient for forward bias depletion capacitance (diode model)	None	0.5
Gscap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear

Cgs ††	zero bias gate-source junction capacitance	F	0.0
Gdcap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	linear
Cgd ††	zero bias gate-drain junction capacitance	F	0.0
Rd	drain ohmic resistance	Ohm	fixed at 0
Rg	gate resistance	Ohm	fixed at 0
Rs	source ohmic resistance	Ohm	fixed at 0
Ld	drain inductance	H	fixed at 0.0
Lg	gate inductance	H	fixed at 0.0
Ls	source inductance	H	fixed at 0.0
Cds ††	drain-source capacitance	F	0.0
Crf ††	used to model frequency-dependent output conductance	F	0.0
Rc †††	additional output resistance for RF operation	Ohm	infinity‡
Gsfwd	0=none, 1=linear, 2=diode	None	linear
Gsrev	0=none, 1=linear, 2=diode	None	none
Gdfwd	0=none, 1=linear, 2=diode	None	none
Gdrev	0=none, 1=linear, 2=diode	None	linear
Vbi †	built-in gate potential	V	0.85
Is	gate junction reverse saturation current (diode model)	A	1.0e-14
Imax	explosion current	A	1.6
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 4)	A	defaults to Imax
N	gate junction emission coefficient (diode model)	None	1
Fnc	flicker noise corner frequency	Hz	0.0
R	gate noise coefficient	None	0.5
P	drain noise coefficient	None	1.0
C	gate-drain noise correlation coefficient	None	0.9
Tnom	nominal ambient temperature	º C	25
wVgfwd	gate junction forward bias warning	V	None
wBvgs	gate-source reverse breakdown voltage warning	V	None
wBvgd	gate-drain reverse breakdown voltage warning	V	None

wBvds	drain-source breakdown voltage warning	V	None
wIdsmax	maximum drain-source current warning	A	None
wPmax	maximum power dissipation warning	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None
† Parameter value varies with temperature based on model Tnom and device Temp. †† Parameter value scales with Area. ††† Parameter value scales inversely with Area. ‡ A value of 0.0 is interpreted as infinity.			

- This model supplies values for a GaAsFET device.
- The P, R, and C parameters model drain and gate noise sources.

$$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTg_m\, P(1 + f_{NC}/f)$$

$$\frac{\langle i_g^2 \rangle}{\Delta f} = 4kT\, C_{gs}^2\, \omega^2\, R/g_m$$

$$\frac{\langle i_g, i_d^* \rangle}{\Delta f} = 4kTj\, C_{gs}\, \omega \sqrt{PR}\, C$$

- Additional parameter equations are given:
  υ_p = Vto − Beta^2 × Vds − Vbi
  υc = (υgs − Vbi - υp)/υp
  If $\upsilon_p \geq 0$ or $\upsilon_c \geq 0$, then ids = 0
  else:

$$id_1 = \left[\frac{(\exp(Tm \bullet \upsilon c)^{-1})}{Tm} - \upsilon c\right] \Big/ \left[1 - \frac{(1 - \exp(-Tm))}{Tm}\right]$$

$$id_2 = Idss \bullet \left[1 - \exp\left(\left(\frac{\upsilon ds}{Vdss}\right) - Ta\left(\frac{\upsilon ds}{Vdss}\right)^2 - Tb\left(\frac{\upsilon ds}{Vdss}\right)^3\right)\right]$$

ids = $id_1 \times id_2$

- Imax and Imelt Parameters

  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).

- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). A nonlinear device model parameter value that is explicitly specified will override the value set by an AllParams association.

Additional Information

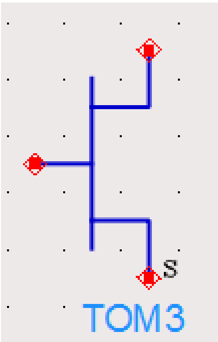
References

- A. Cappy, "Noise Modeling and Measurement Techniques," *IEEE Transactions on Microwave Theory and Techniques* , Vol. 36, No. 1, pp. 1-10, Jan. 1988.

TOM3 (TriQuint TOM3 Scalable Nonlinear FET)

TOM3 (TriQuint TOM3 Scalable Nonlinear FET)

Symbol



Range of Usage

> *W > 0*
> *Ng > 0*

Parameters

Name	Description	Units	Default
Model	name of a TOM3_Model	None	TOM3M1
W	gate width	m	no scaling
Ng	number of gate fingers	None	no scaling
Temp	device instance temperature	°C	25
Trise	device temperature relative to circuit ambient (if Temp not specified)	°C	0
Noise	noise generation option: yes or no	None	yes

Name	Description	Units	Default
_M	number of devices in parallel	None	1

- W and Ng are used for scaling device instance. See TOM3_Model information for details. Area/finger scaling is performed only if both W and Ng are specified and their values are positive.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgsi)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Cgs	Gate-source capacitance (dQg/dVgsi)	farads
Cgd	Gate-drain capacitance (dQg/dVgdi)	farads
Ggse	Gate-source diode conductance	siemens
Ggde	Gate-drain diode conductance	siemens
Ggsi	Gate-source leakage conductance	siemens
Ggdi	Gate-drain leakage conductance	siemens
Vgse	Gate-source voltage	volts
Vgde	Gate-drain voltage	volts

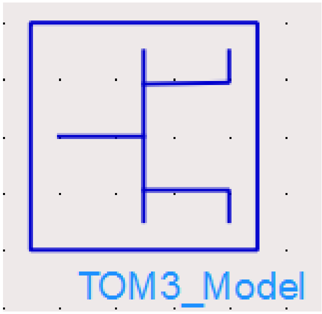
Name	Description	Units
Vcvs	Gate voltage offset	volts
dVcvs_dVc	Controlling coefficient for VCVS	
Vgs	External gate-source voltage	volts
Vds	External drain-source voltage	volts

- This device has no default artwork associated with it.

TOM3 Model (TriQuint TOM3 Scalable Nonlinear FET Model)

TOM3_Model (TriQuint TOM3 Scalable Nonlinear FET Model)

Symbol



The published TOM3 model [1, 2] is capacitance-based, which corresponds to setting Capmod=1 (refer to Gate Capacitances). In general, the bias-dependent capacitor models are known to be less robust, which sometimes leads to non-convergence problems. ADS implementation of TOM3 is enhanced by providing a charge-based model, which corresponds to setting Capmod=2 (refer to Gate Charge Model). Charge-based models are normally more robust and they are better justified theoretically.
Please note that the distribution of the charge between the drain and source is not exactly the same for the two modes of the capacitance model. Therefore, simulation results for the two modes may slightly differ. Implementation of the TOM3 model is based on [1] and [2].

Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NFET	N-channel type: yes or no	None	YES
PFET	P-channel type: yes or no	None	NO
Tnom	model temperature at which all parameters were derived	°C	25
Ugw	gate width to which model parameters are normalized	m	1e-6
Ngf	number of gate fingers to which model parameters are normalized	None	1

Vto †	threshold voltage	V	-2.0
Alpha †	saturation parameter in Ids equation	1/V	3.0
Beta † , †††	transconductance parameter in Ids equation	A/V^Q	0.05
Lambda	channel length modulation / output conductance	1/V	0
Gamma †	coefficient for pinch-off change with respect to Vds	None	0.1
Q	power generalizing the square-law for Ids current	None	2.0
K	knee function power law coefficient	None	3.0
Vst †	subthreshold slope voltage	V	0.05
Mst †	parameter for subthreshold slope voltage dependence on Vds	1/V	0
Ilk †††	reverse leakage saturation current - diode models	A	0.1e-6
Plk	reverse leakage reference voltage - diode models	V	2.25
Kgamma	feedback coefficient for the internal VCVS	None	0.33
Taugd	series Ctau-Rtau time constant (implicit definition of Rtau)	sec	1.0e-9
Ctau	dispersion model capacitance	F	1.0e-15
Qgql †††	low-power gate charge nonlinear term coefficient	C	0.2e-12
Qgqh †††	high-power gate charge nonlinear term coefficient	C	0.1e-12
Qgi0 †††	reference current in high-power gate charge nonlinear Ids term	A	0.1e-3
Qgag	low-power gate charge nonlinear term exponential coefficient	1/V	0.75
Qgad	low-power gate charge nonlinear term exponential Vds coefficient	1/V	0.65
Qggb ††	transition coefficient for combined low-high power charge	1/W	3.0
Qgcl †††	low-power gate charge linear terms coefficient	F	0.1e-12
Qgsh †††	high-power gate charge linear Vgsi term coefficient	F	0.2e-12
Qgdh †††	high-power gate charge linear Vgdi term coefficient	F	0.1e-12
Qgg0 †††	combined low-high power additional linear terms coefficient	F	0
Capmod	capacitance model: 1=bias-dependent capacitances, 2=charge	None	2
Cds †††	drain-source capacitance	F	0
Tau	transit time under gate	sec	0
Rd †, ††	drain ohmic resistance	Ohm	0
Rdtc	temperature linear coefficient for Rd	1/°C	0
Rg ‡	gate resistance	Ohm	0

Rgmet ‡	gate metal resistance	Ohm	0
Rs †, ††	source ohmic resistance	Ohm	0
Rstc	temperature linear coefficient for Rs	1/°C	0
Is †, †††	saturation current in forward gate current diode models	A	1e-12
Eta	emission coefficient for gate diode models	None	1.25
Alphatce	temperature exponential coefficient for Alpha	1/°C	0
Gammatc	temperature linear coefficient for Gamma	1/°C	0
Msttc	temperature linear coefficient for Mst	1/(V °C)	0
Vsttc	temperature linear coefficient for Vst	V/°C	0
Vtotc	temperature linear coefficient for Vto	V/°C	0
Betatce	temperature exponential coefficient for Beta	1/°C	0
Xti	temperature exponent for saturation current	None	2.5
Eg	energy gap for temperature effect on Is	eV	1.11
Imax	explosion current	A	1.6
Fnc	flicker noise corner frequency	Hz	0
R	gate noise coefficient	None	0.5
P	drain noise coefficient	None	1.0
C	gate-drain noise correlation coefficient	None	0.9
Kf	flicker noise coefficient	None	0
Af	flicker noise exponent	None	1.0
Ffe	flicker noise frequency exponent	None	1.0
wVgfwd	gate junction forward bias warning	V	None
wBvgs	gate-source reverse breakdown voltage warning	V	None
wBvgd	gate-drain reverse breakdown voltage warning	V	None
wBvds	drain-source breakdown voltage warning	V	None
wIdsmax	maximum drain-source current warning	A	None
wPmax	maximum power dissipation warning	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

† Parameter value varies with temperature based on model Tnom and device Temp. †† Parameter value scales inversely with area. ††† Parameter value scales with area. ‡ Total gate resistance is Rg + Rgmet.

- All model parameters except for Vto (and Vtotc) are identical for the corresponding N- and P-channel devices. The signs of Vto and Vtotc must be changed in order to generate consistent results for N- and P-type transistors.
- The dispersion branch consists of a series connection of a capacitance Ctau and a resistance Rtau. Rtau does not appear among the model parameters; instead, the model parameters include the time constant Taugd of that branch, and thus Rtau is implicitly defined as Rtau = Taugd / Ctau.
- To prevent numerical problems, the setting of some model parameters to 0 is trapped by the simulator. The following parameters are maintained by the simulator at a minimum value:

  > *Rd = 1e-4*
  >
  > *Rs = 1e-4*
  >
  > *Rg = 1e-4*

  If the user wants any of the extrinsic resistances Rd, Rg, and Rs to be exactly zero, their values should not be entered. The default is a short circuit. If a value is entered, it must be positive.
- Imax and Imelt Parameters
  Imax specifies the P-N junction explosion current for D1, D2, D3 and D4 diodes. Imax can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  The Imelt parameter, available in several other ADS models, is not currently implemented in the TOM3 model.
- For SDD compatibility use Taugd = 1.0e-6 if "tau_gd = Slow" mode was used, Taugd= 10.0e-9 if "taug_gd=Fast" mode was used, and Rgmet = 0.1, Rdtc = 0.0044, Rstc = 0.0016, Xti = 2 × Eta, Eg = 0.9, Imax = 1.0e6.
- Several parameters are restricted to values > 0. If the user violates this restriction, an error message will be written in the status window, and the simulation will not proceed.
- Model parameters such as Ls, Ld, Lg are not currently used by the TOM3 device in the simulator. Extrinsic components must be added externally by the user.

DC Drain-Source Current

The TOM3 DC drain-source current is calculated using the following equations [2].

$$I_{ds} = I_0 \times (1 + \lambda V_{ds})$$

where:

$$I_0 = \beta \times (V_G)^Q \times f_k$$

$$f_k = \frac{\alpha V_{ds}}{(1 + (\alpha V_{ds})^k)^{1/k}}$$

$$V_G = Q \times V_{ST} \times \ln(1 + \exp(u))$$

$$u = \frac{V_{gsi} - V_{TO} + \gamma V_{ds}}{Q \times V_{ST}}$$

$$V_{ST} = V_{ST0} \times (1 + M_{ST0} \times V_{ds})$$

The model parameters for the drain current are: λ (Lambda), β (Beta), Q (Q), α (Alpha), *k* (K), V_{TO}(Vto), γ (Gamma), V_{ST0}(Vst) and MST0 (Mst).

For time-varying drain-source current, the voltage V_{gsi} is delayed by the transit time Tau.

Gate Capacitances

The gate capacitances in the TOM3 model are derived from the following charge equations (see [1, 2]). The total gate charge is given as:

$$Q_{GG} = Q_{GL} \times f_T + Q_{GH} \times (1 - f_T) + Q_{GG0} \times (V_{gsi} + V_{gdi})$$

where

$$f_T = \exp(-Q_{GGB} \times I_{ds} \times V_{ds})$$

is a transition function combining the *low power* charge

$$Q_{GL} = Q_{GQL} \times \exp(Q_{GAG} \times (V_{gsi} + V_{gdi})) \times \cosh(Q_{GAD} \times V_{ds}) + Q_{GCL} \times (V_{gsi} + V_{gdi})$$

with the *high power* charge

$$Q_{GH} = \left(Q_{GQH} \times \ln\left(1 + \frac{I_{ds}}{Q_{GI0}}\right) + Q_{GSH} \times V_{gsi}\right) + Q_{GDH} \times V_{gdi}$$

The model parameters for the gate charge are: Q_{GG0} (Qgg0), Q_{GGB} (Qggb), Q_{GQL} (Qgql), Q_{GAG} (Qgag), Q_{GAD} (Qgad), Q_{GCL} (Qgcl), Q_{GQH} (Qgqh), Q_{GI0} (Qgi0), Q_{GSH} (Qgsh) and Q_{GDH} (Qgdh).

There are two capacitance models in the TOM3 implementation in ADS. The first model corresponds to other TriQuint implementations of the TOM3 model, including the SDD implementation in ADS. That model is invoked by setting Capmod = 1 (bias-dependent capacitances). The gate-source and gate-drain self-capacitances are then defined as:

$$C_{gs} = \left.\frac{\partial Q_{GG}}{\partial V_{gsi}}\right|_{V_{gdi} = \text{const}}$$

$$C_{gd} = \left.\frac{\partial Q_{GG}}{\partial V_{gdi}}\right|_{V_{gsi} = \text{const}}$$

and, correspondingly, their contribution to the drain, gate and source currents follows the partitioning as:

$$I_{Cgsi} = C_{gs}(V_{gsi}, V_{gdi}) \times \frac{dV_{gsi}}{dt}$$

and

$$I_{Cgdi} = C_{gd}(V_{gsi}, V_{gdi}) \times \frac{dV_{gdi}}{dt}$$

Gate Charge Model

The other capacitance model in the TOM3 implementation in ADS is invoked by setting Capmod = 2 (charge model). The total gate charge is partitioned 50/50 onto the gate-source and gate-drain charges. Their derivatives with respect to the voltages V_{gsi} and V_{gdi} define the corresponding self- and trans-capacitances.

For this release the user cannot control how the gate charge is partitioned.

Gate Diode Currents

The four diodes in the TOM3 model are intended to account for gate diode, leakage and breakdown. The following equations are used for the respective diodes [2].

Diodes D1 and D2:

$$I_{gse} = I_s \times \left(\exp\left(\frac{V_{gse}}{\eta V_T} \right) - 1 \right)$$

$$I_{gde} = I_s \times \left(\exp\left(\frac{V_{gde}}{\eta V_T} \right) - 1 \right)$$

Diodes D3 and D4:

$$I_{Dgsi} = I_{LK} \times \left(1 - \exp\left(\frac{-V_{gsi}}{\varphi_{LK}} \right) \right)$$

$$I_{Dgdi} = I_{LK} \times \left(1 - \exp\left(\frac{-V_{gdi}}{\varphi_{LK}} \right) \right)$$

where VT is the thermal voltage:

$$V_T = \frac{k \times T}{q}$$

> $k = 1.38 \times 10^{-23}$ *(Boltzmann's constant)*
>
> $q = 1.602 \times 10^{-19}$ *(electron charge)*

I_S (Is), η (Eta), I_{LK} (Ilk), φ_{LK} (Plk) are the model parameters. T is either equal to the device instance parameter Temp, or if Temp is not specified then T = ambient_circuit_temperature + Trise. V_{gse}, V_{gde}, V_{gsi} and V_{gdi} are instantaneous voltages across the respective diodes. Please note that the models are symmetric for the drain and source diodes.

Dimensional Scaling Relations

For each device instance, area/finger scaling is performed only if both W and Ng device parameters are specified and their values are positive. The width scaling factor is determined as:

> *width_scale = W / Ugw*

where W is the actual device gate width and Ugw is a model parameter whose meaning is the gate width to which all model parameters have been normalized (or Ugw is the actual gate width of the measured device if the extracted model parameters have not been normalized).

Similarly, the finger scaling factor is determined as;

> *finger_scale = Ng / Ngf*

where Ng is the actual device number of fingers and Ngf is a model parameter whose meaning is the number of gate fingers to which all the model parameters have been normalized (or Ngf is the actual number of gate fingers of the measured device if the extracted model parameters have not been normalized).

It is strongly recommended that model parameters Ugw and Ngf are always specified without relying on their default values.

The following model parameters are scaled with *area = width_scale * finger_scale*

> *Beta, Is, Cds, Qgql, Qgqh, Qgi0, Qgcl, Qgsh, Qgdh, Qgg0, Ilk*

The following model parameters are scaled inversely with *area*:

> *Qggb, Rd, Rs, Rg*

Rgmet is scaled with:

> *width_scale / finger_scale*

Drain Dispersion and Self-Heating Effects

The TOM3 model topology is almost identical to other GaAs FET models. The main difference is an addition of a VCVS which modifies the internal gate voltages based on a portion of V_{ds} - the gain of the VCVS is the value of the model parameter Kgamma (shown as Kg in the Equivalent Circuit). According to the authors of the model, this internal feedback accounts well for self-heating effects.

The branch Rtau-Ctau, as in other GaAs FET models, accounts for drain dispersion.

Temperature Scaling Relations

The TOM3 model uses an extensive set of temperature scaling relations that permit the analysis of drain current, gate current, capacitances, and even parasitic resistances over ambient temperature changes. The scaling relations assume the unscaled (nominal) parameters were extracted at Tnom.

It is strongly recommended that the model parameter Tnom is always specified without relying on its default value.

The parameters are scaled to an arbitrary operating temperature through the temperature scaling relations. Note that the user specifies the temperatures in °C and the program converts them to units of Kelvin. Three types of scaling equations are used for the TOM3 model parameters: linear, exponential and diode.

The following equations summarize temperature scaling. The value of T is either the device instance parameter Temp, or if Temp is not specified then it is evaluated as:

> *T = ambient_circuit_temperature + Trise.*

For linear scaling, absolute scale, the equation is:

$$Par = Par_{nom} + scale \times (T - T_{nom})$$

For linear scaling, relative scale, the equation is:

$$Par = Par_{nom} \times (1 + scale \times (T - T_{nom}))$$

For exponential scaling, the equation is:

$$Par = Par_{nom} \times (1.01)^{scale \times (T - T_{nom})}$$

For diode saturation current scaling, the equation is:

$$Is = Is_{nom} \times \exp\left(\frac{E_g}{\eta \frac{kT_{nom}}{q}} - \frac{E_g}{\eta \frac{kT}{q}} + \frac{X_{ti}}{\eta} \ln\left(\frac{T}{T_{nom}}\right)\right)$$

where:

> *Is_{nom} (Is), E_g (Eg), X_{ti} (Xti) and η (Eta) are model parameters*
> *$k = 1.38 \times 10^{-23}$ (Boltzmann's constant)*
> *$q = 1.602 \times 10^{-19}$ (electron charge)*

This type of temperature scaling applies to Is, the saturation current for D1 and D2 diodes. The energy gap Eg is not scaled with the temperature.
The following parameters are scaled linearly (absolute scale) with temperature:

> *Vto, Gamma, Vst, and Mst*

Scale factors are Vtotc, Gammatc, Vsttc, and Msttc, respectively.

The following parameters are scaled linearly (relative scale) with temperature:

> *Rd and Rs*

Scale factors are Rdtc and Rstc, respectively.

The following parameters are scaled exponentially with temperature:

> *Alpha, Beta*

Scale factors are Alphatce and Betatce, respectively.

Noise Model

Thermal noise generated by resistors Rg, Rs and Rd is characterized by the following spectral density.

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

Parameters P, R, and C model drain and gate noise sources [3].

$$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTg_m\,P + 4kTg_m\,PFnc\;/f + Kf\;Ids^{Af}\;/f^{Ffe}$$

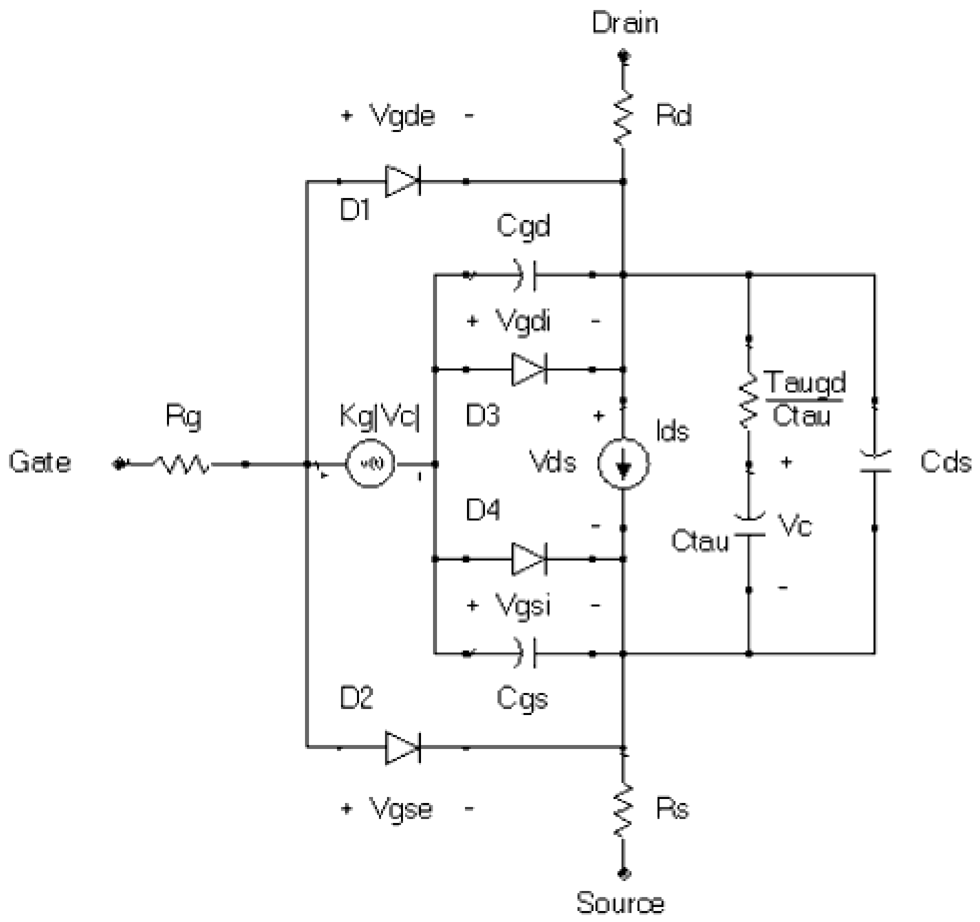
$$\frac{\langle i_g^2 \rangle}{\Delta f} = 4kT\,C_{gs}^{\;2}\;\omega^2\;R/g_m$$

$$\frac{\langle i_g, i_d^* \rangle}{\Delta f} = 4kTj\;C_{gs}\;\omega\sqrt{PR}\;C$$

For SDD compatibility, set P=2/3, R=0, C=0, and Fnc=0; copy Kf, Af, and Ffe from the SDD model.

Additional Information

Equivalent Circuit



References

- R. B. Hallgren and P. H. Litzenberg, "TOM3 Capacitance Model: Linking Large- and Small-Signal MESFET Models in SPICE," *IEEE Trans. Microwave Theory and Techniques* , vol. 47, 1999, pp. 556-561.
- R. B. Hallgren and D. S. Smith, "TOM3 Equations," a document provided by TriQuint, Revised: 2 December 1999.
- A. Cappy, "Noise Modeling and Measurement Techniques," *IEEE Transactions on Microwave Theory and Techniques* , Vol. 36, No. 1, pp. 1-10, Jan. 1988.

TOM4 (TriQuint TOM4 Scalable Nonlinear FET)

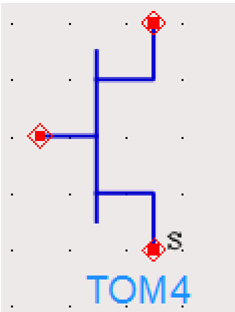
TOM4 (TriQuint TOM4 Scalable Nonlinear FET)

NOTE

Some information for this model was not available when ADS 2008 Update 1 was released. For updated documentation see our website at:

> http://www.keysight.com/find/eesof-docs
> *Select ADS 2008 Update 1, then choose* ***Components*** *>* ***Analog/RF*** *>* ***Nonlinear Devices*** *>* ***TOM4***

Symbol



Parameters

Name	Description	Units	Default
Model	Name of a TOM4_Model	None	TOM4M1
W	Gate width	m	no scaling
Ng	Number of gate fingers	None	no scaling
Temp	Device instance temperature	°C	25
Trise	Device temperature relative to circuit ambient (if Temp not specified)	°C	0
Mode	Nonlinear spectral model on/off	None	1
Noise	Noise generation option: yes (1) or no (0)	None	1

Netlist syntax

```
modelName:instanceName d g s parm=value
```

TOM4 Model (TriQuint TOM4 Scalable Nonlinear FET Model)

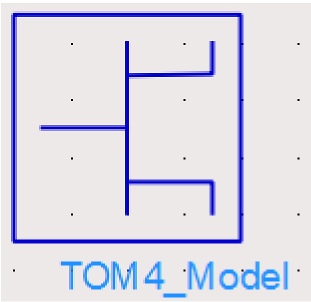
TOM4_Model (TriQuint TOM4 Scalable Nonlinear FET Model)

NOTE

Some information for this model was not available when ADS 2008 Update 1 was released. For updated documentation see our website at:

> http://www.keysight.com/find/eesof-docs
> *Select ADS 2008 Update 1, then choose **Components** > **Analog/RF** > **Nonlinear Devices** > **TOM4 Model***

Symbol



Parameters

Model parameters must be specified in SI units.

Name (Alias)	Description	Units	Default
Tnom	Parameter measurement temperature	°C	25
BETA	Channel current scaling parameter	A / µm	0.0002
LAMBDA	Channel channel current slope parameter	1/V	-0.044
ALF0	Knee function parameter	1 / V	2.8
KALF	Knee parameter correction factor	1 / V	-0.7
GAMMA	Threshold voltage reduction parameter	None	0.062
VTO	Threshold voltage	V	-0.5

Name (Alias)	Description	Units	Default
Q_0	Channel current power law exponent	None	1.6
KQ1	First order Q correction factor	1 / V	0
KQ2	Second order Q correction factor	1 / V	0
VST	Channel current subthreshold parameter	V	0.05
MST	Subthreshold slope parameter	1 / V	0
ISO	Gate diode saturation current	A / µm	1.4e-014
ETA	Gate diode ideality factor	None	1.25
KGAMMA	GD feedback parameter	None	0.033
R_S	Extrinsic Source resistance	Ω-µm	370
R_D	Eextrinsic Drain resistance	Ω-µm	715
R_G	Extrinsic Gate resistance	Ω-µm	750
CDS	Drain-source capacitance	F /µm	2.6e-016
TAU	Channel conductance time delay	sec	4e-012
C_J	Junction capacitance scaling parameter	F / µm	1e-012
V_J	Junction capacitance voltage parameter	V	0.6
M_J	Junction capacitance slope parameter	None	0.5
F_C	Junction voltage limit parameter	None	0.9
CGGI	Depleted capacitance scaling parameter	F / µm	1e-015
CGSS	Minimum gate-source capacitance	F / µm	3e-016

Name (Alias)	Description	Units	Default
KGIL	Depleted capacitance low-side slope	1 / V	2e-016
KGIH	Depleted capacitance high-side slope	1 / V	2e-016
VTH	Depleted capacitance partition voltage	V	0.3
CGG0	Series capacitance scaling parameter	F / µm	1e-015
CGDS	Minimum gate-drain capacitance	F / µm	3e-016
KG01	Series capacitance first-order correction factor	1 / V	2e-016
KG02	Series capacitance second-order correction factor	1 / V	2e-016
PHI0	Junction capacitance offset voltage	V	0.2
KPHI	Offset voltage correction factor	1 / V	0
T_D	Gate diode diffusion time constant	sec	1e-006
ILK			3.8e-012
PLK			0.844
ALPHATCE	Temperature exponential coefficient for Alpha	1/°C	-0.4
GAMMATC	Temperature linear coefficient for Gamma	1/°C	0
CGSTCE		1/°C	0
CGDTCE		1/°C	0
MSTTC	Temperature linear coefficient for Mst	1/(V °C)	0
VSTTC	Temperature linear coefficient for Vst	V/°C	0
VTOTC	Temperature linear coefficient for Vto	V/°C	-0.00091

Name (Alias)	Description	Units	Default
BETATCE	Temperature exponential coefficient for Beta	1/°C	0
Af	Flicker noise exponent	None	1
Kf	Flicker noise coefficient	None	3.86e-011
Ffe	Flicker noise frequency exponent	None	1
E_G	Energy gap for temperature effect on Is	eV	0.3
XTI	Temperature exponent for saturation current	None	2
CapMod	Capacitance model: 1=bias-dependent capacitances, 0=charge	None	1

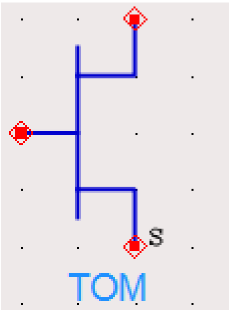
Netlist syntax

model ModelName TOM4 ...

TOM (TriQuint Scalable Nonlinear GaAsFET)

TOM (TriQuint Scalable Nonlinear GaAsFET)

Symbol



Range of Usage

W > 0
N > 0

Parameters

Name	Description	Units	Default
Model	name of a TOM_Model	None	TOMM1
W	new unit gate width, in length units		1.0
N	new number of gate fingers	None	0
Temp	device operating temperature	°C	25
_M	number of devices in parallel	None	1

- W and N are used for scaling device instance as described in the TOM_Model information.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

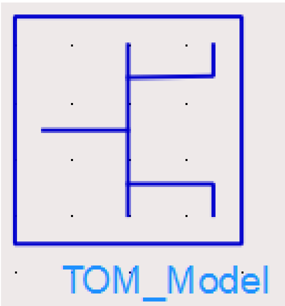
Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Ggs	Gate to source conductance	siemens
Ggd	Gate to drain conductance	siemens
dIgs_dVgd	(dIgs/dVgd)	siemens
dIgd_dVgs	(dIgd/dVgs)	siemens
dIds_dVgb	Backgate transconductance (dIds/dVgb)	siemens
Cgs	Gate-source capacitance	farads
Cgd	Gate-drain capacitance	farads
Cds	Drain-source capacitance	farads
dQgs_dVgd	(dQgs/dVgd)	farads
dQgd_dVgs	(dQgd/dVgs)	farads
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts

- This device has no default artwork associated with it.

TOM Model (TriQuint Scalable Nonlinear GaAsFET Model)

TOM_Model (TriQuint Scalable Nonlinear GaAsFET Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
Idsmod	Ids model: 1=CQ 2=CC 3=Statz 4=Materka 5=Tajima 6=symbolic 7=TOM 8=Modified Materka	None	7
Vto [†]	nonscalable portion of threshold voltage	V	-2.0
Alpha	saturation voltage coefficient	1/V	2.0
Beta [†, †††]	transconductance coefficient	A/V^Q	1.0e-4
Tqdelta [††]	output feedback coefficient	1/W	0.0
Tqgamma	DC drain pull coefficient	None	0.0
TggammaAc	AC pinchoff change with vds	None	0.0
Tnom	nominal ambient temperature at which these model parameters were derived	°C	25
Q	power law exponent	None	2.0
Tau	gate transit time delay	sec	0.0
Vtotc	Vto temperature coefficient	V/°C	0.0
Betatce	drain current exponential temperature coefficient	%/°C	0.0

Cgs [†, †††]	zero-bias gate-source capacitance	F	0.0
Cgd [†, †††]	zero-bias gate-drain capacitance	F	0.0
Vbi	gate diode built-in potential	V	0.85
Tqm	temperature coefficient for TriQuint junction capacitance	None	0.2
Vmax	maximum junction voltage before capacitance limiting		0.5
Fc	coefficient for forward bias depletion capacitance (diode model)	None	0.5
Delta1	capacitance saturation transition voltage	V	0.3
Delta2	capacitance threshold transition voltage	V	0.2
M	grading coefficient	None	0.5
Is [†, †††]	gate diode saturation current (diode model)	A	1.0e-14
N	gate diode emission coefficient (diode model)	None	1
Eg	energy gap for temperature effect on Is		1.11
Xti	temperature exponent for saturation current	None	3.0
Vbr	Gate diode breakdown voltage	V	1e100
Rg [‡‡]	gate ohmic resistance	Ohm	fixed at 0
Rd [††]	drain contact resistance	Ohm	fixed at 0
Rs [††]	source contact resistance	Ohm	fixed at 0
Trg1	linear temperature coefficient for Rg	1/°C	0.0
Trd1	linear temperature coefficient for Rd	1/°C	0.0
Trs1	linear temperature coefficient for Rs	1/°C	0.0
Cds [†††]	drain source capacitance	F	0.0
Rdb	R for frequency-dependent output conductance	Ohm	0.0
Cbs	C for frequency-dependent output capacitance	F	0.0
Rgmet [‡‡]	gate metal resistance	Ohm	0.0
Vtosc [††]	scalable portion of threshold voltage	V	0
Ris [††]	source end channel resistance	Ohm	0.0
Rid [††]	drain end channel resistance	Ohm	0.0
Vgr	Vg(s,d)c includes voltage across Rg(s,d): yes or no	None	No
Imax	explosion current	A	1.6
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 4)	A	defaults to Imax

Fnc	flicker noise corner frequency	Hz	0.0
R	gate noise coefficient	None	0.5
P	drain noise coefficient	None	1.0
C	gate drain noise correlation coefficient	None	0.9
Taumdl	Use 2nd order Bessel polynomial to model tau effect in transient: yes or no	None	no
Ugw	unit gate width of device	um	1e-6
Ngf	number of device gate fingers	None	1
wVgfwd	gate junction forward bias warning	V	None
wBvgs	gate-source reverse breakdown voltage warning	V	None
wBvgd	gate-drain reverse breakdown voltage warning	V	None
wBvds	drain-source breakdown voltage warning	V	None
wIdsmax	maximum drain-source current warning	A	None
wPmax	maximum power dissipation warning	W	None
Gscap	0=none, 1=linear, 2=junction, 3=Statz charge, 5=Statz cap	None	Statz
Gsfwd	0=none, 1=linear, 2=diode	None	diode
Gsrev	0=none, 1=linear, 2=diode	None	diode
Gdcap	0=None 1=Linear 2=Junction 3=Statz charge 5=Statz cap 6=Statz charge conserving	None	Statz
Gdfwd	0=none, 1=linear, 2=diode	None	diode
Gdrev	0=none, 1=linear, 2=diode	None	diode
Kf	flicker noise coefficient	None	0.0
Af	flicker noise exponent	None	1.0
Ffe	flicker noise frequency exponent	None	1.0
AllParams	Data Access Component (DAC) Based Parameters	None	None
† Parameter value varies with temperature based on model Tnom and device Temp. †† Parameter value scales inversely with Area. ††† Parameter value scales with Area. ‡ Value of 0.0 is interpreted as infinity. ‡‡ Total gate resistance is Rg + Rgmet.			

- Implementation of the TOM model is based on the work of McCaman et al, and includes some features not covered in McCaman's work. These enhancements include scaling with gate area and a seamless method for simulating with two different values for the parameters Tqgamma and TqgammaAc (one extracted at DC and the other adjusted to fit AC output conductance).
- Model parameters such as Ls, Ld, Lg are not used by the TOM device in the simulator. Only those parameters in the parameters list are part of the TOM device. Extrinsic devices must be added externally by the user.

- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- To prevent numerical problems, the setting of some model parameters to 0 is trapped by the simulator. The parameter values are changed internally:

  > $Rd = 10^{-4}$
  > $Rs = 10^{-4}$
  > $Rg = 10^{-4}$
  > $Ris = 10^{-4}$
  > $Rid = 10^{-4}$
  > $Rgmet = 10^{-4}$

  Other parameters are restricted to values > 0. If the user violates this restriction, the parameters will be internally fixed by the simulator:

  > $Vbi = 0.1$
  > $N = 1.0$
  > $Tqdelta = 0.0$

Equations/Discussion

DC Drain-Source Current

The Tom DC drain-source current model is an enhanced version of the one published by McCamant et al. It includes the same features as the version implemented by TriQuint in PSPICE for their foundry customers (minus temperature effects). The TOM model DC drain-source current is given by the following expressions:

$$Ids = \frac{Idso}{1 + \delta \times Vds \times Idso}$$

where

$$Idso = \beta(V_{gs} - V_t)^Q \times \left[1 - \left[1 - \frac{\alpha Vds}{3}\right]^3\right]$$

for $0 < Vds < 3/\alpha$

$$Idso = \beta(V_{gs} - V_t)^Q$$

for Vds ≥ 3/α

The threshold voltage V_t is given by:

> *Vt = (Vto + Vtosc) - Tqgamma × Vds*

where δ is Tqdelta, α is Alpha, β is Beta, and Vtosc represents the scalable portion of the zero-bias threshold voltage.

The current is set to zero for Vgs < Vt.

Gate Capacitances

The gate capacitances in the TOM model come from Statz et al.

The gate-source capacitance:

$$\frac{Cgs}{\sqrt{1-\frac{Vn}{Vbi}}}\times\frac{1}{2}\left[1+\frac{Veff-Vto}{\sqrt{(Veff-Vto)^2+Delta2^2}}\right]\times\frac{1}{2}\left[1+\frac{Vgs-Vgd}{\sqrt{(Vgs-Vgd)^2+Delta^2}}\right]+Cgd\times\frac{1}{2}\left[1-\frac{Vgs-Vgd}{\sqrt{(Vgs-Vgd)^2+Delta^2}}\right]$$

The gate-drain capacitance:

$$\frac{Cgs}{\sqrt{1-\frac{Vn}{Vbi}}}\times\frac{1}{2}\left[1+\frac{Veff-Vto}{\sqrt{(Veff-Vto)^2+Delta2^2}}\right]\times\frac{1}{2}\left[1-\frac{Vgs-Vgd}{\sqrt{(Vgs-Vgd)^2+Delta^2}}\right]+Cgd\times\frac{1}{2}\left[1+\frac{Vgs-Vgd}{\sqrt{(Vgs-Vgd)^2+Delta^2}}\right]$$

where

> *Delta = Delta1 if Delta1 is specified, otherwise Delta =* $\frac{1}{Alpha}$
>
> $$Veff = \frac{1}{2}\left(Vgs+Vgd+\sqrt{(Vgs-Vgd)^2+Delta^2}\right)$$
>
> $$Vnew = \frac{1}{2}\left(Veff+Vto+\sqrt{(Veff-Vto)^2+Delta2^2}\right)$$

> *Vn = Vnew if Vnew < Min (Fc × Vbi, Vmax) otherwise Vn = Min (Fc × Vbi, Vmax)*

High-Frequency Output Conductance

In their paper McCaman et al., discuss the effects of the parameter

$$Idso = \beta(V_{gs} - V_t)^Q \times \left[1 - \left[1 - \frac{\alpha Vds}{3}\right]^3\right]$$

on the output conductance of the TOM model. Keysight's implementation permits the user to input both a DC (Tqgamma) and high frequency (TqgammaAc) value into the model. Given these two γ values, two separate values of the drain-source current function Ids can be calculated, one for DC and one for AC:

> Ids^{DC} = *Ids (Vgs (t-Tau), Vds, Tqgamma)*
> Ids^{AC} = *Ids (Vgs (t-Tau), Vds, TqgammaAc)*

These two current functions can be seamlessly integrated into the nonlinear model by setting the current source in the equivalent circuit to the difference of these two functions:
Idb (Vgs (t-Tau), Vds) = Ids^{AC} - Ids^{DC}
The circuit elements Rdb and Cbs are both linear elements that are used to control the frequency at which the current source Idb becomes a factor. Note that at DC the source Idb has no impact on the response and the drain-source current is just the DC value. At very high frequency and with Rdb set to a very large quantity, the sources Ids and Idb add, giving the AC value for the drain-source current. The frequency at which the current (conductance) is midway between its two transitional extremes is:

$$f_o = \frac{1}{2\pi\tau_{disp}}$$

where

$$\tau_{disp} = Rdb \times Cbs$$

The user may select this transition frequency by setting the parameters Rdb and Cbs. However, it is recommended that Rdb be kept at a large value so it remains an effective open to the circuit.

Parameters Rdb and Cbs should not be set to zero; they should either be set to non-zero values or left blank. When they are left blank, the drain-source current dispersion effect is not modeled.

Dimensional Scaling Relations

Scaling of TOM_Model parameters is accomplished through the use of the model parameters Ugw and Ngf and the device parameters Ugw (same name as the model parameter) and N. From these four parameters, the following scaling relations can be defined:

$$sf = \frac{W \times N}{Ugw \times Ngf}$$

$$sfg = \frac{Ugw \times N}{W \times Ngf}$$

where W represents the device parameter Ugw, the new unit gate width.
Scaling will be disabled if N is not specified. The new parameters are calculated internally by the simulator according to the following equations:

$$Beta^{new} = Beta \times sf$$

$$Tqdelta^{new} = \frac{Tqdelta}{sf}$$

$$Vtosc^{new} = \frac{Vtosc}{sf}$$

$$Is^{new} = Is \times sf$$

$$Ris^{new} = \frac{Ris}{sf}$$

$$Rid^{new} = \frac{Rid}{sf}$$

Temperature Scaling Relations

TOM_Model uses an extensive set of temperature scaling relations that permit the analysis of drain current, gate current, capacitances and even parasitic resistances over ambient temperature changes. The scaling relations assume the unscaled (nominal) parameters were extracted at Tnom. The parameters are scaled to an arbitrary operating ambient temperature (Temp) through the temperature scaling relations. Note that the user must specify the temperatures Temp and Tnom in °C; the program converts these temperatures to units of Kelvin. The equations that follow use temperature in Kelvin.

$$Vbi(Temp) = Vbi \times \left(\frac{Temp}{Tnom}\right) - 3V_t \log\left(\frac{Temp}{Tnom}\right)$$

$$-E_g(Tnom) \times \left(\frac{Temp}{Tnom}\right) + E_g(Temp)$$

$$Beta(Temp) = Beta \times 1.01^{Betatce \times (Temp - Tnon}$$

$$Vto(Temp) = Vto + Vtotc \times (Temp - Tnom)$$

$$Is(Temp) = exp\left[\left(\frac{Temp}{Tnom} - 1\right) \times \frac{Eg}{V_t}\right] \times Is\left(\frac{Temp}{Tnom}\right)^{\frac{Xti}{N}}$$

$$Rd(Temp) = Rd \times (1 + Trd1 \times (Temp - Tnom))$$

$$Rs(Temp) = Rs \times (1 + Trs1 \times (Temp - Tnom))$$

$$Cgs(Temp) = Cgs\left[1 + Tqm \times \left[4.0 \times 10^{-4}(Temp - Tnom) + 1 - \frac{Vbi(Temp)}{Vbi}\right]\right]$$

$$Cgd(Temp) = Cgd\left[1 + Tqm \times \left[4.0 \times 10^{-4} \times \left((Temp - Tnom) + 1 - \frac{Vbi(Temp)}{Vbi}\right)\right]\right]$$

where:

$$V_t = \frac{V \times Temp}{q}$$

$$E_g(T) = \frac{1.519 - 5.405 \times 10^{-4} T^2}{T + 204}$$

where:

K = Boltzmann's constant = $8.62 \times 10^{-5} eV\, K^{-1}$

q = electron charge = $1.602 \times 10^{-19} C$

.

Noise Model

Thermal noise generated by resistors Rg, Rs and Rd is characterized by the following spectral density.

$$\frac{< i^2 >}{\Delta f} = \frac{4kT}{R}$$

Parameters P, R, and C model drain and gate noise sources.

$$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTg_m\, P + 4kTg_m\, PFnc\ /f + Kf\, Ids^{Af}\ /f^{Ffe}$$

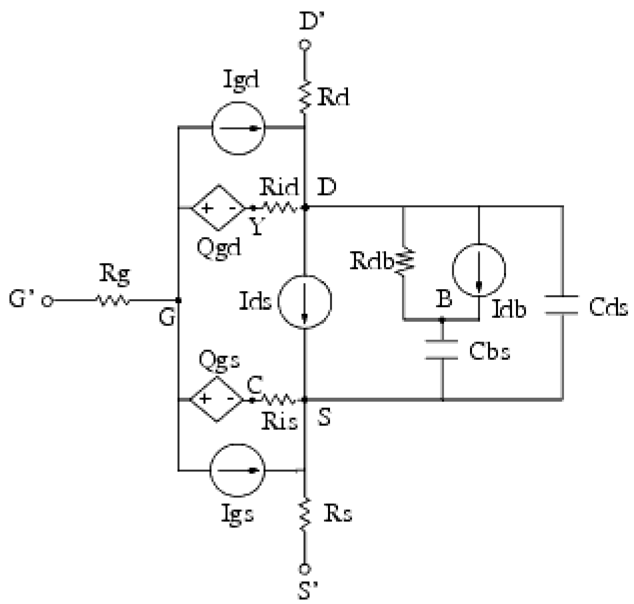
$$\frac{\langle i_g^2 \rangle}{\Delta f} = 4kT\, C_{gs}^{\;2}\, \omega^2\, R/g_m$$

$$\frac{\langle i_g, i_d^{*} \rangle}{\Delta f} = 4kTj\, C_{gs}\, \omega \sqrt{PR}\, C$$

For Series IV compatibility, set P=2/3, R=0, C=0, and Fnc=0; copy Kf, Af, and Ffe from the Series IV model.

Additional Information

Equivalent Circuit



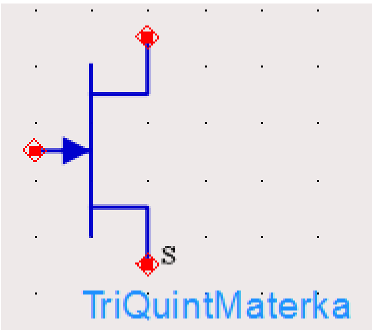
References

- A. McCaman, G. McCormack and D. Smith. "An Improved GaAs MESFET Model for SPICE", *IEEE Trans. on Microwave Theory Tech* ., vol. MTT-38,
pp. 822-824, June 1990.
- H. Statz, P. Newman, I. Smith, R. Pucel and H. Haus. "GaAs FET Device and Circuit Simulation in SPICE", *IEEE Trans. on Electron Devices* , vol. ED-34,
pp. 160-169, Feb. 1987.
- A. Cappy, "Noise Modeling and Measurement Techniques," *IEEE Transactions on Microwave Theory and Techniques* , Vol. 36, No. 1, pp. 1-10, Jan. 1988.

TriQuintMaterka (TriQuint-Materka Nonlinear FET)

TriQuintMaterka (TriQuint-Materka Nonlinear FET)

Symbol



Range of Usage

> *W > 0*
> *N > 0 (if specified)*

Parameters

Name	Description	Units	Default
Model	name of a TriQuintMaterka_Model instance	None	MESFETM1
W	gate width	m	1.0
N	number of gate fingers	None	no scaling
Temp	device instance temperature	°C	25
Trise	device temperature relative to circuit ambient (if Temp not specified)	°C	0
Noise	noise generation option: yes or no	None	yes

Name	Description	Units	Default
_M	number of devices in parallel	None	1

- W and N are used for scaling the device instance. Refer to TriQuintMaterka_Model (TriQuint-Materka Nonlinear FET Model) for details.

NOTE Area/finger scaling will be disabled if N is not specified.

The default value for W is 1 m, while typical values are in the order of micrometers; so, the recommendation is to not rely on this default value.

- The Temp parameter specifies the physical (operating) temperature of the device. If this is different than the temperature at which the model parameters are valid or extracted (specified by the Tnom parameter of the corresponding TriQuintMaterka_Model) certain parameters and responses are scaled so that the device is simulated at its operating temperature. Refer to TriQuintMaterka_Model (TriQuint-Materka Nonlinear FET Model) for details.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Ggs	Gate to source conductance	siemens
Ggd	Gate to drain conductance	siemens
dIgs_dVgd	(dIgs/dVgd)	siemens
dIgd_dVgs	(dIgd/dVgs)	siemens

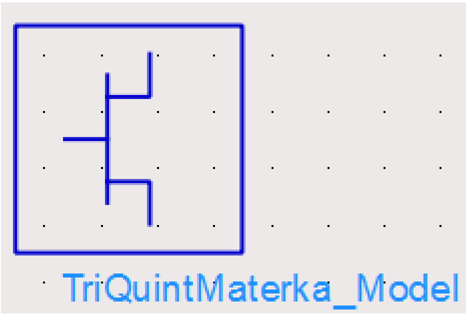
Name	Description	Units
dIds_dVgb	Backgate transconductance (dIds/dVgb)	siemens
Cgs	Gate-source capacitance	farads
Cgd	Gate-drain capacitance	farads
Cds	Drain-source capacitance	farads
dQgs_dVgd	(dQgs/dVgd)	farads
dQgd_dVgs	(dQgd/dVgs)	farads
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts

- This device has no default artwork associated with it.

TriQuintMaterka Model (TriQuint-Materka Nonlinear FET Model)

TriQuintMaterka_Model (TriQuint-Materka Nonlinear FET Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	UCM/SDD Name	Description	Units	Default
Idsmod		Ids model (do not change the default value)	None	9
NFET		N-channel type: yes or no	None	yes
PFET		P-channel type: yes or no	None	no
Tnom		model temperature at which all parameters were derived	°C	25
Ugw		gate width to which model parameters are normalized	m	1e-6
Ngf		number of gate fingers to which model parameters are normalized	None	1
Idss	IDSS	saturation drain current	A	0
Vto	VPO	threshold voltage	V	-2.0
Beta2	GAMA	coefficient for pinch-off change with respect to Vds	None	0
Ee	E	exponent defining dependence of saturation current	None	2.0

Ke	KE	coefficient for exponent dependence on gate voltage	1/V	0
Kg	KG	drain current dependence on Vgs in linear region	1/V	0
Sl	SL	linear region slope of Vgs=0 drain characteristic	1/ Ohm	1.0
Ss	SS	saturation region drain slope characteristic at Vgs=0	1/ Ohm	0
Tau	TAU	transit time under gate	sec	0
Idstc		Ids temperature linear coefficient	1/°C	0
Vtotc		Vto temperature linear coefficient	V/°C	0
Gsfwd		gate-source forward model: 0=none 1=linear 2=diode	None	diode
Gdfwd		gate-drain forward model: 0=none 1=linear 2=diode	None	None
Is	IG0	gate junction saturation current	A	1.0e-14
Alfg	ALFG	Schottky current exponent multiplier	1/V	22
Eg		energy gap for temperature effect on Is	eV	1.11
Xti		temperature exponent for saturation current	None	3.0
Rf		gate forward resistance if Gsfwd or Gdfwd = linear	Ohm	open circuit
Gsrev		gate-source breakdown model: 0=none 1=linear 2=diode	None	None
Gdrev		gate-drain breakdown model: 0=none 1=linear 2=diode	None	diode
Ir	IGD0	gate reverse saturation current	A	1.0e-14
Vbr	VBR, refer to note 4	gate junction reverse bias breakdown voltage	V	1e100
Alpvb	ALPVB	breakdown exponent fitting factor	1/V	0.4
AlfdA	A	fitting factor in Igd current exponent	1/V	0
AlfdB	B	fitting factor in Igd current exponent	1/\ (V^2)	0
R1		breakdown resistance if Gsrev or Gdrev = linear	Ohm	open circuit
R2		resistance relating breakdown voltage to channel	Ohm	0
Gscap		mode: 0=none, 1=const, 2=junction, 3=Statz charge, 5=Statz cap	None	None

Cgs	CGS	zero bias gate-source junction capacitance	F	0
Gdcap		mode 0=none, 1=const, 2=junction, 3=Statz charge, 5=Statz cap	None	const
Cgd	CGD	zero bias gate-drain junction capacitance	F	0
Vbi		built-in gate potential \(junction capacitance models)	V	0.85
Fc		coefficient for forward bias depletion junction capacitance	None	0.5
Delta1		capacitance saturation transition voltage \(Statz models)	V	0.3
Delta2		capacitance threshold transition voltage \(Statz models)	V	0.2
Vmax		maximum voltage before capacitance limiting \ (Statz models)	V	0.5
Rin	RI	channel resistance	Ohm	0
RLgs	RGS, refer to note 5	gate-source leakage resistance	Ohm	open circuit
RLgd	RGD, refer to note 5 and note 6	gate-drain leakage resistance	Ohm	open circuit
Rc	RRF, refer to note 7	dispersion model resistance	Ohm	0
Crf	CRF, refer to note 7	dispersion model capacitance	F	0
Cds	CDS	drain-source capacitance	F	0
Rd	RD	drain resistance	Ohm	0
Trd1		temperature linear coefficient for Rd	1/°C	0
Rg	RG	gate resistance	Ohm	0
Trg1		temperature linear coefficient for Rd	1/°C	0
Rs	RS	source resistance	Ohm	0
Trs1		temperature linear coefficient for Rd	1/°C	0
Ld	LD	drain inductance	H	0
Lg	LG	gate inductance	H	0
Ls	LS	source inductance	H	0
Taumdl		use 2nd order Bessel polynomial to model Tau effect in transient: yes or no	None	no
Imax		explosion current	A	1.6

Imelt		explosion current similar to Imax; defaults to Imax (refer to Note 12)	A	defaults to Imax
Fnc		flicker noise corner frequency	Hz	0
R		gate noise coefficient	None	0.5
P		drain noise coefficient	None	1.0
C		gate-drain noise correlation coefficient	None	0.9
wVgfwd		gate junction forward bias warning	V	
wBvgs		gate-source reverse breakdown voltage warning	V	
wBvgd		gate-drain reverse breakdown voltage warning	V	
wBvds		drain-source breakdown voltage warning	V	
wIdsmax		maximum drain-source current warning	A	
wPmax		maximum power dissipation warning	W	
AllParams		Data Access Component (DAC) Based Parameters	None	None
† A value of 0.0 is interpreted as infinity.				

- Implementation of the TriQuint-Materka model is based on [1-3].
- The UCM/SDD column in the Parameters table shows the names of the parameters that were used either in the User Compiled Model implementation or in the SDD implementation of the TriQuint-modified Materka model. These names must be changed to the name given in the Name column. Note that the Name is case sensitive. Also, do not rely on the default values as, in general, they are different from those in the UCM or SDD.
  Parameters listed in the Name column that do not have corresponding UCM/SDD parameters are used for extended features of this model with respect to the UCM/SDD implementations. Refer to Notes 4 through 9 for specific translation issues.
- The breakdown voltage parameter Vbr is internally converted to its absolute value at parsing. Thus, the negative values used in UCM/SDD do not need to be changed to conform to the ADS convention.
- When using other than UI means of entering model parameters, (e.g., file-based, do not use the parameter names Rgs and Rgd). The correct translation of the UCM/SDD parameters RGS and RGD is RLgs and RLgd.
- In the UCM implementation, the parameters RGS and RGD are not scaled with area. The corresponding leakage resistances RLgs and RLgd, however, are dimensionally scaled (inversely proportional to area). Therefore, they should be accordingly adjusted if the device instance scaling parameters call for dimensional scaling.
- In SDD implementation, the parameters CRF and RRF are not scaled with the area. The corresponding parameters in the built-in model (capacitance/resistance Crf/Rc), however, are dimensionally scaled (directly/inversely proportional to the area). Therefore, they should be accordingly adjusted if the device instance scaling parameters call for dimensional scaling.
- The functionality of the UCM/SDD scaling parameters is replaced by the use of two device parameters (W, N) and two model parameters (Ugw, Ngf). Refer to the section Dimensional Scaling Relations for details and translation rules.
- For UCM/SDD compatibility use Temp = Tnom, Gsfwd=2, Gdrev=2, Imax=230, follow Notes 3 through 8, and use defaults for other parameters that were not present in UCM/SDD.

- The standard emission coefficient N is implicitly defined by the parameter Alfg as N = 1 / (Alfg × V_{Tnom}), where V_{Tnom} is the thermal voltage corresponding to the value of the parameter Tnom. Refer to the section Forward Gate Diode Models (Gsfwd=2 and/or Gdfwd=2) for details.
- To prevent numerical problems, the simulator maintains the following minimum parameter values:

  Rd = 1e-4

  Rs = 1e-4

  Rg = 1e-4

  If the user wants any of the extrinsic resistances Rd, Rg, and Rs to be exactly zero, their values should not be entered. The default is a short circuit. If a value is entered, it must be different from zero.
- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) then the junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Several parameters are restricted to positive, non-zero, or non-negative values. If the user violates this restriction, an error message will be written in the status window, and the simulation will not proceed.

Drain-Source Current

The TriQuintMaterka_Model drain-source current is calculated using the same equation as the Modified_Materka_Model.

Let

$$VP = Vto + Beta2 \times V_{ds}$$

If

$$VP < 0 \quad \text{and} \quad V_{gs} > VP$$

then

$$I_{ds} = Idss \times \left(1 - \frac{V_{gs}}{VP}\right)^{(Ee + Ke \times V_{gs})} \times \tanh\left(\frac{Sl \times V_{ds}}{Idss \times (1 - Kg \times V_{gs})}\right) \times \left(1 + \frac{Ss \times V_{ds}}{Idss}\right)$$

otherwise

$$I_{ds} = 0$$

For time-varying drain-source current, the voltage V_{gs} is delayed by the transit time Tau. Idss, Vto, Beta2, Ee, Ke, Sl, Kg and Ss are model parameters.

Gate Capacitances

There are several options in modeling the junction capacitance of a device; these options are shared with other GaAs FET models. The first option is to model the junction as a linear component (a constant capacitance); the second option is to model the junction using a diode depletion capacitance model. If a non-zero value of Cgs is specified and Gscap=1 (linear), the gate-source junction capacitance will be modeled as a linear component. Similarly, specifying a non-zero value for Cgd and Gdcap=1 result in a linear gate-drain model. A non-zero value for either Cgs or Cgd together with Gscap=2 (junction) or Gdcap=2 will force the use of the diode depletion capacitance model for that particular junction. Refer to Curtice2_Model (Curtice-Quadratic GaAsFET Model) for details and equations.

The other options Gscap=3 or Gdcap=3 (Statz Charge) and Gscap=5 or Gdcap=5 (Statz Cap) correspond to the Statz-based models [4, 5]. Refer to Statz_Model (Statz Raytheon GaAsFET Model) for details and equations.

Note that each junction is modeled independent of the other; hence, it is possible to model one junction as a linear component while the other is treated nonlinearly.

Gate Conduction Currents

The gate conduction currents are controlled by four flags: Gsfwd, Gsrev, Gdfwd, and Gdrev. Each of them can be set to 0, 1, or 2. Setting any of these flags to 0 results in a corresponding open circuit. For non-zero settings, the following sections describe the respective behaviors.

Linear Gate Conduction Models (flag=1)

The simplest models assume an effective value of forward bias resistance Rf and an approximate breakdown resistance R1 (refer to Curtice3_Model (Curtice-Cubic GaAsFET Model)). The linear model of the forward conduction current is used when Rf is specified (must be different from zero) and Gsfwd=1 and/or Gdfwd=1. For example, if Gsfwd=1 then the gate-source forward conduction current is given by:

If $V_{gs} > Vbi$

$$I_{gs} = (V_{gs} - Vbi) / Rf$$

otherwise:

$$I_{gs} = 0$$

Vbi and Rf are model parameters. A similar expression defines I_{gd}.

The linear model of the reverse breakdown current is used when R1 is set and Gsrev=1 and/or Gdrev=1. For example, if Gdrev = 1

If $V_{gd} < - Vb$

$$I_{gd} = (V_{gd} + Vb) / R1$$

otherwise:

$I_{gd} = 0$

In the above equation, Vb is a modified breakdown voltage defined as:

$Vb = Vbr + R2 \times I_{ds}$

Vbr, R1 and R2 are model parameters. Note that Vbr is assumed to be positive (the actual breakdown voltage in terms of Vgd would be negative for an n-channel device). A similar expression defines I_{gs}.

Forward Gate Diode Models (Gsfwd=2 and/or Gdfwd=2)

This model is controlled by the model parameters Is and Alfg, and is similar for both Igs and Igd. For example, the Igs current is determined as

$$I_{gs} = Is \times [\exp(Alfg \times V_{gs}) - 1]$$

The parameter Alfg must be positive. It is converted to the standard emission coefficient N (see note 10) and the following equation is used instead.

$$I_{gs} = Is \times \left[\exp\left(\frac{V_{gs}}{N \times V_T}\right) - 1\right]$$

where VT is the thermal voltage:

$$V_T = \frac{k \times Temp}{q}$$

$k = 1.38 \times 10^{-23}$ (Boltzmann's constant)
$q = 1.602 \times 10^{-19}$ (electron charge)

This facilitates temperature dependence of the exponent on *Temp* , which is either equal to the device instance parameter Temp, or if Temp is not specified, to *Temp* = ambient_circuit_temperature + Trise.

Large negative and large positive exponent values are handled similarly to other GaAs FET models. Refer to (for example) Statz_Model (Statz Raytheon GaAsFET Model) information for details.

Reverse Breakdown Gate-Drain Diode Model (Gdrev=2)

The diode model of the reverse gate-drain breakdown has been modified by TriQuint to include its dependence on the gate-source voltage Vgs. Following [2]|TriQuintMaterka Model (TriQuint-Materka Nonlinear FET Model)#reference1], the Igd current is calculated as:

$$I_{gd} = -Ir \times \exp(AlfdA \times V_{gs} + AlfdB \times V_{gs} \times V_{gs} - Alpvb \times (Vb + V_{gd}))$$

In the above equation, Vb is a modified breakdown voltage defined as:

$Vb = Vbr + R2 \times I_{ds}$

Ir, AlfdA, AlfdB, Alpvb, R2, and Vbr are model parameters. Note that Vbr is assumed to be positive (the actual breakdown voltage in terms of Vgd would be negative for an n-channel device).

Reverse Breakdown Gate-Source Diode Model (Gsrev=2)

The gate-source breakdown diode model, if used, takes the standard exponential form:

$$I_{gs} = -Ir \times [\exp(-Alpvb \times (Vb + V_{gs})) - 1]$$

In the above equation, Vb is a modified breakdown voltage defined as:

$Vb = Vbr + R2 \times I_{ds}$

Time Delay

Like other GaAs FET models, TriQuintMaterka_Model uses an ideal time delay to model transit time effects under the gate. In the time domain, the drain source current for the ideal delay is given by:

$$I_{ds}(t) = I_{ds}(V_j(t - Tau), V_{ds}(t))$$

where Vj = Vgs or Vj = Vgd (depending on whether Vds is positive or negative). Tau is a model parameter. In the frequency domain, only the transconductance is impacted by this delay and the familiar expression for transadmittance is obtained:

$$y_m = g_m \times \exp(-j\omega Tau)$$

High-Frequency Output Conductance

A series-RC network comprised of the parameters Crf and Rc is included to provide a correction to the AC output conductance. At a frequency high enough such that Crf is an effective short, the output conductance of the device can be increased by the factor 1/Rc.

Dimensional Scaling Relations

For each device instance, area/finger scaling is performed only if the device parameter N is specified, and its value is positive. The width scaling factor is determined as:

width_scale = W / Ugw

where W is the actual device gate width and Ugw is a model parameter whose meaning is the gate width to which all the model parameters have been normalized (or Ugw is the actual gate width of the measured device if the extracted model parameters have not been normalized).

Similarly, the finger scaling factor is determined as:

> *finger_scale = N / Ngf*

where N is the actual device number of fingers and Ngf is a model parameter whose meaning is the number of gate fingers to which all the model parameters have been normalized (or Ngf is the actual number of gate fingers of the measured device if the extracted model parameters have not been normalized).

It is strongly recommended that the model parameters Ugw and Ngf are always specified without relying on their default values.

The following model parameters are scaled with area = width_scale * finger_scale:

> *Idss, Sl, Ss, Is, Ir, Cgs, Cgd, Cds, Crf*

The following model parameters are scaled inversely with area:

> *Rd, Rs, RLgs, RLgd, Rc, Rin*

The following model parameters are scaled with width_scale / finger_scale:

> *Rg, Lg*

The inductances Ld and Ls are not scaled.

For compatibility with the UCM or SDD implementation, the values of device/model scaling parameters W, N, Ugw and Ngf must be determined from the UCM/SDD scaling parameters (see Note 8). In terms of the parameters W, N, Ugw and Ngf, the UCM parameters AREA and SFING can be expressed as:

> *AREA = (W / Ugw) * (N / Ngf)*
> *SFING = Ngf / N*

If the actual values of Ugw and Ngf are not known, they can be set arbitrarily. Then, given the values of AREA, SFING, Ugw and Ngf, the device parameters W and N must be set as:

> *W = Ugw × AREA × SFING*
> *N = Ngf / SFING*

Similarly, in terms of W, N, Ugw and Ngf parameters, the SDD Size and Original Size parameters can be expressed as:

> *Size = W × N*
> *OriginalSize = Ugw × Ngf*

SDD Finger and OriginalFinger parameters mean the same as N and Ngf parameters, respectively. Therefore, the translation rules for SDD scaling parameters are:

> *Ugw = OriginalSize / OriginalFinger*
> *Ngf = OriginalFinger*

W = Size/Finger
N = Finger

Temperature Scaling Relations

The TriQuintMaterka_Model model uses several temperature scaling relations which modify the model behavior when the ambient temperature changes. The scaling relations assume the unscaled (nominal) parameters were extracted at Tnom.
It is strongly recommended that the model parameter Tnom is always specified without relying on its default value.

The parameters are scaled to an arbitrary operating temperature through the temperature scaling relations. Note that the user specifies the temperatures in °C and the program converts them to units of Kelvin. The value of *Temp* is either the device instance parameter Temp, or if Temp is not specified then it is evaluated as
Temp = ambient_circuit_temperature + Trise.

The emission coefficient *N* used in the equations is evaluated from the parameter Alfg (see Note 10), or it assumes the default value of 1 if Alfg=0. In addition to the thermal voltage in the forward diode equations, the following temperature scaling is used.

The saturation current Is scales as:

$$Is^{NEW} = Is \times \exp\left[\left(\frac{Temp}{Tnom} - 1\right)\frac{q \times Eg}{k \times N \times Temp} + \frac{Xti}{N} \times \ln\left(\frac{Temp}{Tnom}\right)\right]$$

The gate depletion capacitances Cgs and Cgd vary as:

$$Cgs^{NEW} = Cgs\left[\frac{1 + 0.5[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + 0.5[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Tnom}]}\right]$$

$$Cgd^{NEW} = Cgd\left[\frac{1 + 0.5[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + 0.5[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Tnom}]}\right]$$

where γ is a function of the junction potential and the energy gap variation with temperature.

The gate junction potential Vbi varies as:

$$Vbi^{NEW} = \frac{Temp}{Tnom} \times Vbi + \frac{2k \times Temp}{q} \times \ln\left(\frac{n_i^{Tnom}}{n_i^{Temp}}\right)$$

where n_i is the intrinsic carrier concentration for silicon, calculated at the appropriate temperature.

The threshold voltage Vto varies as:

$$Vto^{NEW} = Vto + Vtotc(Temp - Tnom)$$

The Ids current, after being evaluated, is scaled linearly using the model parameter Idstc, as:

$$I_{ds}^{NEW} = I_{ds} \times (1 + Idstc \times (Temp - Tnom))$$

The extrinsic resistances are also scaled linearly as:

$$Rx^{NEW} = Rx \times (1 + Trx1 \times (Temp - Tnom))$$

where x stands for d, g, or s, and correspondingly, Rd, Rg, Rs, Trd1, Trg1 and Trs1 are model parameters.

Noise Model

The resistors Rg, Rs and Rd generate thermal noise, which is characterized by the following spectral density.

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

The P, R, and C parameters model drain and gate noise sources [6].

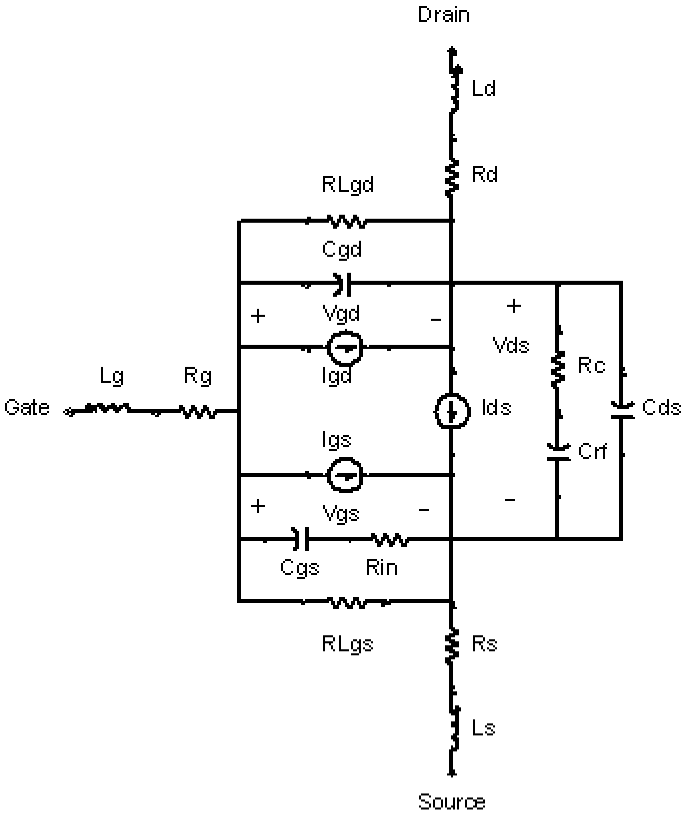
$$\frac{\langle i_d^2 \rangle}{\Delta f} = 4kTg_m\ P(1 + f_{NC}/f)$$

$$\frac{\langle i_g^2 \rangle}{\Delta f} = 4kT\ C_{gs}^2\ \omega^2\ R/g_m$$

$$\frac{\langle i_g, i_d^* \rangle}{\Delta f} = 4kTj\ C_{gs}\ \omega\sqrt{PR}\ C$$

Additional Information

Equivalent Circuit



References

- A. Materka and T. Kacprzak "Computer Calculation of Large-Signal GaAs FET Amplifier Characteristics," IEEE Trans. Microwave Theory and Techniques, Vol. MTT-33, No. 2, February 1985.
- An internal document describing model parameters and equations, Private communication from TriQuint.
- Igd "Breakdown Equation" developed by D. R. Bridges and W. Anholt, Private communication from TriQuint.
- H. Statz, P. Newman, I. Smith, R. Pucel and H. Haus. "GaAs FET device and circuit simulation in SPICE," IEEE Trans. Electron Devices, vol. ED-34, pp. 160-169, Feb. 1987.
- D. Divekar, Comments on "GaAs FET device and circuit simulation in SPICE," IEEE Trans. Electron Devices, Vol. ED-34, pp. 2564-2565, Dec. 1987.
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Devices and Models, GaN

Devices and Models, GaN

ADS provides the following industry standard non-linear FET-based models for amplifier design. There exists a direct link to IC-CAP for model extraction.

- Angelov_GaN_FET (Angelov Nonlinear GaNFET)
- Angelov_GaN Model (Angelov (Chalmers) Nonlinear GaNFET Model)

Bin Model

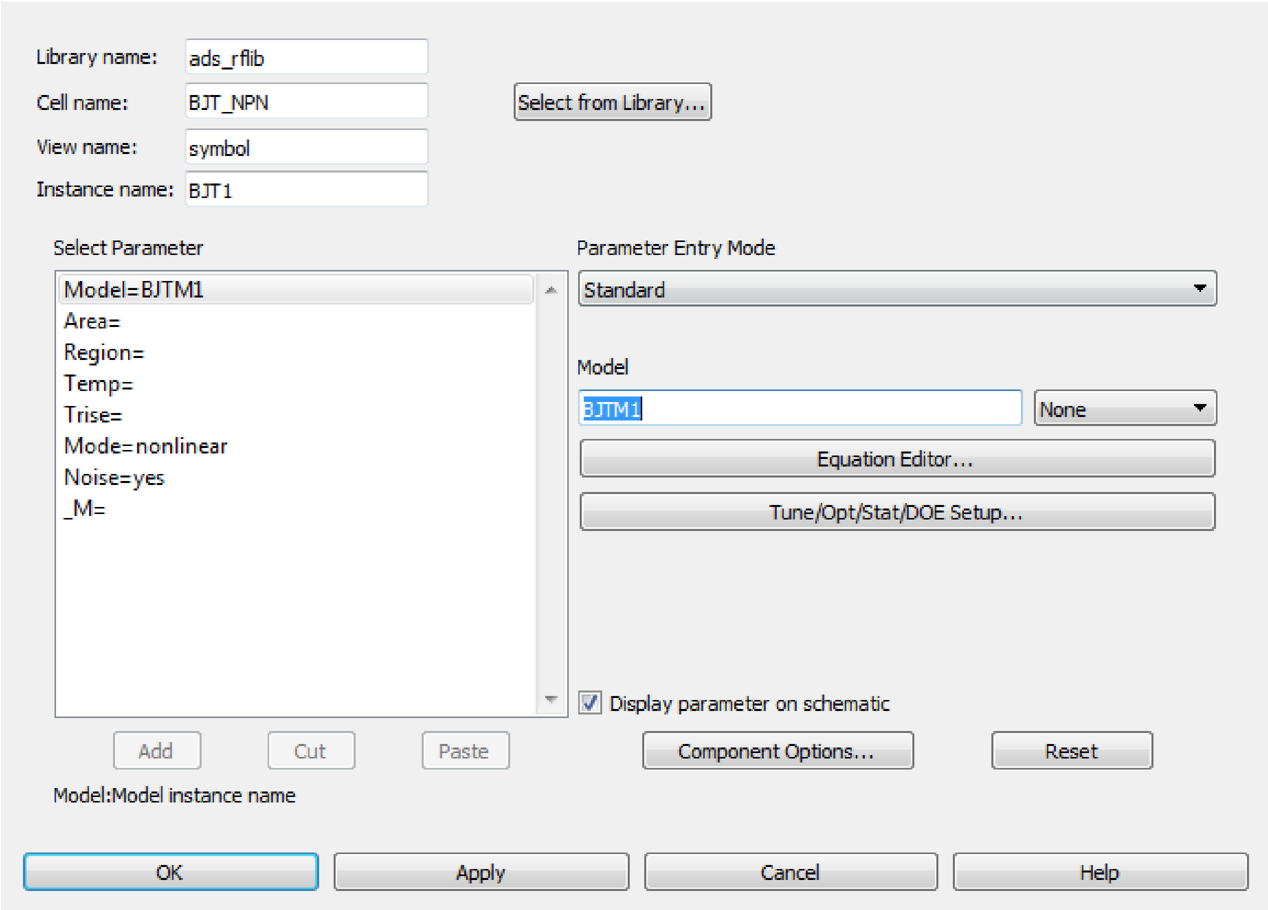
The BinModel in the GaN library allows you to sweep a parameter (usually a geometry, such as gate length), then enable the simulator to automatically select between different model cards. This alleviates the problem that one scalable model typically doesn't work for all sizes of a device.

For information on the use of the binning feature, refer to "BinModel" in *Introduction to Circuit Components*.

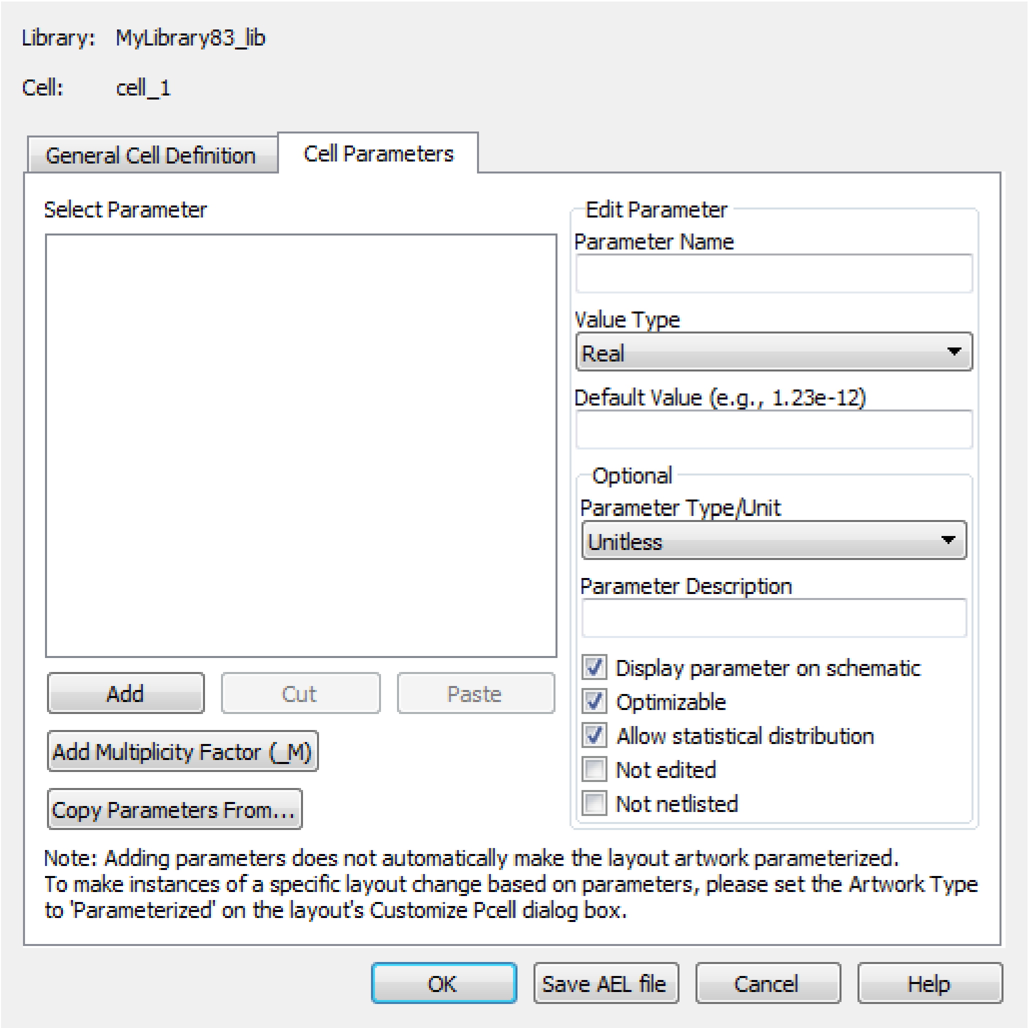
Multiplicity Parameter _M

The multiplicity feature provides a way to scale components or entire sub-circuits containing many components and sub-circuits. Given a component with a multiplicity value *M*, the simulator treats this component as if there were *M* such components all connected in parallel. Sub-circuits within sub-circuits will be appropriately scaled.

The _M parameter is available at the component level as shown here. (For components that do not explicitly have a Multiplicity parameter, the same functionality can be achieved by placing the component in a sub-circuit and using the sub-circuit's Multiplicity parameter, as described next.)



For sub-circuits, the parameter is enabled by selecting **File** > **Design Parameters** from the Schematic window. In the dialog box, select the **Parameters** tab. To add the Multiplicity parameter, choose **Add Multiplicity Factor_M**.



Netlist Syntax

Models for the ADS circuit simulator have the following syntax:

```
model modelname modeltype [param=value]*
```

where `model` is a keyword, `modelname` is the user-defined name for the model and `modeltype` is one of the predefined model types (e.g., Diode, BJT, MOSFET). After these three required fields comes zero or more `param=value` pairs. `param` is a model keyword and value is its user-assigned value. There is no required order for the `param=value` pairs. Model keywords that are not specified take on their default values. Refer to documentation for each model type to see the list of model parameters, their meanings and default values.

The model statement must be on a single line. Use the backslash "\" as a line continuation character. The instance and model parameter names are case sensitive. Most, but not all, model parameters have their first character capitalized and the rest are lower case. Scale factors (e.g., $p=10^{-12}$, $n=10^{-9}$, $u=10^{-6}$, $m=10^{-3}$, $k=10^{+3}$, $M=10^{+6}$) can be used with numbers for numeric values. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

A netlist translator is available for translating models and subcircuits from Pspice, Hspice, and Spectre syntax to the form used by the ADS Circuit Simulator. Refer to "Netlist Translator for SPICE and Spectre" for more information.

Parameter Aliases

For compatibility with other simulators, some models accept two or more different keywords for the same parameter. For example, the Diode model accepts both model keywords Is and Js for the saturation current. In the documentation, the parameter Name column lists the aliases in parentheses after the main parameter name. The main parameter name is the one that appears in the ADS dialog box for the model.

Tnom

All nonlinear device models have a parameter that specifies the temperature at which the model parameters were extracted. Normally called Tnom, some models may use Tref, Tr, or Tmeas. The default value for Tnom is specified on the Options item in the Tnom field. If Options.Tnom is not specified it defaults to 25°C. This is true for all nonlinear devices.

It is strongly suggested that the user explicitly set Tnom in each model and not depend on its default value. First, this provides a self-documenting model; other users of the device will not have to guess at what Tnom should be. Second, different users of the same model would get different results for the same circuit if they simulate with different values of Options.Tnom.

Temp and Trise

The ADS circuit simulation allows the user to directly specify the temperature of each individual device instance. This is done with the device instance parameter Temp which is the device temperature in degrees Celsius. If it is not specified, it defaults to the ambient temperature set with Options.Temp, which defaults to 25°C.

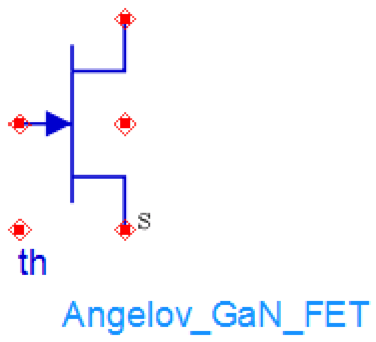
For compatibility with other simulators, many of the nonlinear devices allow the user to specify Trise for each device instance, which specifies actual device temperature as an increase from ambient. It defaults to zero. The Trise instance value is used only if the Temp instance value is not specified. If the user does not specify Trise on the instance, a default value for Trise can also be specified in the model. It defaults to zero. The following shows the logic of how the instance temperature is calculated if it is not explicitly specified.

```
if Instance.Temp is not specified
 if instance.Trise is not specified
   Instance.Temp = Options.Temp + Model.Trise
 else
   Instance.Temp = Options.Temp + Instance.Trise
```

Angelov_GaN_FET (Angelov Nonlinear GaNFET)

Angelov_GaN_FET (Angelov Nonlinear GaNFET)

Symbol



Parameters

Name	Description	Units	Default
Model	name of an Angelov_GaN Model	None	ANGELOV_GAN_M1
Temp	device operating temperature	°C	25
Trise	temperature rise over ambient	None	0
Noise	noise generation option: yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

DC Operating Point Information

The following table lists the DC operating point parameters that can be sent to the dataset.

Name	Description	Units
Id	Drain current	amperes

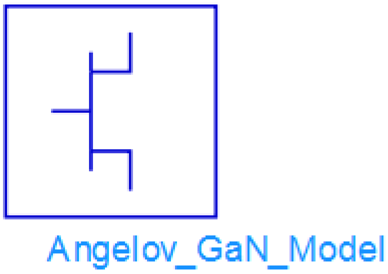
Name	Description	Units
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Ggs	Gate-source conductance	siemens
Ggd	Gate-drain conductance	siemens
Cgs	Gate-source capacitance	farads
Cgd	Gate-drain capacitance	farads
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts

This device has no default artwork associated with it.

Angelov_GaN Model (Angelov (Chalmers) Nonlinear GaNFET Model)

Angelov_GaN Model (Angelov (Chalmers) Nonlinear GaNFET Model)

Symbol



This model is based on the original Angelov (Chalmers) model described in [1] and [2], but includes the latest developments made by Prof. Itcho Angelov that have not been published. The original Angelov model is not symmetrical (which corresponds to setting Idsmod=0). ADS implementation of the Angelov model is enhanced by providing a symmetrical Ids equation which corresponds to setting Idsmod=1. It should be used when simulating switches or resistive mixers. Part of this work was published in [6] .

Parameters

The following table lists the model parameters. The parameters must be specified in SI units.

Name	Description	Units	Default
Version	Version number	None	2.4
VersionWarning	If set, issues warning if different version	None	
Idsmod	Ids Current Model	None	0
Igmod	Select gate diode model	None	0
Capmod	Select cap model	None	2
Ipk0 †	Current for maximum transconductance	A	0.05
Vpks	Gate voltage for maximum transconductance	V	-0.2
Dvpks	Delta gate voltage at peak Gm	V	0.2

Name	Description	Units	Default
P1 †	Polynomial coefficient P1 for channel current	1/V	0.8
P2	Polynomial coefficient P2 for channel current	1/V^2	0.0
P3	Polynomial coefficient P3 for channel current	1/V^3	0.0
Alphar	Saturation parameter alpha_r	1/V	0.1
Alphas	Saturation parameter alpha	1/V	1.0
Vkn	Knee voltage (obsolete)	V	4.0
Lambda	Channel length modulation parameter	None	0.001
Lambda1 ††	Channel length modulation parameter	None	0.0
Lvg	Coefficient for Lambda parameter	None	0.0
B1	Unsaturated coefficient for P1	None	0.1
B2	Unsaturated coefficient for P2	1/V	4.0
Lsb0 †	Soft breakdown model parameter	None	0.0
Vtr	Soft breakdown model parameter	V	50.0
Vsb2	Surface breakdown model parameter	V	0.0
Ebd	Surface breakdown model parameter	1/V	0.2
Cds	Zero-bias D-S junction capacitance	F	0.0
Cgspi	Gate-source pinch-off capacitance	F	0.0
Cgs0 †	Gate-source capacitance parameter	F	0.0
Cgdpi	Gate-drain pinch-off capacitance	F	0.0
Cgd0 †	Gate-drain capacitance	F	0.0
Cgdpe	External gate-drain capacitance	F	0.0
P10	Polynomial coefficient P10 for capacitance	None	0.0
P11	Polynomial coefficient P11 for capacitance	None	1.0
P20	Polynomial coefficient P20 for capacitance	None	0.0

Name	Description	Units	Default
P21	Polynomial coefficient P21 for capacitance	None	0.2
P30	Polynomial coefficient P30 for capacitance	None	0.0
P31	Polynomial coefficient P31 for capacitance	None	0.2
P40	Polynomial coefficient P40 for capacitance	None	0.0
P41	Polynomial coefficient P41 for capacitance	None	1.0
P111	Polynomial coefficient P111 for capacitance	None	0.0
P222	Polynomial coefficient P222 for capacitance	None	0.0
P10pk	Polynomial coefficient P10pk for capacitance	None	2.0
m	Coefficient for capacitance	None	5.0
Ij	Gate fwd saturation current	A	0.00005
Pg	Gate current parameter	None	15.0
Ne	Gate p-n emission coefficient	None	1.0
Vjg	Gate current parameter	V	0.8
Rg	Gate ohmic resistance	Ohm	0.05
Rd	Drain ohmic resistance	Ohm	0.05
Rd2	Variable Drain ohmic resistance	Ohm	0.0
Ri	Input ohmic resistance	Ohm	0.05
Rs	Source ohmic resistance	Ohm	0.05
Rgd	Gate-drain resistance	Ohm	0.05
Lg	Gate ohmic inductance	H	0.0
Ld	Drain ohmic inductance	H	0.0
Ls	Source ohmic inductance	H	0.0
Ldc	Backgate node inductance to ground	H	100.
Tau	Internal time delay	sec	0.0
Rcmin	Minimum value of Rc resistance	Ohm	1.0e3

Name	Description	Units	Default
Rc†	R for frequency dependent output conductance	Ohm	10.0e3
Crf†	C for frequency dependent output conductance	F	0.0
Rcin	R for frequency dependent input conductance	Ohm	100.0e3
Crfin	C for frequency dependent input conductance	F	0.0
Rdel	R for frequency dependent input conductance	Ohm	1
Cdel	C for frequency dependent input conductance	F	0.0
Kbgate	Polynomial coefficient for frequency dependent input conductance	1/V	0.0
Krfdc	Coefficient Krfdc will set division between Ids and Dispersion IdsRF current	None	0.0
Rth	Thermal resistance	K/W	0.001
Cth	Thermal capacitance	Ws/K	0.0001
Tcipk0	Temperature coefficient of Ipk0 parameter	1/K	-0.002
Tcp1	Temperature coefficient of P1 parameter	1/K	-0.002
Tccgs0	Temperature coefficient of Cgs0 parameter	1/K	0.002
Tccgd0	Temperature coefficient of Cgd0 parameter	1/K	0.002
Tclsb0	Temperature coefficient of Lsb0 parameter	1/K	0.0
Tcrc	Temperature coefficient of Rc parameter	1/K	0.0
Tccrf	Temperature coefficient of Crf parameter	1/K	0.0
Tcrs	Linear temp coefficient for Rs	1/K	0.003
TcRtherm	Linear temp coefficient for Rth	1/K	0.002
TcVpk	Linear temp coefficient for Vpk	1/K	0.001
TcVjg	Linear temp coefficient for Vjg	1/K	-0.001
Kbdgate	Gate breakdown parmeter	V	1.0
Vbdgs	Gate source breakdown voltage	V	10.0
Vbdgd	Gate drain breakdown voltage	V	100.0

Name	Description	Units	Default
Pbdg	Gate breakdown exponent	1/V	0.5
Noimod	Noise model selector	None	0
NoiseR	Gate noise coefficient	None	0.5
NoiseP	Drain noise coefficient	None	1.0
NoiseC	Gate-drain noise correlation coefficient	None	0.9
Fnc	Flicker-noise corner frequency	Hz	0.0
Kf	Flicker noise coefficient	None	0.0
Af	Flicker noise exponent	None	1.0
Ffe	Flicker noise parameter	None	1.0
Tg	Gate equivalent temperature	°C	25
Td	Drain equivalent temperature	°C	25
Td1	Drain equivalent temperature	°C	0.1
Tmn	Noise fitting coefficient	None	1.0
Klf	Flicker noise coefficient	None	1.0e14
Fgr	G-R frequency corner	Hz	60.0e3
Np	Flicker noise frequency exponent	None	0.3
Lw	effective gate noise width	mm	0.1
Tnom	Parameter measurement temperature	°C	25

† This parameter varies with temperature. †† This parameter is only used with Idsmod=3

References

1. I. Angelov, H. Zirath, N. Rorsmann, "A New Empirical Nonlinear Model for HEMT and MESFET Devices," *IEEE MTT* Vol. 40, No. 12, December 1992.
2. I. Angelov, L. Bengtsson, M. Garcia, "Extensions of the Chalmers Nonlinear HEMT and MESFET Model," *IEEE MTT* Vol. 44, No. 10, October 1996.
3. M. Pospieszalski, "Modelling of noise parameters of MESFETs and MOSFETs and their frequency and temperature dependence," *IEEE Trans. MTT* ., Vol. 37, pp. 1340-1350, Sept. 1989.
4. B. Hughes, "A Temperature Noise Model for Extrinsic FETs," *IEEE Trans. MTT* ., Vol. 40, pp. 1821-1832, Sept. 1992.

5. I. Angelov, "On the Performance of Low-Noise Low-DC-Power-Consumption Cryogenic Amplifiers," *IEEE Trans. MTT* ., Vol. 50, No. 6, June 2002.
6. I. Angelov, L. Bengtsson, M. Garcia, F. van Raay, G. Kompa, "Extensions and model verification of the Chalmers Nonlinear HEMT and MESFET Model" Kassel 1997.

Devices and Models, JFET

Devices and Models, JFET

- JFET Model (Junction FET Model)
- JFET NFET, JFET PFET (Nonlinear Junction FETs, P-Channel, N-Channel)
- NeuroFet Model
- r3 (Three-Terminal Nonlinear Diffused and Poly-Silicon Resistor and JFET Model and Instance)
- DynaFet Model

Bin Model

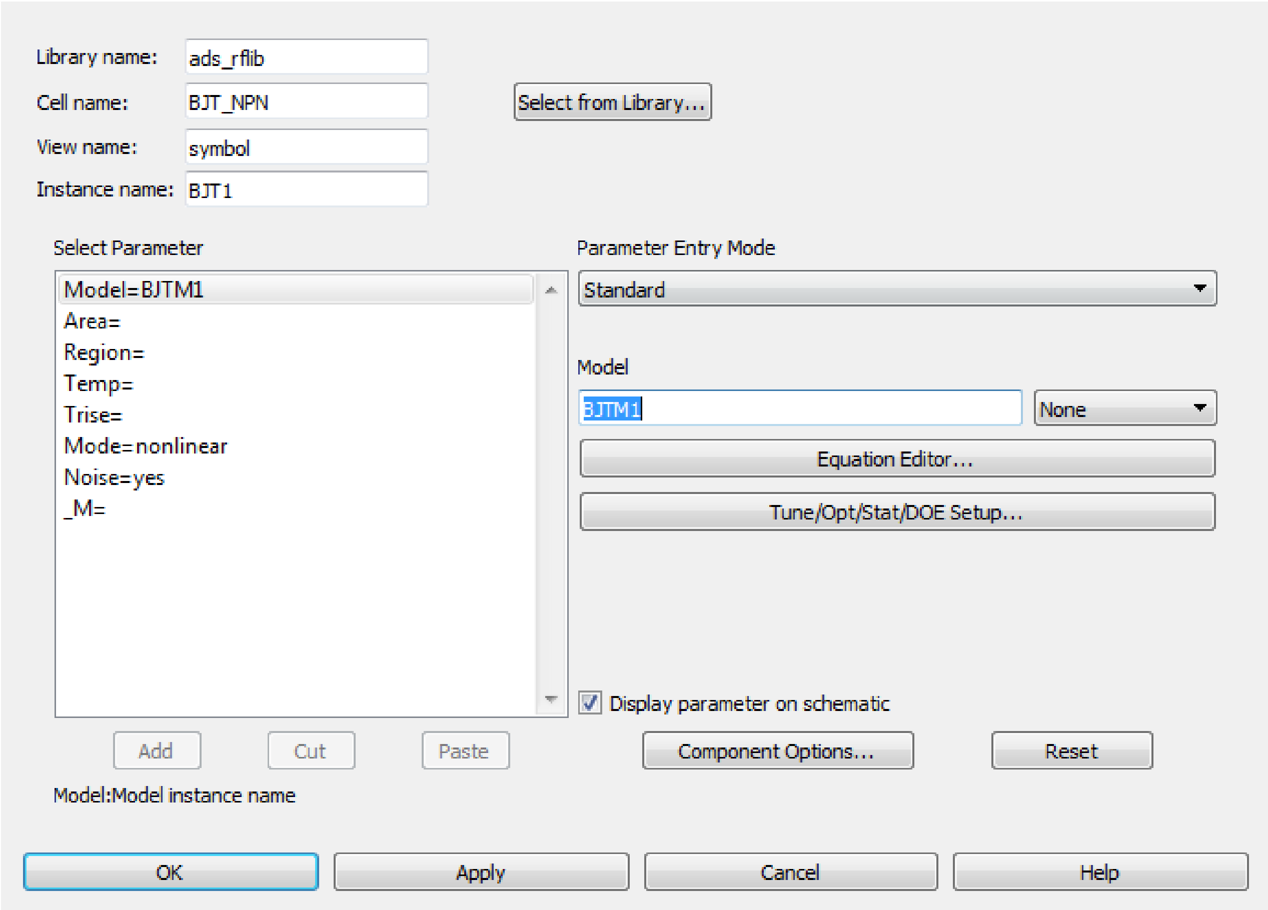
The BinModel in the JFET library allows you to sweep a parameter (usually a geometry, such as gate length), then enable the simulator to automatically select between different model cards. This alleviates the problem that one scalable model typically doesn't work for all sizes of a device.

For information on the use of the binning feature, refer to BinModel.

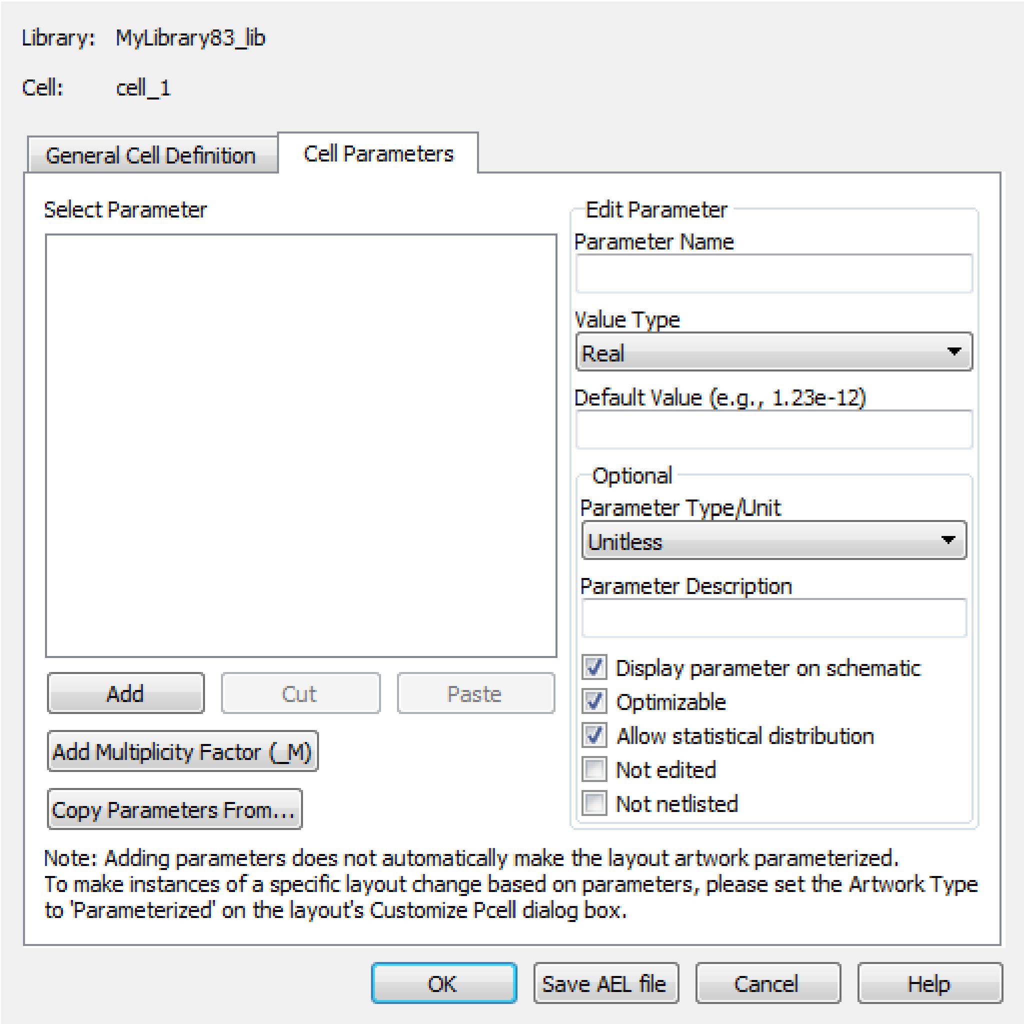
Multiplicity Parameter _M

The multiplicity feature provides a way to scale components or entire sub-circuits containing many components and sub-circuits. Given a component with a multiplicity value *M* , the simulator treats this component as if there were *M* such components all connected in parallel. Sub-circuits within sub-circuits will be appropriately scaled.

The _M parameter is available at the component level as shown here. (For components that do not explicitly have a Multiplicity parameter, the same functionality can be achieved by placing the component in a sub-circuit and using the sub-circuit's Multiplicity parameter, as described next.)



For sub-circuits, the parameter is enabled by selecting **File** > **Design Parameters** from the Schematic window. In the dialog box, select the **Parameters** tab. To add the Multiplicity parameter, choose **Add Multiplicity Factor_M**.



Netlist Syntax

Models for the ADS circuit simulator have the following syntax:

```
model modelname modeltype [param=value]*
```

where `model` is a keyword, `modelname` is the user-defined name for the model and `modeltype` is one of the predefined model types (e.g., Diode, BJT, MOSFET). After these three required fields comes zero or more `param=value` pairs.

`param` is a model keyword and value is its user-assigned value. There is no required order for the `param=value` pairs. Model keywords that are not specified take on their default values. Refer to documentation for each model type to see the list of model parameters, their meanings and default values.

The model statement must be on a single line. Use the backslash "\" as a line continuation character. Instance and model parameter names are case sensitive; most (not all) model parameters have their first character capitalized and the rest are lower case. Scale factors (e.g., p=10^{-12}, n=10^{-9}, u=10^{-6}, m=10^{-3}, k=10^{+3}, M=10^{+6}) can be used with numbers for numeric values. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

A netlist translator is available for translating models and subcircuits from Pspice, Hspice, and Spectre syntax to the form used by the ADS Circuit Simulator. Refer to the Netlist Translator for SPICE for more information.

Parameter Aliases

For compatibility with other simulators, some models accept two or more different keywords for the same parameter. For example, the Diode model accepts both model keywords Is and Js for the saturation current. In the documentation, the parameter Name column lists the aliases in parentheses after the main parameter name. The main parameter name is the one that appears in the ADS dialog box for the model.

Tnom

All nonlinear device models have a parameter that specifies the temperature at which the model parameters were extracted. Normally called Tnom, some models may use Tref, Tr, or Tmeas. The default value for Tnom is specified on the Options item in the Tnom field. If Options.Tnom is not specified it defaults to 25°C. This is true for all nonlinear devices.

It is strongly suggested that the user explicitly set Tnom in each model and not depend on its default value. First, this provides a self-documenting model; other users of the device will not have to guess at what Tnom should be. Second, different users of the same model would get different results for the same circuit if they simulate with different values of Options.Tnom.

Temp and Trise

The ADS circuit simulation allows the user to directly specify the temperature of each individual device instance. This is done with the device instance parameter Temp which is the device temperature in degrees Celsius. If it is not specified, it defaults to the ambient temperature set with *Options.Temp*, which defaults to 25° C.

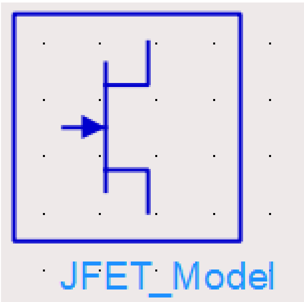
For compatibility with other simulators, many of the nonlinear devices allow the user to specify Trise for each device instance, which specifies actual device temperature as an increase from ambient. It defaults to zero. The Trise instance value is used only if the Temp instance value is not specified. If the user does not specify Trise on the instance, a default value for Trise can also be specified in the model. It defaults to zero. The following shows the logic of how the instance temperature is calculated if it is not explicitly specified.

```
if Instance.Temp is not specified
  if instance.Trise is not specified
    Instance.Temp = Options.Temp \+ Model.Trise
  else
    Instance.Temp = Options.Temp \+ Instance.Trise
```

JFET Model (Junction FET Model)

JFET_Model (Junction FET Model)

Symbol



FET_Model equations are based on the FET model of Shichman and Hodges. For more information on JFET_Model, its parameters and equations, see [1]. Charge storage is modeled by nonlinear depletion layer capacitance for both gate junctions. These capacitances vary as 1/Sqrt (Junction Voltage) and are defined by Cgs, Cgd and Pb.

- The DC characteristics of a JFET_Model are defined by:
  - Vto and Beta: determine variation in drain current with respect to gate voltage.
  - Lambda: determines the output conductances
  - Is: saturation current of the two gate junctions.

Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NFET	N-channel model: yes or no	None	yes
PFET	P-channel model: yes or no	None	no
Vto †	zero-bias threshold voltage	V	-2.0
Beta †, ††	transconductance parameter	$A/(V \times m)^2$	1.0e-4
Lambda	channel-length modulation	1/V	0.0

Rd [††]	drain ohmic resistance	Ohm	fixed at 0
Rs [††]	source ohmic resistance	Ohm	fixed at 0
Is [†], [††]	gate-junction saturation current	A	1.0e-14
Cgs [†]	zero-bias gate-source junction capacitance	F	0.0
Cgd [†]	zero-bias gate-drain junction capacitance	F	0.0
Pb [†]	gate-junction potential	V	1.0
Fc	forward-bias junction capacitance coefficient	None	0.5
Tnom	nominal ambient temperature at which these model parameters were derived	°C	25
Trise	temperature rise above ambient	°C	0
Kf	flicker-noise coefficient	None	0.0
Af	flicker-noise exponent	None	1.0
Imax	explosion current	A	1.6
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 5)	A	defaults to Imax
N	gate P-N emission coefficient	None	1.0
Isr [†]	gate P-N recombination current parameter	A	0.0
Nr	Isr emission coefficient	None	2.0
Alpha	ionization coefficient	1/V	0.0
Vk	ionization knee voltage	V	0.0
M	gate P-N grading coefficient	None	0.5
Vtotc	Vto temperature coefficient	V/°C	0.0
Betatce	Beta exponential temperature coefficient	1/°C	0.0
Xti	temperature coefficient	None	3.0
Ffe	flicker noise frequency exponent	None	1.0
Gdsnoise	generate noise from gds as well as gm: yes=1, no=0	None	no
wBvgs	gate-source reverse breakdown voltage (warning)	V	None
wBvgd	gate-drain reverse breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
AllParams	DataAccessComponent-based parameters	None	None

† Parameter value varies with temperature based on model Tnom and device Temp. †† Parameter value is scaled with Area specified with the JFET device.

- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to DataAccessComponent (Data Access Component)). Note that model parameters that are explicitly specified take precedence over those specified via AllParams.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to the *Design Kit Development*.

```
model modelname JFET [parm=value]*
```

The model statement starts with the required keyword *model* . It is followed by the *modelname* that will be used by JFET components to refer to the model. The third parameter indicates the type of model; for this model it is *JFET* . Use either parameter NFET=yes or PFET=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example

```
model  U310  JFET \
 Vto=-3 Beta=3e-4 NFET=yes
```

Equations/Discussions

Temperature Scaling

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device item Temp parameter. (Temperatures in the following equations are in Kelvin.)

The saturation currents Is and Isr scale as:

$$Is^{NEW} = Is \times exp\left[\left(\frac{Temp}{Tnom} - 1\right)\frac{q \times Eg}{k \times N \times Temp} + \frac{Xti}{N} \times ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Isr^{NEW} = Isr \times exp\left[\left(\frac{Temp}{Tnom} - 1\right)\frac{q \times Eg}{k \times Nr \times Temp} + \frac{Xti}{Nr} \times ln\left(\frac{Temp}{Tnom}\right)\right]$$

The depletion capacitances Cgs and Cgd vary as:

$$Cgs^{NEW} = Cgs\left[\frac{1 + M[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + M[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

$$Cgd^{NEW} = Cgd\left[\frac{1 + M[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + M[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

where γ is a function of the junction potential and the energy gap variation with temperature.

The gate junction potential Pb varies as:

$$Pb^{NEW} = \frac{Temp}{Tnom} \times Pb + \frac{2k \times Temp}{q} 1n\left(\frac{n_i^{Tnom}}{n_i^{Temp}}\right)$$

where n_i is the intrinsic carrier concentration for silicon, calculated at the appropriate temperature.

The threshold voltage Vto varies as:

$$Vto^{NEW} = Vto + Vtotc(Temp - Tnom)$$

The transconductance Beta varies as:

$$Beta^{NEW} = Beta \times 1.01^{Betatce(Temp - Tnom)}$$

Noise Model

Thermal noise generated by resistors Rs and Rd is characterized by the following spectral density:

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

Channel noise and flicker noise (Kf, Af, Ffe) generated by the DC transconductance g_m and current flow from drain to source is characterized by the following spectral density:

$$\frac{\langle i_{DS}^2 \rangle}{\Delta f} = \frac{8kTg_m}{3} + Kf\frac{I_{DS}^{Af}}{f^{Ffe}}$$

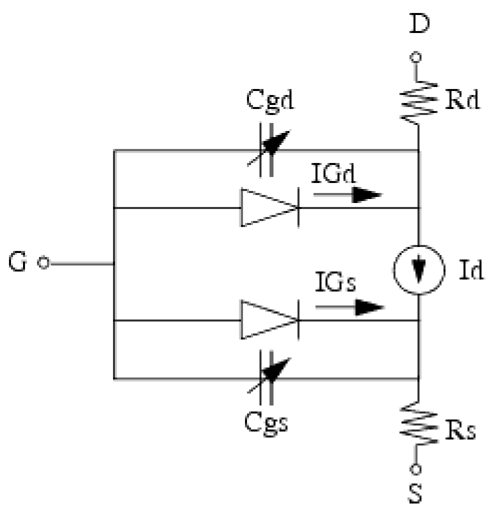
If the model parameter *Gdsnoise=yes*, the channel noise is instead characterized by the following:

$$\frac{\langle i_{DS}^2 \rangle}{\Delta f} = \frac{8}{3}kT(g_m + g_{DS})\left[\frac{3}{2} - \frac{min(Vds, Vdsat)}{2Vdsat}\right] + K_f\frac{I_{DS}^{Af}}{f^{Ffe}}$$

In the above expressions, *k* is Boltzmann's constant, *T* is the operating temperature in Kelvin, *q* is the electron charge, *Kf*, *Af*, and *Ffe* are model parameters, *f* is the simulation frequency, and Δ *f* is the noise bandwidth.

Additional Information

Equivalent Circuit



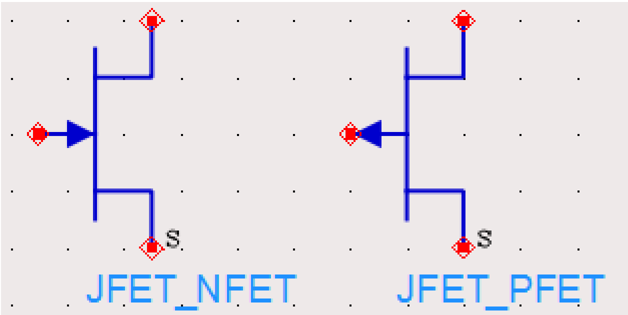
References

- P. Antognetti and G. Massobrio. *Semiconductor device modeling with SPICE*, New York: McGraw-Hill, Second Edition 1993.

JFET NFET, JFET PFET (Nonlinear Junction FETs, P-Channel, N-Channel)

JFET_NFET, JFET_PFET (Nonlinear Junction FETs, P-Channel, N-Channel)

Symbol



Parameters

Name	Description	Units	Default
Model	name of a JFET_Model	None	JFETM1
Area	scaling factor that scales certain parameter values of the JFET_Model	None	1.0
Region	DC operating region, 0=off, 1=on, 2=rev, 3=ohmic	None	on
Temp	device operating temperature	°C	25
Trise	temperature rise above ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (refer to note 2)	None	Nonlinear
Noise	Noise generation option; yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

- The Temp parameter specifies the physical (operating) temperature of the device. If this is different than the temperature at which the model parameters are valid or extracted (specified by the Tnom

parameter of the associated JFET_Model) certain model parameters are scaled such that the device is simulated at its operating temperature. Refer to JFET_Model (Junction FET Model) to see which parameter values are scaled.
- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Cgs	Gate-source capacitance	farads
Cgd	Gate-drain capacitance	farads
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts

- This device has no default artwork associated with it.

Additional Information

References

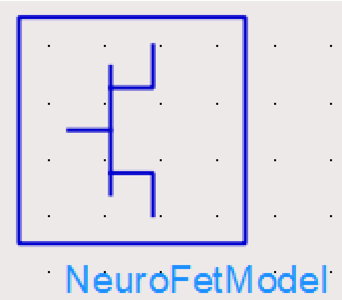
- *SPICE2: A Computer Program to Simulate Semiconductor Circuits,* University of California, Berkeley.
- P. Antognetti and G. Massobrio. *Semiconductor Device Modeling with SPICE,* Second Edition, McGraw-Hill, Inc., 1993.

NeuroFet Model

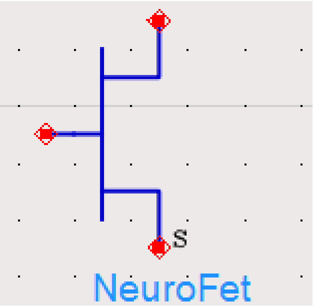
NeuroFet Model

Symbol

Model Symbol



Instance Symbol



Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

> *model modelName NeuroFET [param=value]**

Example

> *model Agilentneurofetmodel NeuroFET NeuroModelPath="file_with_data" ImplicitEquationWeight=0.01 tau_disp=1.0e-7 ExtrapolationWarningFlag=1 Rd0=rd0*R_alpha Rg0=0 Rgs0=rg*R_alpha Rs0=rs0*R_alpha Ld=ld Lg=lg Ls=ls Cgsman=cgsman Cdsman=cdsman Cgdman=cgdman Cdsext=cdsext Cgsxo=cgsxo*

Model Parameters

Name (Alias)	Description	Default Value	Default Visibility	Units
NeuroModelFile	Name of model file	AgilentNeuroFETModel1	on	
Wtot0	total width of the reference device (N0*(finger width of reference device))	value is found in NeuroModelFile	on	m
N0	Number of gate fingers of the reference device	value is found in NeuroModelFile	on	
Rg0	Gate extrinsic parasitic resistance of the reference device	value is found in NeuroModelFile	off	Ω
Rgs0	Correction term compensating for gate current dispersion effects of the reference device	value is found in NeuroModelFile	off	Ω
Rd0	Drain extrinsic parasitic resistance of the reference device	value is found in NeuroModelFile	off	Ω
Rs0	Source extrinsic parasitic resistance of the reference device	value is found in NeuroModelFile	off	Ω
R_alpha	Correction coefficient for extrinsic parasitic resistance	value is found in NeuroModelFile	off	Ω
Lg0	Gate extrinsic parasitic inductance of the reference device	value is found in NeuroModelFile	off	H
Ld0	Drain extrinsic parasitic inductance of the reference device	value is found in NeuroModelFile	off	H
Ld1	Parameter for scaling the drain extrinsic parasitic inductance	value is found in NeuroModelFile	off	H

Name (Alias)	Description	Default Value	Default Visibility	Units
Ls0	Source extrinsic parasitic inductance of the reference device	value is found in NeuroModelFile	off	H
Ls1	Parameter for scaling the source extrinsic parasitic inductance	value is found in NeuroModelFile	off	H
Cgsman0	Gate extrinsic parasitic manifold capacitance of the reference device	value is found in NeuroModelFile	off	F
Cgsxo0	Gate extrinsic parasitic inner layer capacitance of the reference device	value is found in NeuroModelFile	off	F
Cdsman0	drain extrinsic parasitic manifold capacitance of the reference device	value is found in NeuroModelFile	off	F
cdsmanCON	constant term of drain extrinsic parasitic manifold capacitance	value is found in NeuroModelFile	off	F
Cdsext0	drain extrinsic parasitic inner layer capacitance of the reference device	value is found in NeuroModelFile	off	F
Cgdsman0	gate-drain extrinsic parasitic manifold capacitance of the reference device	value is found in NeuroModelFile	off	F
tau_disp	time-constant for drain current dispersion effect	value is found in NeuroModelFile	off	s
NoiseR	Gate noise coefficient	0	off	
NoiseP	Drain noise coefficient	0	off	
NoiseC	Gate-drain noise correlation coefficient	0	off	
Fnc	Flicker noise corner frequency	0	off	Hz

Name (Alias)	Description	Default Value	Default Visibility	Units
Af	Flicker (1/f) noise exponent	1	off	
Kf	Flicker (1/f) noise coefficient	0	off	A^{2-A_f}
Ffe	Flicker noise frequency exponent	1	off	
ExtrapolationWarning	warn if extrapolation is used for converged solution	yes	off	yes,no
Extrapolation_Ig_DC	set extrapolation for DC gate	yes	off	yes,no
Extrapolation_Id_DC	set extrapolation for DC drain	yes	off	yes,no
Extrapolation_Qg	set extrapolation for gate charge	yes	off	yes,no
Extrapolation_Qd	set extrapolation for drain charge	yes	off	yes,no
Extrapolation_Idhf	set extrapolation for high frequency drain current	yes	off	yes,no
ExtrapolationParameter1_Ig_DC	first parameter for extrapolation for DC gate	0.0001	off	
ExtrapolationParameter1_Id_DC	first parameter for extrapolation for DC drain	0.05	off	
ExtrapolationParameter1_Qg	first parameter for extrapolation of gate charge	0	off	
ExtrapolationParameter1_Qd	first parameter for extrapolation of drain charge	0	off	

Name (Alias)	Description	Default Value	Default Visibility	Units
Extrapolationarameter1_ Idhf	first parameter for extrapolation of high frequency drain current	0	off	
ExtrapolationParameter2	second parameter for extrapolation	0.05	off	
ImplicitEquationWeight	weight factor for convergence	0.0001	off	

- R_alpha is a correction coefficient for parasitic resistances that ensures a well behaved mathematical formulation of the model.
- Extrapolation is controlled by two parameters: Extrapolation parameter 1 and Extrapolation parameter 2.
  - Extrapolation parameter 1 changes the sensitivity near the boundary.
  - Extrapolation parameter 2 changes the sensitivity far away from the boundary.
- ImplicitEquationWeight parameter controls convergence at low power levels. Decrease the value if the simulation does not converge at low power levels. The range of use is 1e-6 to 1e-3.
- It is recommended to turn extrapolation on by setting: `Extrapolation_Ig_DC=`2, `Extrapolation_Id_DC=`2

Instance Netlist Format

> *"modelName" [:Name] n1 nc n2*

Example

> *Agilentneurofetmodel:NeuroFET N_17 N18 N_16 Width=Width Fingers=Fingers*

Instance Parameters

Name (Alias)	Description	Default Value	Default Visibility	Units
Model	Model instance name	AgilentNeuroFETModel1	on	
Wtot	total width (N*finger width)	Specify a value to run the simulation	on	m
N	Number of gate fingers	Specify a value to run the simulation	on	
Rg	gate extrinsic parasitic resistance	defaults to the value calculated using model parameters in the scaling equations	off	Ω

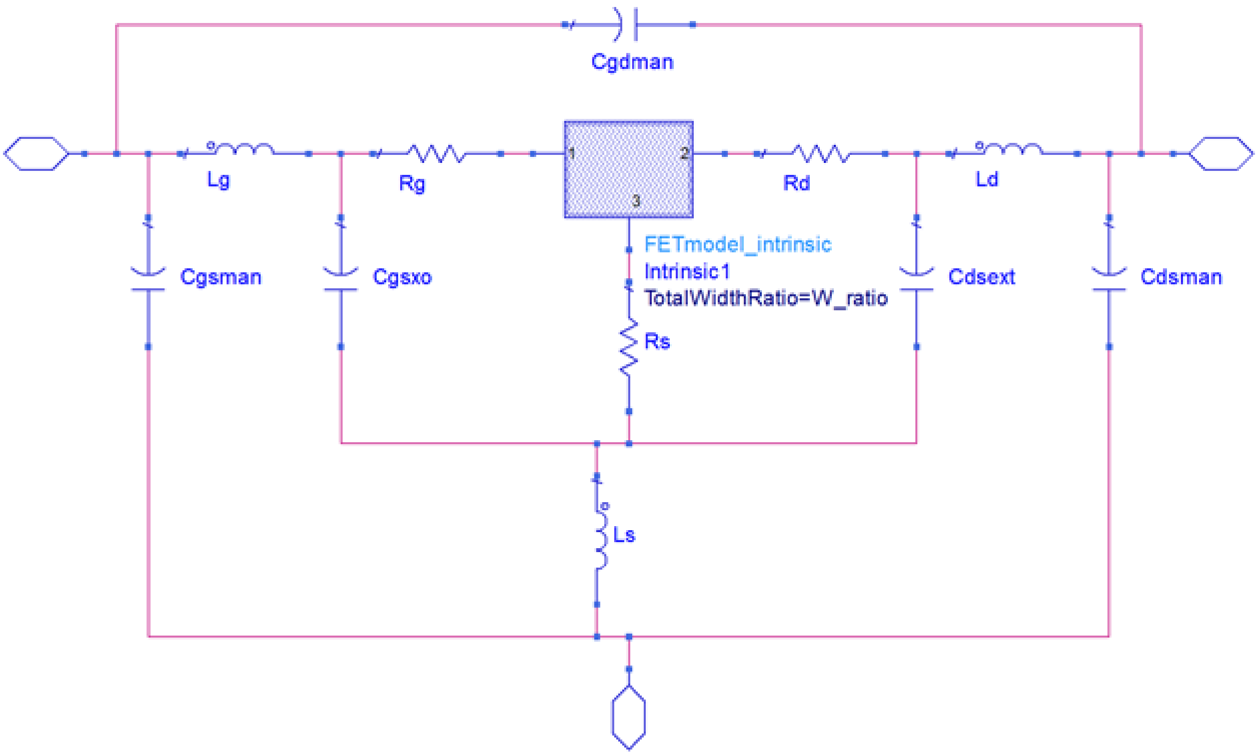
Name (Alias)	Description	Default Value	Default Visibility	Units
Rd	drain extrinsic parasitic resistance	defaults to the value calculated using model parameters in the scaling equations	off	Ω
Rs	source extrinsic parasitic resistance	defaults to the value calculated using model parameters in the scaling equations	off	Ω
Lg	gate extrinsic parasitic inductance	defaults to the value calculated using model parameters in the scaling equations	off	H
Rd	drain extrinsic parasitic inductance	defaults to the value calculated using model parameters in the scaling equations	off	H
Rs	source extrinsic parasitic inductance	defaults to the value calculated using model parameters in the scaling equations	off	H
Cgsman	gate extrinsic parasitic manifold capacitance	defaults to the value calculated using model parameters in the scaling equations	off	F
Cgsxo	gate extrinsic parasitic inner layer capacitance	defaults to the value calculated using model parameters in the scaling equations	off	F
Cdsman	drain extrinsic parasitic manifold capacitance	defaults to the value calculated using model parameters in the scaling equations	off	F
Cdsext	drain extrinsic parasitic inner layer capacitance	defaults to the value calculated using model parameters in the scaling equations	off	F

Name (Alias)	Description	Default Value	Default Visibility	Units
Cgdsman	gate-drain extrinsic parasitic manifold capacitance	defaults to the value calculated using model parameters in the scaling equations	off	F

The default value on the instance line overwrites the value in the model card without applying any scaling.

Scalable NeuroFET Model

Following is the scalable device model:



Modeled device:

> w_0=*FingerWidth_extract*
>
> W_0=*TotalWidth_extract*
>
> F_0=*Fingers_extract*
>
> $W_0=F_0 \; ^* \; _0$

Scaled device:

w=FingerWidth
W=TotalWidth
F=Fingers

*W=F*w*

$W\_ratio = W/W_0$

$F\_ratio = F/F_0$

Scaling of the Intrinsic Model

Intrinsic model is scaled in the NN-functions based on the W_ratio.

Scaling of the Extrinsic Parasitic Resistances

$$R_g = \left(r_{g0} \cdot \frac{W\_ratio}{F\_ratio^2} + \frac{r_{gs0}}{W\_ratio} \right) \cdot R\_alpha$$

$$R_d = \frac{r_{d0}}{W\_ratio} \cdot R\_alpha$$

$$R_s = \frac{r_{s0}}{W\_ratio} \cdot R\_alpha$$

where, r_{g0}, r_{gs0}, r_{d0}, and R_alpha are model parameters related to the extrinsic parasitic resistances. Parameters r_{g0}, r_{gs0}, and r_{d0} are the extrinsic resistances of the reference device.

Scaling of the Extrinsic Parasitic Inductance

$$L_g = L_{g0} \cdot \frac{W\_ratio}{F\_ratio^2}$$

$$L_d = \frac{L_{d0}}{\sqrt{F\_ratio}} + \frac{\left(\frac{W}{F} - \frac{W_0}{F_0} \right)}{\sqrt{\frac{F}{2}}} \cdot L_{d1}$$

$$L_s = \frac{L_{s0}}{\sqrt{F\_ratio}} + \frac{\left(\frac{W}{F} - \frac{W_0}{F_0} \right)}{\sqrt{\frac{F}{2}}} \cdot L_{s1}$$

where, L_{d1} and L_{s1} have the default value of 0.5pH respectively.
L_{g0}, L_{d0}, L_{d1}, L_{s0}, and L_{s1} are model parameters related to the extrinsic parasitic inductances.

Scaling of the Extrinsic Parasitic Capacitance

$$C_{gsman} = c_{gsman0}$$
$$C_{gsxo} = c_{gsxo0} \cdot F\_ratio$$
$$C_{dsman} = c_{dsman0} \cdot F\_ratio + c_{dsmanCON} \cdot (1 - F\_ratio)$$
$$C_{dsext} = c_{dsext0} \cdot W\_ratio$$
$$C_{gdman} = c_{gdman0} \cdot F\_ratio$$

where, C_{gsman0}, C_{gsx0}, C_{gdman0}, C_{dsman0}, $C_{dsmanCON}$, and C_{dsext0} are model parameters related to the extrinsic parasitic capacitances.

r3 (Three-Terminal Nonlinear Diffused and Poly-Silicon Resistor and JFET Model and Instance)

r3 (Three-Terminal Nonlinear Diffused and Poly-Silicon Resistor and JFET Model and Instance)

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

> *model modelName r3 [param=value]**

Example:

> *model Nch r3 rsh=100*

Model Parameters

Name (Alias)	Description	Units	Default
Gender	+1=N-type, -1=P-type		1(n),-1(p)
Tnom	Parameter measurement temperature	deg C	27
Secured	Secured model parameters		0
version	model version		1
subversion	model subversion		0
revision	model revision		0
level	model level		1003
type	resistor type: -1=n-body and +1=p-body		-1
scale	scale factor for instance geometries		1

Name (Alias)	Description	Units	Default
shrink	shrink percentage for instance geometries		0
tmin	minimum ambient temperature		-100
tmax	maximum ambient temperature		500
rthresh	threshold to switch end resistance to V=I*R form		0.001
gmin	minimum conductance		1e-12
imax	current at which to linearize diode currents		1
lmin	minimum allowed drawn length		0
lmax	maximum allowed drawn length		9.9e+09
wmin	minimum allowed drawn width		0
wmax	maximum allowed drawn width		9.9e+09
jmax	maximum current density		100
vmax	maximum voltage w.r.t. control node nc		9.9e+09
tminclip	clip minimum temperature		-100
tmaxclip	clip maximum temperature		500
rsh	sheet resistance		100
xw	width offset (total)		0
nwxw	narrow width width offset correction coefficient		0
wexw	webbing effect width offset correction coefficient (for dogboned devices)		0
fdrw	finite doping width offset reference width		1

Name (Alias)	Description	Units	Default
fdxwinf	finite doping width offset width value for wide devices		0
xl	length offset (total)		0
xlw	width dependence of length offset		0
dxlsat	additional length offset for velocity saturation calculation		0
nst	subthreshold slope parameter		1
ats	saturation smoothing parameter		0
dfinf	depletion factor for wide/long device		0.01
dfw	depletion factor 1/w coefficient		0
dfl	depletion factor 1/l coefficient		0
dfwl	depletion factor 1/(w*l) coefficient		0
sw_dfgeo	switch for depletion factor geometry dependence: 0=drawn and 1=effective		1
dp	depletion potential		2
ecrit	velocity saturation critical field		4
ecorn	velocity saturation corner field		0.4
du	mobility reduction at ecorn		0.02
rc	resistance per contact		0
rcw	width adjustment for contact resistance		0
fc	depletion capacitance linearization factor		0.9
isa	diode saturation current per unit area		0

Name (Alias)	Description	Units	Default
na	ideality factor for isa		1
ca	fixed capacitance per unit area		0
cja	depletion capacitance per unit area		0
pa	built-in potential for cja		0.75
ma	grading coefficient for cja		0.33
aja	smoothing parameter for cja		-0.5
isp	diode saturation current per unit perimeter		0
np	ideality factor for isp		1
cp	fixed capacitance per unit perimeter		0
cjp	depletion capacitance per unit perimeter		0
pp	built-in potential for cjp		0.75
mp	grading coefficient for cjp		0.33
ajp	smoothing parameter for cjp		-0.5
vbv	breakdown voltage		0
ibv	current at breakdown		1e-06
nbv	ideality factor for breakdown current		1
kfn	flicker noise coefficient (unit depends on afn)		0
afn	flicker noise current exponent		2
bfn	flicker noise 1/f exponent		1

Name (Alias)	Description	Units	Default
sw_fngeo	switch for flicker noise geometry calculation: 0=drawn and 1=effective		0
ea	activation voltage for diode temperature dependence		1.12
xis	exponent for diode temperature dependence		3
tc1	resistance linear TC		0
tc2	resistance quadratic TC		0
tc1l	resistance linear TC length coefficient		0
tc2l	resistance quadratic TC length coefficient		0
tc1w	resistance linear TC width coefficient		0
tc2w	resistance quadratic TC width coefficient		0
tc1rc	contact resistance linear TC		0
tc2rc	contact resistance quadratic TC		0
tc1kfn	flicker noise coefficient linear TC		0
tc1vbv	breakdown voltage linear TC		0
tc2vbv	breakdown voltage quadratic TC		0
tc1nbv	breakdown ideality factor linear TC		0
gth0	thermal conductance fixed component		1e+06
gthp	thermal conductance perimeter component		0
gtha	thermal conductance area component		0
gthc	thermal conductance contact component		0

Name (Alias)	Description	Units	Default
cth0	thermal capacitance fixed component		0
cthp	thermal capacitance perimeter component		0
ctha	thermal capacitance area component		0
cthc	thermal capacitance contact component		0
nsig_rsh	number of standard deviations of global variation for rsh		0
nsig_w	number of standard deviations of global variation for w		0
nsig_l	number of standard deviations of global variation for l		0
sig_rsh	global variation standard deviation for rsh (relative)		0
sig_w	global variation standard deviation for w (absolute)		0
sig_l	global variation standard deviation for l (absolute)		0
smm_rsh	local variation standard deviation for rsh (relative)		0
smm_w	local variation standard deviation for w (absolute)		0
smm_l	local variation standard deviation for l (absolute)		0
sw_mmgeo	switch for flicker noise geometry calculation: 0=drawn and 1=effective		0

Instance Netlist Format

> *"modelName" [:Name] n1 nc n2*

Example:

> *Nch:M1 2 1 0 w=10u l=0.9u*

Instance Parameters

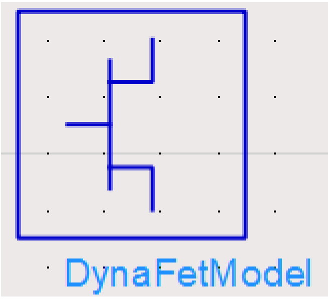
Name (Alias)	Description	Units	Default
Temp	Device operating temperature	deg C	25
Mode	Nonlinear spectral model on/off		1
Noise	Noise generation on/off		1
M	multiplicity factor		1
w	design width of resistor body		1e-06
l	design length of resistor body		1e-06
wd	dogbone width (total; not per side)		0
a1	area of node n1 partition		0
p1	perimeter of node n1 partition		0
c1	# contacts at node n1 terminal		0
a2	area of node n2 partition		0
p2	perimeter of node n2 partition		0
c2	# contacts at node n2 terminal		0
sw_noise	switch for including noise: 0=no and 1=yes		1
sw_et	switch for self-heating: 0=no and 1=yes		1
sw_mman	switch for mismatch analysis: 0=no and 1=yes		0
nsmm_rsh	number of standard deviations of local variation for rsh		0
nsmm_w	number of standard deviations of local variation for w		0
nsmm_l	number of standard deviations of local variation for l		0

DynaFet Model

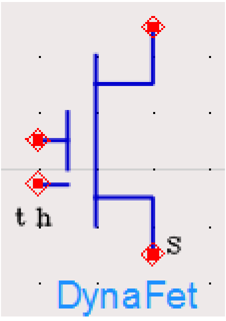
DynaFet Model

Symbol

Model Symbol



Instance Symbol



Model Parameters

Name	Description
DynaModelFile	Name of the model file
Extrapolation_Ig_DC	Set extrapolation for DC gate current
Extrapolation_Id_DC	Set extrapolation for DC drain current
Extrapolation_Qg	Set extrapolation for gate charge

Name	Description
Extrapolation_Qd	Set extrapolation for drain charge
ExtrapolationParameter1_Igs	First parameter for extrapolation for Igs
ExtrapolationParameter1_Id_DC	First parameter for extrapolation for DC drain current
ExtrapolationParameter1_Qgs	First parameter for extrapolation of gate charge
ExtrapolationParameter1_Qds	First parameter for extrapolation of drain charge
ExtrapolationParameter1_Igs2	First parameter for extrapolation of Igs2
ExtrapolationParameter1_Ids2	First parameter for extrapolation of Ids2
ExtrapolationParameter1_Qgs2	First parameter for extrapolation of Qgs2
ExtrapolationParameter1_Qds2	First parameter for extrapolation of Qds2
ExtrapolationParameter2	Second parameter for extrapolation
ImplicitEquationWeight	second parameter for extrapolation
Qd_LPF	Switch to select between intrinsic or extrinsic charge model
ExtrapolationWarning	Warn if extrapolation is used for converged solution
Force0	Forces drain source current to zero, when Vds=0 and extrapolating
ld0	Drain extrinsic parasitic inductance of the reference device
lg0	Gate extrinsic parasitic inductance of the reference device
ls0	Source extrinsic parasitic inductance of the reference device
rd0	Drain extrinsic parasitic resistance of the reference device
rg0	Gate extrinsic parasitic resistance of the reference device

Name	Description
rs0	Source extrinsic parasitic resistance of the reference device
cgsman0	Gate extrinsic parasitic manifold capacitance of the reference device
cgdman0	Gate-drain extrinsic parasitic manifold capacitance of the reference device
cdsman0	drain extrinsic parasitic manifold capacitance of the reference device
cdsext0	Drain extrinsic inner layer parasitic capacitance of the reference device
cgsxo0	Gate-source extrinsic parasitic inner layer capacitance of the reference device
rgs0	Correction term compensating for gate current dispersion effects of the reference device
NoiseP	Drain noise coefficient
NoiseR	Gate noise coefficient
NoiseC	Gate-drain noise correlation coefficient
Kf	Flicker (1/f)
Af	Flicker (1/f)
Ffe	Flicker noise frequency exponent
Fnc	Flicker noise corner frequency
TAVE	Averaging Time constant
r_alpha	Correction coefficient for extrinsic parasitic resistances
N0	Number of gate fingers of the reference device

Name	Description
Wtot0	Total width of the reference device (N0*(finger-width of reference device)
cdsmanCON	Constant term of the drain extrinsic parasitic manifold capacitance
Remit1	Gate-trapping network parallel resistance
Rcapt1	Gate-trapping network series resistance
Iscapt1	Gate-trapping network diode leakage current
V2	Drain-trapping network diode junction potential
V1	Gate-trapping network diode junction potential
Ctrap1	Gate-trapping network capacitance
Rth0	Thermal resistance
Tau_thermal	NOT USED
cgdxo0	Gate-drain extrinsic parasitic inner layer capacitance of the reference device
Iscapt2	Drain-trapping network diode leakage current
Rcapt2	Drain-trapping network series resistance
Remit2	Drain-trapping network parallel resistance
Ctrap2	Drain-trapping network capacitance
Rg0wexp	Exponent of the Total-Width ratio dependence of RG
Rg0fexp	Exponent of the Finger ratio dependence of RG
Rd0wexp	Exponent of the Total-Width ratio dependence of RD

Name	Description
Rd0fexp	Exponent of the Finger ratio dependence of RD
Rs0wexp	Exponent of the Total-Width ratio dependence of RS
Rs0fexp	Exponent of the Finger ratio dependence of RS
Lg0wexp	Exponent of the Total-Width ratio dependence of LG
Lg0fexp	Exponent of the Finger ratio dependence of LG
Ld0wexp	Exponent of the Total-Width ratio dependence of LD
Ld0fexp	Exponent of the Finger ratio dependence of LD
Ls0wexp	Exponent of the Total-Width ratio dependence of LS
Ls0fexp	Exponent of the Finger ratio dependence of LS
Rth0wexp	Exponent of the Total-Width ratio dependence of Rth
Cth0wexp	Exponent of the Total-Width ratio dependence of Cth
Cth0	Thermal capacitance
Version	Model version

Instance Parameters

Name	Description
N	Number of gate fingers
Wtot	Total width (N*finger-width)
Ld	Drain extrinsic parasitic inductance
Lg	Gate extrinsic parasitic inductance

Name	Description
Ls	Source extrinsic parasitic inductance
Rd	Drain extrinsic parasitic resistance
Rg	Gate extrinsic parasitic resistance
Rs	Source extrinsic parasitic resistance
Cgsman	Gate extrinsic parasitic manifold capacitance
Cgdman	gate-drain extrinsic parasitic manifold capacitance
Cgsxo	Gate-source extrinsic parasitic inner layer capacitance
Cdsman	Drain extrinsic parasitic manifold capacitance
Cdsext	Drain extrinsic inner layer parasitic capacitance
Cgdxo	Gate-drain extrinsic parasitic inner layer capacitance

Parasitic Definitions

`W_Ratio` is the ratio of the total gate width of the device to the total gate width of the measured device. It is calculated as the instance parameter (`Width`) over the model parameter (`Wnom`) if `Width` is specified. If `Width` is not specified, `W_Ratio` is set to 1 (and the `Width` is set to `Wnom`).

`F_Ratio` is the ration of the number of fingers of the device to that of the measured device. It is calculated as the instance parameter (`Nfg`) over the model parameter (`Nfgnom`) if `Nfg` is specified. If `Nfg` is not specified, it is set to 1.

Source inductance (`Ls`) is an instance parameter. If the user sets `Ls`, this is the value which is used in the model for the source inductance.
`Ls0` is a model parameter. It can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the location. If `Ls` is not set at the instance level, the source inductance will be calculated as
`Ls0*pow(W_Ratio, Ls0wexp)*pow(F_Ratio, Ls0fexp)`
where, `Ls0wexp` and `Ls0fexp` are set at the model card.

Drain inductance `Ld` is an instance parameter. If the user sets `Ld`, this is the value which is used in the model for the drain inductance.

`Ld0` is a model parameter, it can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the location. If `Ld` is not set at the instance level, the drain inductance will be calculated as
`Ld0*pow(W_Ratio, Ld0wexp)*pow(F_Ratio, Ld0fexp)`
where, `Ld0wexp` and `Ld0fexp` are set at the model card.

Gate inductance `Lg` is an instance parameter. If the user sets `Lg`, this is the value which is used in the model for the gate inductance.
`Lg0` is a model parameter. It can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the location. If `Lg` is not set at the instance level, the gate inductance will be calculated as
`Lg0*pow(W_Ratio, Lg0wexp)*pow(F_Ratio, Lg0fexp)`
where, `Lg0wexp` and `Lg0fexp` are set at the model card.

Drain resistance `Rd` is an instance parameter. If the user sets `Rd`, this is the value which is used in the model for the drain resistance.
`Rd0` is a model parameter. It can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the location. If `Rd` is not set at the instance level, the drain resistance will be calculated as
`Rd0*pow(W_Ratio, Rd0wexp)*pow(F_Ratio, Rd0fexp)`
where, `Rd0wexp` and `Rd0fexp` are set at the model card.

Source resistance `Rs` is an instance parameter. If the user sets `Rs`, this is the value which is used in the model for the source resistance.
`Rs0` is a model parameter. It can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the location. If `Rs` is not set at the instance level, the source resistance will be calculated as
`Rs0*pow(W_Ratio, Rs0wexp)*pow(F_Ratio, Rs0fexp)`
where, `Rs0wexp` and `Rs0fexp` are set at the model card.

Gate resistance `Rg` is an instance parameter. If the user sets `Rg`, this is the value which is used in the model for the gate resistance.
`Rg0` and `Rgs0` are model parameters, they can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the location. If `Rg` is not set at the instance level, the source resistance will be calculated as
`Rg0*pow(W_Ratio, Rg0wexp)*pow(F_Ratio, Rg0fexp)+Rgs0/W_Ratio`
where, `Rg0wexp` and `Rg0fexp` are set at the model card.

Gate extrinsic parasitic manifold capacitance `Cgsman` is an instance parameter. If the user sets `Cgsman`, this is the value which is used in the model for the Gate extrinsic parasitic manifold capacitance.
`Cgsman0` is a model parameter. It can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the

location. If `Cgsman` is not set at the instance level, the Gate extrinsic parasitic manifold capacitance will be calculated as `Cgsman0`.

Gate-drain extrinsic parasitic manifold capacitance `Cgdman` is an instance parameter. If the user sets `Cgdman`, this is the value which is used in the model for the Gate-drain extrinsic parasitic manifold capacitance.
`Cgdman0` is a model parameter. It can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the location. If `Cgdman` is not set at the instance level, the Gate-drain extrinsic parasitic manifold capacitance will be calculated as `Cgdman0`.

Gate-source extrinsic parasitic inner layer capacitance `Cgsxo` is an instance parameter. If the user sets `Cgsxo`, this is the value which is used in the model for the Gate-source extrinsic parasitic inner layer capacitance.
`Cgsxo0` is a model parameter. It can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the location. If `Cgsxo` is not set at the instance level, the Gate-source extrinsic parasitic inner layer capacitance will be calculated as `Cgsxo0*F_ratio`.

Gate-drain extrinsic parasitic inner layer capacitance `Cgdxo` is an instance parameter. If the user sets `Cgdxo`, this is the value which is used in the model for the Gate-drain extrinsic parasitic inner layer capacitance.
`Cgdxo0` is a model parameter. It can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the location. If `Cgdxo` is not set at the instance level, the Gate-drain extrinsic parasitic inner layer capacitance will be calculated as `Cgdxo0*F_ratio`.

Drain extrinsic parasitic manifold capacitance `Cdsman` is an instance parameter. If the user sets `Cdsman`, this is the value which is used in the model for the Drain extrinsic parasitic manifold capacitance.
`CdsmanCON` and `Cdsman0` are model parameters. They can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the location. If `Cdsman` is not set at the instance level, the Drain extrinsic parasitic manifold capacitance will be calculated as `XdsmanCON+(cdsman0-cdsmanCON)*F_Ratio`.

Drain extrinsic inner layer parasitic capacitance `Cdsext` is an instance parameter. If the user sets `Cdsext`, this is the value which is used in the model for the Drain extrinsic inner layer parasitic capacitance.
`Cdsext0` is model parameter. It can be set at the model card level, or in the extrinsics file. The model card value will overwrite the extrinsics file, but it needs to be set explicitly in either of the location. If `Cdsext` is not set at the instance level, the Drain extrinsic inner layer parasitic capacitance will be calculated as `Cdsext0*W_Ratio`.

Thermal resistance `Rth` is an instance parameter. If the user sets `Rth`, this is the value which is used in the model for the Thermal resistance.
`Rth0` is model parameter and can be set at the model card level. If `Rth` is not set at the instance level, the Thermal resistance will be calculated as `Rth0/pow(W_Ratio, Rth0wexp)`
where, `Rth0wexp` is set at the model card.

Thermal capacitance `Cth` is an instance parameter. If the user sets `Cth`, this is the value which is used in the model for the Thermal capacitance.
`Cth0` is model parameter and can be set at the model card level. If `Cth` is not set at the instance level, the Thermal capacitance will be calculated as `Cth0*pow(W_Ratio, Rth0wexp)`
where, `Cth0wexp` is set at the model card.

Devices and Models, MOS

Devices and Models, MOS

- MOS Model9 Single (Philips MOS Model 9, Single Device)
- MOS Model11 Electrical (Philips MOS Model 11, Electrical)
- MOS Model11 Physical (Philips MOS Model 11, Physical)
- MOS Model11 Binned (Philips MOS Model 11, Binned)
- MOSVAR (PSP-Based MOS Varactor Model)
  - MOSVAR_1_0 (PSP-Based MOS Varactor Version 1.0 Model and Instance)
  - MOSVAR_1_1 (PSP-Based MOS Varactor Version 1.1 Model and Instance)
  - MOSVAR_1_2 (PSP-Based MOS Varactor Version 1.2 Model and Instance)
  - MOSVAR_1_3 (PSP-Based MOS Varactor Version 1.3 Model and Instance)
- LETI UTSOI (Ultra-Thin Fully Depleted SOI MOSFET Model)
  - UTSOI 1.14
  - UTSOI 2
  - UTSOI 2.1
  - UTSOI 2.11
  - UTSOI 2.20
  - UTSOI 2.30
- Keysight Si or SiC PowerMOS Model
- Keysight IGBT Model

NOTE MOS Model 20 (Model is discontinued by NXP, refer to NXP documentation)

Bin Model

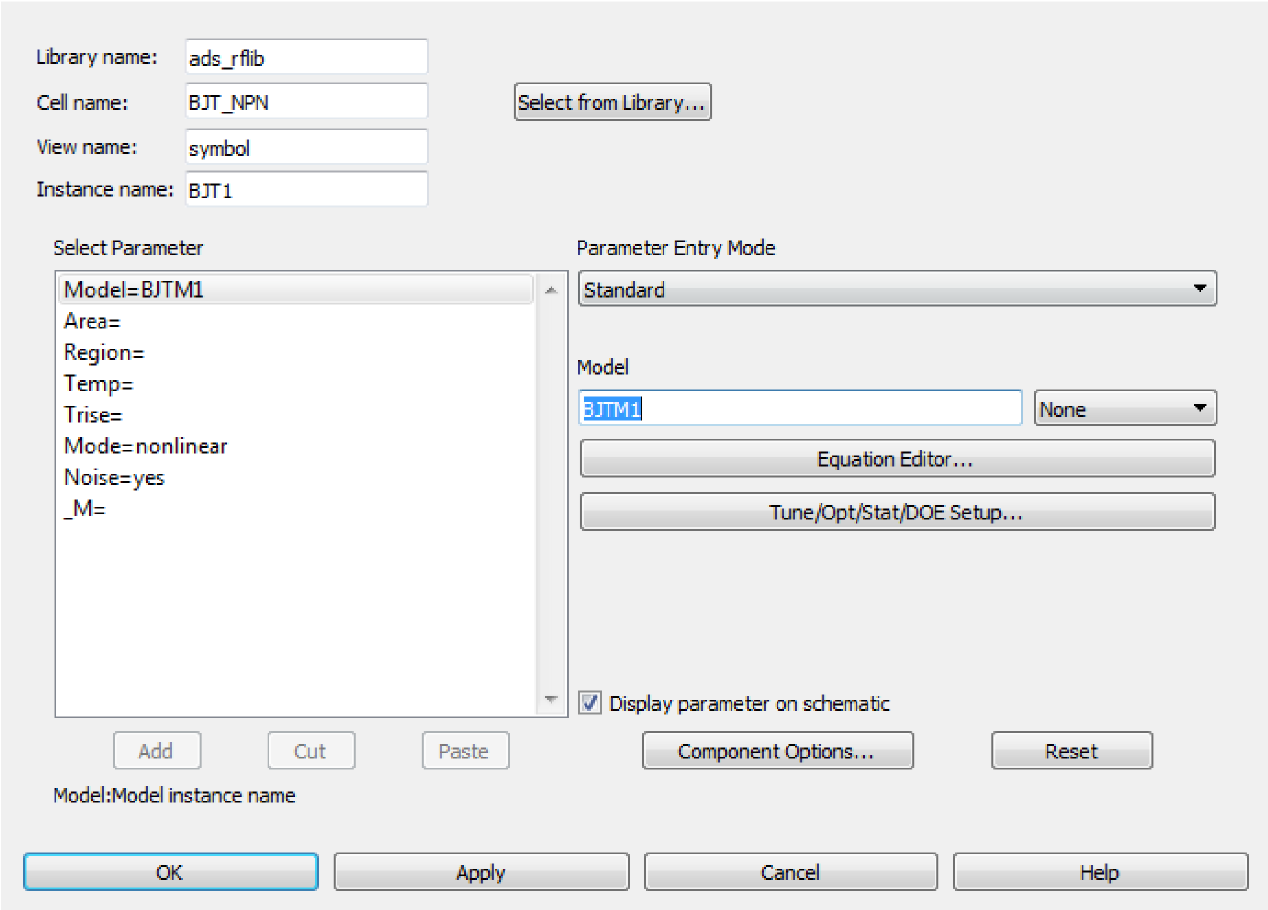
The BinModel in the MOS library allows you to sweep a parameter (usually a geometry, such as gate length), then enable the simulator to automatically select between different model cards. This alleviates the problem that one scalable model typically doesn't work for all sizes of a device.

For information on the use of the binning feature, refer to "BinModel" in *Introduction to Circuit Components*.

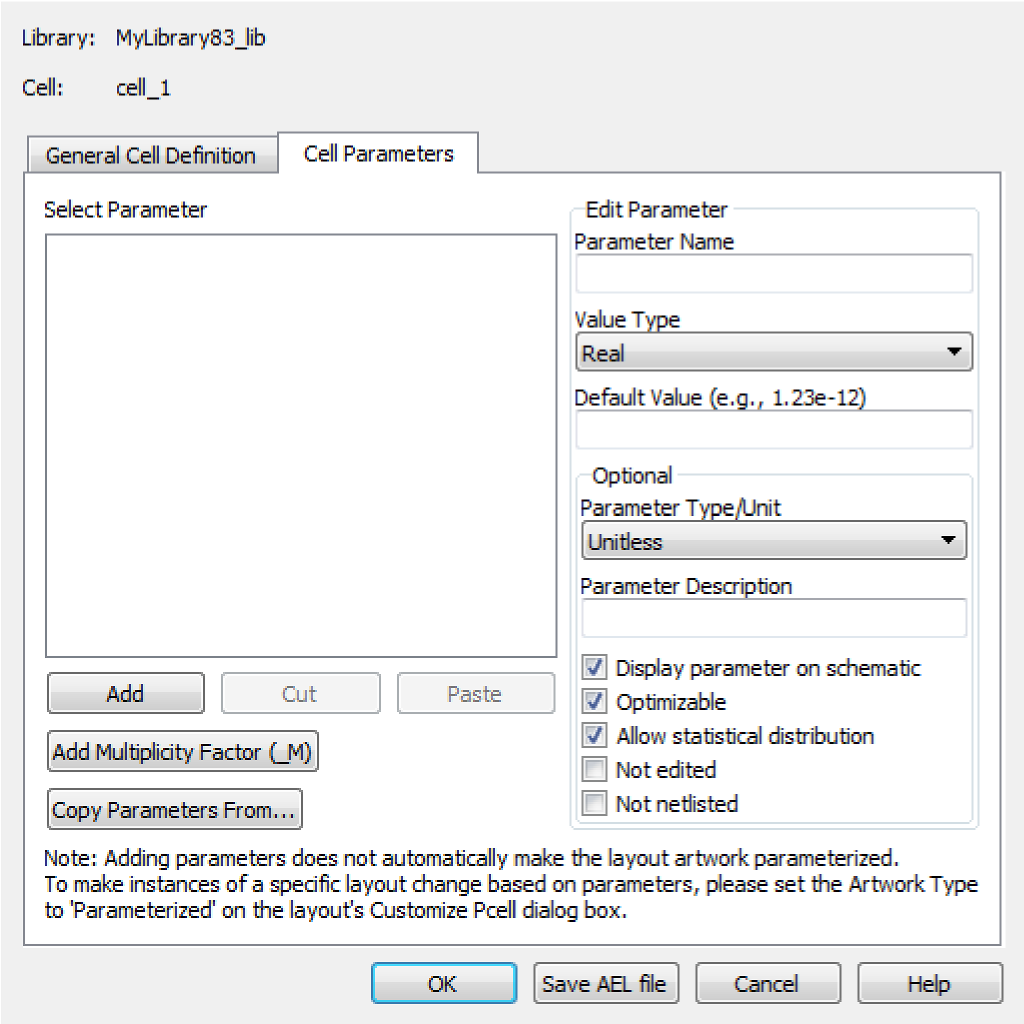
Multiplicity Parameter _M

The multiplicity feature provides a way to scale components or entire sub-circuits containing many components and sub-circuits. Given a component with a multiplicity value *M* , the simulator treats this component as if there were *M* such components all connected in parallel. Sub-circuits within sub-circuits will be appropriately scaled.

The _M parameter is available at the component level as shown here. (For components that do not explicitly have a Multiplicity parameter, the same functionality can be achieved by placing the component in a sub-circuit and using the sub-circuit's Multiplicity parameter, as described next.)



For sub-circuits, the parameter is enabled by selecting **File** > **Design Parameters** from the Schematic window. In the dialog box, select the **Parameters** tab. To add the Multiplicity parameter, choose **Add Multiplicity Factor (_M)**.



Netlist Syntax

Models for the ADS circuit simulator have the following syntax:

> *model modelname modeltype [param=value]**

where `model` is a keyword, `modelname` is the user-defined name for the model and `modeltype` is one of the predefined model types (e.g., Diode, BJT, MOSFET). After these three required fields comes zero or more `param=value` pairs. `param` is a model keyword and value is its user-assigned value. There is no required order for the `param=value` pairs. Model keywords that are not specified take on their default values. Refer to documentation for each model type to see the list of model parameters, their meanings and default values.

The model statement must be on a single line. Use the backslash "\" as a line continuation character. The instance and model parameter names are case sensitive. Most, but not all, model parameters have their first character capitalized and the rest are lower case. Scale factors (e.g., p=10^{-12}, n=10^{-9}, u=10^{-6}, m=10^{-3}, k=10^{+3}, M=10^{+6}) can be used with numbers for numeric values. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

A netlist translator is available for translating models and subcircuits from Pspice, Hspice, and Spectre syntax to the form used by the ADS Circuit Simulator. Refer to *Netlist Translator for SPICE and Spectre* for more information.

Parameter Aliases

For compatibility with other simulators, some models accept two or more different keywords for the same parameter. For example, the Diode model accepts both model keywords Is and Js for the saturation current. In the documentation, the parameter Name column lists the aliases in parentheses after the main parameter name. The main parameter name is the one that appears in the ADS dialog box for the model.

Tnom

All nonlinear device models have a parameter that specifies the temperature at which the model parameters were extracted. Normally called Tnom, some models may use Tref, Tr, or Tmeas. The default value for Tnom is specified on the Options item in the Tnom field. If Options.Tnom is not specified it defaults to 25° C. This is true for all nonlinear devices.

It is strongly suggested that the user explicitly set Tnom in each model and not depend on its default value. First, this provides a self-documenting model; other users of the device will not have to guess at what Tnom should be. Second, different users of the same model would get different results for the same circuit if they simulate with different values of Options.Tnom.

Temp and Trise

The ADS circuit simulation allows the user to directly specify the temperature of each individual device instance. This is done with the device instance parameter Temp which is the device temperature in degrees Celsius. If it is not specified, it defaults to the ambient temperature set with Options.Temp, which defaults to 25° C.

For compatibility with other simulators, many of the nonlinear devices allow the user to specify Trise for each device instance, which specifies actual device temperature as an increase from ambient. It defaults to zero. The Trise instance value is used only if the Temp instance value is not specified. If the user does not specify Trise on the instance, a default value for Trise can also be specified in the model. It defaults to zero. The following shows the logic of how the instance temperature is calculated if it is not explicitly specified.

```
if Instance.Temp is not specified
  if instance.Trise is not specified
    Instance.Temp = Options.Temp \+ Model.Trise
  else
    Instance.Temp = Options.Temp \+ Instance.Trise
```

MOSFET Parameter Nlev

The MOSFET noise model is controlled by the model parameter Nlev. The following table shows which noise equations are used for each value of Nlev. These equations are always used for the BSIM1, BSIM2, LEVEL1, LEVEL2, LEVEL3 and LEVEL3_MOD models. For a BSIM3, these equations can be used to override the standard BSIM3v3 noise equations only when Nlev ≥ 1.

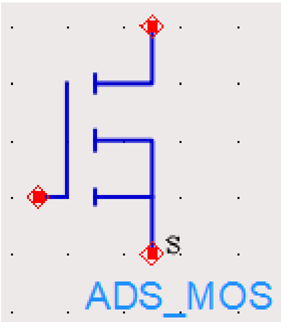
Equations Used for Nlev parameter

Nlev Value	Channel Noise	Flicker Noise	Default
-1	8/3k T g_m	$\frac{Kf\lvert I_{DS}\rvert^{Af}}{f^{Ffc}}$	ADS default (not usable with BSIM3v3)
0	8/3k T g_m	$\frac{Kf\lvert I_{DS}\rvert^{Af}}{f^{Ffc}C_{OX}L^2Eff}$	Spice2G6
1	8/3k T g_m	$\frac{Kf\lvert I_{DS}\rvert^{Af}}{f^{Ffc}C_{OX}W_{EffLEff}}$	Hspice Nlev=1
2	8/3k T g_m	$\frac{Kfg_m^{\ 2}}{f^{Ffc}C_{OX}W_{Eff}L_{Eff}}$	Hspice Nlev=2
3	$\frac{8}{3}kTB\langle V_{GS}-V_T\rangle\frac{1+a+a^2}{1+a}Gdsnoi$ 1 (pinchoff) a=1 - V_{DS}/V_{DSAT} (linear) 0 (saturation)	$\frac{Kfg_m^{\ 2}}{f^{Ffc}C_{OX}W_{Eff}L_{Eff}}$	Hspice Nlev=3

ADS MOS (ADS Root MOS Transistor)

ADS_MOS (ADS_Root MOS Transistor)

Symbol



Parameters

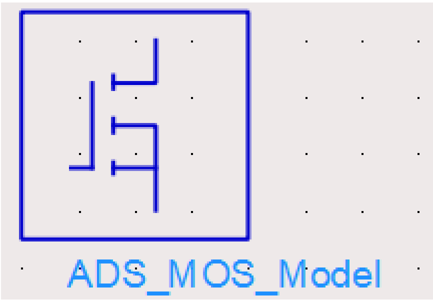
Name	Description	Units	Default
Model	Model instance name	None	ADSMOSM1
Wtot	Total gate width		1.0e-4
N	number of gate fingers	None	1
_M	number of devices in parallel	None	1

- Wtot and N are optional scaling parameters that make it possible to scale the extracted model for different geometries.
- Wtot is the *total* gate width-not the width per finger; N is the number of fingers. Therefore, the width per finger is Wtot / N. The scaling remains valid for ratios up to 5:1.
- The parameters Ggs, Gds, Gmr, dQg_dVgs, and the rest are the small-signal parameters of the device evaluated at the DC operating point. To be displayed, they must be listed among the OUTPUT_VARS in the analysis component.

ADS MOS Model (ADS Root MOS Transistor Model)

ADS_MOS_Model (ADS_Root MOS Transistor Model)

Symbol



Parameters

Name	Description	Units	Default
File	name of rawfile	None	None
Rs	source resistance	None	None
Rg	gate resistance	None	None
Rd	drain resistance	None	None
Ls	source inductance	None	None
Lg	gate inductance	None	None
Ld	drain inductance	None	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

- The values of Rs, Rg, Rd, Ls, Lg, and Ld are meant to override the extracted values stored in the data file named in the File parameter. Generally, these parameters should not be used.
- Because this model is measurement-based, extrapolation warning messages may occur if the Newton iteration exceeds the measurement range. If these messages occur frequently, check that the measurement data is within the simulation range.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via *AllParams*. Set *AllParams* to the DataAccessComponent instance name.
- For a list of ADS Root Model references, refer to ADS_Diode_Model (ADS_Root Diode Model).

ASM HEMT Model (ASM HEMT MOSFET Model and Instance)

ASM HEMT Model (ASM HEMT MOSFET Model and Instance)

This topic lists the model and instance parameters.

NOTE In the current ADS release, this model is not supported in HSpice® formats.

Description

Advanced Spice Model for High Electron Mobility Transistors (ASM-HEMT) was developed by researchers at University of California, Berkeley, Indian Institute of Technology Kanpur, and Macquarie University.[1] Copyright Macquarie University and Indian Institute of Technology Kanpur. It is a Compact Model Coalition (CMC) standard.[2]

ASM-HEMT models GaN power devices. It is based on surface potential based. It is an analytical model and therefore computationally efficient. It includes velocity saturation, access region resistance, DIBL, temperature dependence, and gate current/noise effects.

Version: 101.0.0

References

[1] Dasgupta, Avirup & Ghosh, Sudip & Khandelwal, Sourabh & Chauhan, Yogesh. “ASM-HEMT: Compact model for GaN HEMTs” IEEE Conference on Electron Devices and Solid-State Circuits (EDSSC), 2015, Singapore DOI: 10.1109/EDSSC.2015.7285159 https://www.researchgate.net/publication/275045749_ASM-HEMT_Compact_model_for_GaN_HEMTs

[2] http://projects.si2.org/cmc_index.php

Process Parameters

Parameters	Units	Default	Description
TNOM	C	27.0	Nominal Temperature in degree Celsius
TBAR	*m*	2.5e-8	Thickness of the AlGaN Layer
L	*m*	0.25e-6	Designed Gate Length

Parameters	Units	Default	Description
W	*m*	200e-6	Designed Gate Width
NF	-	1	Number of fingers(Integer)
LSG	*m*	1e-6	Length of Source-Gate Access Region
LDG	*m*	1e-6	Length of Drain-Gate Access Region
EPSILON	*F /m*	10.66e-11	Dielectric permittivity of AlGaN layer
GAMMA0I	-	2.12e-12	Schrödinger-Poisson solution variable
GAMMA1I	-	3.73e-12	Schrödinger-Poisson solution variable

Model Controllers

Parameters	Units	Default	Description
RDSMOD	-	1	Selects Access region Resistance Model; 0-simplified, 1-more accurate
GATEMOD	-	0	Model to turn OFF/ON the gate cur- rent model;0 to turn off,1 to turn on the model
SHMOD	-	1	Self Heating Model Controller; 0-Turns OFF Self Heating Model 1-Turns ON Self Heating Model
TRAPMOD	-	0	Selects Trap Model;0-Turns off the model; 1-turns on RF trap model; 2-turns on pulsed IV trap model; 3-turns on basic trap model
FNMOD	-	0	Selects Flicker noise Model; 0-Turns off the model 1 to turn on
TNMOD	-	0	Selects Thermal noise Model; 0-Turns off the model 1 to turn on
FP1MOD	-	0	Field Plate 1 Model Selector; 0- No Field Plate; 1- Gate Field Plate; 2-Source Field Plate
FP2MOD	-	0	Field Plate 2 Model Selector; 0- No Field Plate; 1- Gate Field Plate; 2-Source Field Plate

Parameters	Units	Default	Description
FP3MOD	-	0	Field Plate 3 Model Selector; 0- No Field Plate; 1- Gate Field Plate; 2- Source Field Plate
FP4MOD	-	0	Field Plate 4 Model Selector; 0- No Field Plate; 1- Gate Field Plate; 2- Source Field Plate
RGATEMOD	-	1	Switch to turn on/off gate Resistance; 0-Turns off the resistance 1 to turn on

Basic Model Parameters

Parameters	Units	Default	Description
VOFF	V	-2.0	Cut-off Voltage
U0	$m2 /V - s$	170e-3	Low field mobility
UA	V^{-1}	0e-9	Mobility Degradation Coefficient
UB	V^{-2}	0e-18	Second Order Mobility Degradation Coefficient
VSAT	m/s	1.9e5	Saturation Velocity
DELTA	-	2	Exponent of Vdeff
LAMBDA	V^{-1}	0	Channel Length Modulation Coefficient
ETA0	-	0e-3	DIBL Parameter
VDSCALE	V	5	DIBL Scaling VDS
THESAT	V^{-2}	1	Velocity Saturation Parameter
NFACTOR	-	0.5	Sub-VOFF Slope parameters

Parameters	Units	Default	Description
CDSCD	-	1e-3	Sub-VOFF Slope Change due to Drain Voltage
IMIN	*A*	1e-15	Minimum Drain Current
GDSMIN	*S*	1e-12	Minimum conductance parameter for Current Convergence

Access Region Resistance Model Parameters

Parameters	Units	Default	Description
VSATACCS	cm/s	50e3	Saturation Velocity for access region
NS0ACCS	$C/m{-}2$	5e17	2-DEG Charge Density per square me- ter in Source Access Region
NS0ACCD	$C/m{-}2$	5e17	2-DEG Charge Density per square me- ter in Drain Access Region
K0ACCS	-	0	Dependence of access region charge at source side on gate voltage
K0ACCD	-	0	Dependence of access region charge at drain side on gate voltage
U0ACCS	$m2\ /V-s$	155e-3	Source Side Access Region Mobility
U0ACCD	$m2\ /V-s$	155e-3	Drain Side Access Region Mobility
MEXPACCS	-	2	Exponent for Source side Access Region Resistance Model
MEXPACCD	-	2	Exponent for Drain side Access Region Resistance Model
RSC	$Ohm-m$	1e-4	Source Contact Resistance
RDC	$Ohm-m$	1e-4	Drain Contact Resistance

Gate Current Model Parameters

Parameters	Units	Default	Description
IGSDIO	$A/m{-}2$	1.0	Gate-source junction diode saturation current
NJGS	-	2.5	Gate-source junction diode current ideality factor
IGDDIO	$A/m{-}2$	-	Gate-drain junction diode saturation current
NJGD	-	2.5	Gate-drain junction diode current ideality factor
KTGS	-	0.0	Temperature co-efficient of gate-source junction diode current
KTGD	-	0.0	Temperature coefficient of gate-drain junction diode current

Trap Model Parameters

Parameters	Units	Default	Description
RTRAP3	*Ohm*	1.0	Trap Network Resistance
CTRAP3	*F*	1.0e-4	Trap Network Capacitance
VATRAP	-	10	Division Factor for V(trap1)
VDLR1	-	2	Slope for Region1
VDLR2	-	20	Slope for Region2
WD	-	0.016	Weak dependence of VDLR1 on *Vdg*
VTB	-	250	Break Point for *Vdg* Effect on *Von*
DELTAX	*m*	50	Smoothing Constant
CDLAG	-	5e-9	Trap Network Capacitance
RDLAG	-	10	Trap Network Resistance

Parameters	Units	Default	Description
IDIO	A	1e0	Saturation current parameter when TRAPMOD=1
ATRAPVOFF	-	0.1	*Vof f* change due to trapping effects
BTRAPVOFF	-	0.3	Vof f change proportional to input power due to trapping effects
ATRAPETA0	-	0	*ET A*0 change due to trapping effects
BTRAPETA0	-	0.05	ET A0 change proportional to input power due to trapping effects
ATRAPRS	-	0.1	*RS* change due to trapping effects
BTRAPRS	-	0.6	*RS* change proportional to input power due to trapping effects
ATRAPRD	-	0.5	*RD* change due to trapping effects
BTRAPRD	-	0.6	*RD* change proportional to input power due to trapping effects
RTRAP1	*Ohm*	1	Trap network resistance
RTRAP2	*Ohm*	1	Trap network resistance
CTRAP1	*F*	10e-6	Trap network capacitance
CTRAP2	*F*	1e-6	Trap network capacitance
A1	-	0.1	Trap contribution to *VOF F* (1st net- work)
VOFFTR	-	0.01	Trap contribution to *VOF F* (2nd net- work)
CDSCDTR	-	0.01	Trap contribution to CDSCD (2nd net- work)
ETA0TR	-	0.01	Trap contribution to DIBL (2nd net- work)
RONTR1	-	0.01	Trap contribution to *Ron* (1st network)
RONTR2	-	0.01	Trap contribution to *Ron* (2nd network)

Parameters	Units	Default	Description
RONTR3	-	0.01	Bias independent trap contribution to *Ron*

Field Plate Model Parameters

Parameters	Units	Default	Description
IMINFP1	*A*	1.0e-15	Minimum Drain Current FP1 region
VOFFFP1	*V*	-25.0	VOFF for FP1
DFP1	*m*	50.0e-9	Distance of FP1 from 2-DEG Charge
LFP1	*m*	1.0e-6	Length of FP1
KTFP1	-	50.0e-3	Temperature Dependence for VOFFFP1
U0FP1	*m2 /V – s*	100.0e-3	FP1 region mobility
VSATFP1	*m/s*	100.0e3	Saturation Velocity of FP1 region
NFACTORFP1	-	0.5	Sub-VOFF Slope parameters
CDSCDFP1	-	0	Sub-VOFF Slope Change due to Drain Voltage
ETA0FP1	-	1.0e-9	DIBL Parameter
VDSCALEFP1	*V*	10.0	DIBL Scaling VDS
GAMMA0FP1	-	2.12e-12	Schrodinger-Poisson solution variable
GAMMA1FP1	-	3.73e-12	Schrodinger-Poisson solution variable
IMINFP2	*A*	1.0e-15	Minimum Drain Current FP2 region
VOFFFP2	*V*	-50.0	VOFF for FP2

Parameters	Units	Default	Description
DFP2	*m*	100.0e-9	Distance of FP2 from 2-DEG Charge
LFP2	*m*	1.0e-6	Length of FP2
KTFP2	-	50.0e-3	Temperature Dependence for VOFFFP2
U0FP2	*m2 ⁄V − s*	100.0e-3	FP2 region mobility
VSATFP2	*m/s*	100.0e3	Saturation Velocity of FP2 region
NFACTORFP2	-	0.5	Sub-VOFF Slope parameters
CDSCDFP2	-	0	Sub-VOFF Slope Change due to Drain Voltage
ETA0FP2	-	1.0e-9	DIBL Parameter
VDSCALEFP2	*V*	10.0	DIBL Scaling VDS
GAMMA0FP2	-	2.12e-12	Schrodinger-Poisson solution variable
GAMMA1FP2	-	3.73e-12	Schrodinger-Poisson solution variable
IMINFP3	*A*	1.0e-15	Minimum Drain Current FP3 region
VOFFFP3	*V*	-75.0	VOFF for FP3
DFP3	*m*	150.0e-9	Distance of FP3 from 2-DEG Charge
LFP3	*m*	1.0e-6	Length of FP3
KTFP3	-	50.0e-3	Temperature Dependence for VOFFFP3
U0FP3	*m2 ⁄V − s*	100.0e-3	FP3 region mobility
VSATFP3	*m/s*	100.0e3	Saturation Velocity of FP3 region

Parameters	Units	Default	Description
NFACTORFP3	-	0.5	Sub-VOFF Slope parameters
CDSCDFP3	-	0	Sub-VOFF Slope Change due to Drain Voltage
ETA0FP3	-	1.0e-9	DIBL Parameter
VDSCALEFP3	*V*	10.0	DIBL Scaling VDS
GAMMA0FP3	-	2.12e-12	Schrodinger-Poisson solution variable
GAMMA1FP3	-	3.73e-12	Schrodinger-Poisson solution variable
IMINFP4	*A*	1.0e-15	Minimum Drain Current FP4 region
VOFFFP4	*V*	-100.0	VOFF for FP4
DFP4	*m*	200.0e-9	Distance of FP4 from 2-DEG Charge
LFP4	*m*	1.0e-6	Length of FP4
KTFP4	-	50.0e-3	Temperature Dependence for VOFFFP4
U0FP4	$m2 / V - s$	100.0e-3	FP4 region mobility
VSATFP4	*m/s*	100.0e3	Saturation Velocity of FP4 region
NFACTORFP4	-	0.5	Sub-VOFF Slope parameters
CDSCDFP4	-	0	Sub-VOFF Slope Change due to Drain Voltage
ETA0FP4	-	1.0e-9	DIBL Parameter
VDSCALEFP4	*V*	10.0	DIBL Scaling VDS
GAMMA0FP4	-	2.12e-12	Schrodinger-Poisson solution variable

Parameters	Units	Default	Description
GAMMA1FP4	-	3.73e-12	Schrodinger-Poisson solution variable

Capacitance Parameters

Parameters	Units	Default	Description
CGSO	*F*	1e-18	Gate-Source overlap capacitance pa- rameter
CGDO	*F*	1e-18	Gate-Drain overlap capacitance param- eter
CDSO	*F*	1e-18	Drain-Source capacitance parameter
CGDL	*F*	0e-15	Parameter for bias *Vds* dependence in CGDO
VDSATCV	*V*	100	Saturation voltage at drain side in CV model
CBDO	*F*	0e-15	Substrate capacitance parameter
CBSO	*F*	0e-15	Substrate capacitance parameter
CBGO	*F*	0e-15	Substrate capacitance parameter
CFG	*F*	0e-18	Gate fringing capacitance parameter
CFD	*F*	0e-12	Drain fringing capacitance parameter
CFGD	*F*	0e-13	Fringing capacitance parameter
CFGDSM	*F*	1.0e-24	Capacitance smoothing parameter
CFGD0	*F*	0e-12	Fringing capacitance parameter
CJ0	*F*	0e-12	Zero *Vds* access region capacitance pa- rameter
VBI	*V*	0.9	Drain end built-in potential parameter
MZ	-	0.5	Parameter governing decay of *Caccd* for high *Vds*

Parameters	Units	Default	Description
AJ	-	115e-3	Parameter for governing bias independent value of *Cds* at low *Vds*
DJ	-	1	Parameter governing decay of *Caccd* for high *Vds*

Quantum Mechanical Effects

Parameters	Units	Default	Description
ADOSI	-	0	Quantum mechanical effect prefactor cum switch in inversion
BDOSI	-	1	Charge centroid parameter - slope of CV curve under QME in inversion
QM0I	-	1e-3	Charge centroid parameter - starting point for QME in inversion
ADOSFP1	-	0	Quantum mechanical effect pre-factor cum switch in inversion
BDOSFP1	-	1	Charge centroid parameter - slope of CV curve under QME in inversion
QM0FP1	-	1.0e-3	Charge centroid parameter - starting point for QME in inversion
ADOSFP2	-	0	Quantum mechanical effect prefactor cum switch in inversion
BDOSFP2	-	1	Charge centroid parameter - slope of CV curve under QME in inversion
QM0FP2	-	1.0e-3	Charge centroid parameter - starting point for QME in inversion
ADOSFP3	-	0	Quantum mechanical effect pre-factor cum switch in inversion
BDOSFP3	-	1	Charge centroid parameter - slope of CV curve under QME in inversion
QM0FP3	-	1.0e-3	Charge centroid parameter - starting point for QME in inversion
ADOSFP4	-	0	Quantum mechanical effect pre-factor cum switch in inversion
BDOSFP4	-	1	Charge centroid parameter - slope of CV curve under QME in inversion
QM0FP4	-	1.0e-3	Charge centroid parameter -starting point for QME in inversion

Cross Coupling Capacitance Parameters

Parameters	Units	Default	Description
CFP1SCALE	-	0	Coupling of charge under FP1
CFP2SCALE	-	0	Coupling of charge under FP2
CFP3SCALE	-	0	Coupling of charge under FP3
CFP4SCALE	-	0	Coupling of charge under FP4
CSUBSCALEI	-	0	Sub Capacitance scaling parameter
CSUBSCALE1	-	0	Sub Capacitance scaling parameter
CSUBSCALE2	-	0	Sub Capacitance scaling parameter
CSUBSCALE3	-	0	Sub Capacitance scaling parameter
CSUBSCALE4	-	0	Sub Capacitance scaling parameter

Gate Resistance Parameters

Parameters	Units	Default	Description
XGW	-	0	Dist from gate contact center to device edge
NGCON	-	1	Number of gate contacts
RSHG	Ω/square	0.1	Gate sheet resistance

Noise Model Parameters

Parameters	Units	Default	Description
NOIA	-	-1.5e29	Flicker Noise parameter

Parameters	Units	Default	Description
NOIB	-	1e32	Flicker Noise parameter
NOIC	-	0.55e34	Flicker Noise parameter
EF	-	1	Exponent of frequency; Determines slope in log plot
TNSC	-	1	Thermal noise scaling parameter

Temperature Dependent and Self-Heating Parameters

Parameters	Units	Default	Description
AT	-	0	Temperature Dependence for saturation velocity
UTE	-	-0.5	Temperature dependence of mobility
KT1	-	0e-3	Temperature Dependence for Voff
KNS0	-	0	Temperature Dependence for 2-DEG charge density at access region
ATS	-	0	Temperature Dependence for saturation velocity at access region
UTES	-	0	Temperature dependence of mobility at access region: Source Side
UTED	-	0	Temperature dependence of mobility at access region: Drain Side
KRSC	-	0	Temperature dependence of Source Contact Resistance for RDSMOD2
KRDC	-	0	Temperature dependence of Drain Contact Resistance for RDSMOD2
KTVBI	-	0	Temperature Dependence for VBI
KTCFG	-	0e-3	Temperature Dependence for Gate fringing capacitance
KTCFGD	-	0e-3	Temperature Dependence for fringing capacitance
RTH0	*Ohm*	5	Thermal Resistance

Parameters	Units	Default	Description
CTH0	*F*	1e-9	Thermal Capacitance
TALPHA	-	-2	Temperature exponent of Rtrap

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelname asmhemt_1_0_1 [parm=value]\*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *asmhemt_1_0_1*. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example

```
model gan1 asmhemt_1_0_1 l=0.35e-6 w=205.0e-6
```

Instance Parameters

Parameters	Units	Default	Description
l	M	0.25e-6	Channel Length
w	M	200.0e-6	Channel Width
nf	-	1	Number of fingers
dfp1	M	50.0e-3	Distance of FP1 from 2-DEG charge
lfp1	M	1.0e-6	Length of FP1

Parameters	Units	Default	Description
dfp2	M	100.0e-9	Distance of FP2 from 2-DEG charge
lfp2	M	1.0e-6	Length of FP2
dfp3	M	150.0e-9	Distance of FP3 from 2-DEG charge
lfp3	M	1.0e-6	Length of FP3
dfp4	M	200.0e-9	Distance of FP4 from 2-DEG charge
lfp4	M	1.0e-6	Length of FP4
ngcon	-	1	Number of gate contacts

DC Operating Point Information

The following table lists the DC operating point parameters that can be sent to the dataset.

Name	Description	Units
idisi	Drain-to-source current	A
vdisi	Drain-to-source voltage	V
vgisi	Gate-to-source voltage	V
gmi	Transconductance	S
gdsi	Output conductance	S
gmbi	Bulk-bias transconductance	S
igs	Gate-source IGS current	A
igd	Gate-drain IGD current	A
qgi	Intrinsic gate charge	C

Name	Description	Units
qdi	Intrinsic drain charge	C
qsi	Intrinsic source charge	C
qbi	Intrinsic bulk charge	C
cggi	Intrinsic gate capacitance	F
cgsi	Intrinsic gate-source transcapacitance	F
cgdi	Intrinsic gate-drain transcapacitance	F
cgbi	Intrinsic gate-bulk transcapacitance	F
cddi	Intrinsic drain capacitance	F
cdgi	Intrinsic drain-gate transcapacitance	F
cdsi	Intrinsic drain-source transcapacitance	F
cdbi	Intrinsic drain-bulk transcapacitance	F
cssi	Intrinsic source capacitance	F
csgi	Intrinsic source-gate transcapacitance	F
csdi	Intrinsic source-drain transcapacitance	F
csbi	Intrinsic source-bulk transcapacitance	F
cbbi	Intrinsic bulk capacitance	F
cbsi	Intrinsic bulk-source transcapacitance	F
cbdi	Intrinsic bulk-drain transcapacitance	F
cbgi	Intrinsic bulk-gate transcapacitance	F

Name	Description	Units
t_total_k	Total device temperature	K
t_total_c	Total device temperature	C
t_delta_sh	Temperature change due to self-heating	K
rd	Drain resistance	Ohms
rs	Source resistance	Ohms
cgs	Gate-source transcapacitance	F
cgd	Gate-drain transcapacitance	F

- DC operating point data is generated for this model. If a DC simulation is performed, device operating point data can be viewed for a component. The procedure for viewing device operating point data for a component is in Using Circuit Simulators.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to DataAccessComponent (Data Access Component)). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.

BSIM Model

BSIM Model

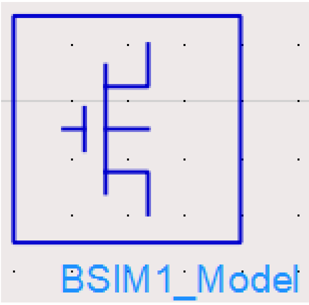
This section describes the following versions of BSIM model.

- BSIM1 Model (BSIM1 MOSFET Model)
- BSIM2 Model (BSIM2 MOSFET Model)
- BSIM3 Model (BSIM3 MOSFET Model)
- BSIM4 Model (BSIM4 MOSFET Model)
- BSIM4 NMOS, BSIM4 PMOS (BSIM4 Transistor, NMOS, PMOS)
- BSIM6 Model (BSIM6 MOSFET Model and Instance)
- BSIM-BULK Model (BSIM-BULK MOSFET Model and Instance)

BSIM1 Model (BSIM1 MOSFET Model)

BSIM1_Model (BSIM1 MOSFET Model)

Symbol



Parameters

Name	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Idsmod	Ids model: 1=LEVEL1 2=LEVEL2 3=LEVEL3 4=BSIM1 5=BSIM2 6=NMOD 8=BSIM3	None	4
Rsh	drain and source diffusion sheet resistance	Ohm/sq	0.0
Js	Gate Saturation Current	A	0.0
Temp	parameter measurement temperature	°C	25
Trise	Temperature rise over ambient	°C	None
Muz	Surface Mobility at VDS=0 VGS=VTH	$cm^2/(V \times s)$	600
Dl	shortening of channel	um	0.0

Name	Description	Units	Default
Dw	narrowing of channel	um	0.0
Vdd	measurement drain bias range	V	5.0
Vfb	flat-band voltage	V	-0.3
Lvfb	Length Dependence of Vfb	um×V	0.0
Wvfb	Width Dependence of Vfb	um×V	0.0
Phi	surface potential at strong inversion	V	0.6
Lphi	Length Dependence of Phi	um×V	0.0
Wphi	Width Dependence of Phi	um×V	0.0
K1	body effect coefficient	$V^{(1/2)}$	0.5
Lk1	Length Dependence of K1	um×$V^{(1/2)}$	0.0
Wk1	Width Dependence of K1	um×$V^{(1/2)}$	0.0
K2	drain-source depletion charge sharing coefficient	None	0.0
Lk2	Length Dependence of K2	um	0.0
Wk2	Width Dependence of K2	um	0.0
Eta	Zero-Bias Drain-Induced Barrier Lowering Coefficient	None	0.0
Leta	Length Dependence of Eta	um	0.0
Weta	Width Dependence of Eta	um	0.0
U0	transverse field mobility degradation coefficient	1/V	670.0
Lu0	Length Dependence of U0	um/V	0.0

Name	Description	Units	Default
Wu0	Width Dependence of U0	um/V	0.0
U1	zero-bias velocity saturation coefficient	um/V	0.0
Lu1	Length Dependence of U1	um^2 /V	0.0
Wu1	Width Dependence of U1	um^2/V	0.0
X2mz	sensitivity of mobility to substrate bias	cm^2/ (V^2×s)	0.0
Lx2mz	Length Dependence of X2mz	um×cm^2/ (V^2×s)	0.0
Wx2mz	Width Dependence of X2mz	um×cm^2/ (V^2×s)	0.0
X2e	Sensitivity of of Eta to Substrate Bias	1/V	-0.07
Lx2e	Length Dependence of X2e	um/V	0.0
Wx2e	Width Dependence of X2e	um/V	0.0
X3e	Sensitivity of of Eta to Drain Bias	1/V	0.0
Lx3e	Length Dependence of X3e	um/V	0.0
Wx3e	Width Dependence of X3e	um/V	0.0
X2u0	Sensitivity of U0 to Substrate Bias	1/V^2	0.0
Lx2u0	Length Dependence of X2u0	um/V^2	0.0
Wx2u0	Width Dependence of X2u0	um/V^2	0.0
X2u1	Sensitivity of U1 to Substrate Bias	um/V^2	0.0

Name	Description	Units	Default
Lx2u1	Length Dependence of X2u1	um^2/V^2	0.0
Wx2u1	Width Dependence of X2u1	um^2/V^2	0.0
X3u1	Sensitivity of U1 to Drain Bias	um/V^2	0.0
Lx3u1	Length Dependence of X3u1	um^2/V^2	0.0
Wx3u1	Width Dependence of X3u1	um^2/V^2	0.0
Mus	Mobility at VDS=VDD VGS=VTH	$cm^2/(V \times s)$	600.0
Lmus	Length Dependence of Mus	$um \times cm^2 / (V \times s)$	0.0
Wmus	Width Dependence of Mus	$um \times cm^2/(V \times s)$	0.0
X2ms	Sensitivity of Mus to Substrate Bias	$cm^2/(V^2 \times s)$	0.0
Lx2ms	Length Dependence of X2ms	$um \times cm^2/(V^2 \times s)$	0.0
Wx2ms	Width Dependence of X2ms	$um \times cm^2/(V^2 \times s)$	0.0
X3ms	Sensitivity of Mus to Drain Bias	$cm^2/(V^2 \times s)$	0.0
Lx3ms	Length Dependence of X3ms	$um \times cm^2/(V^2 \times s)$	0.0
Wx3ms	Width Dependence of X3ms	$um \times cm^2/(V^2 \times s)$	0.0

Name	Description	Units	Default
N0	Zero-Bias Subthreshold Slope Coefficient	None	None
Ln0	Length Dependence of N0	um	0.0
Wn0	Width Dependence of N0	um	0.0
Nb	Sens. of N0 to Substrate Bias	1/V	0.0
Lnb	Length Dependence of N0	um/V	0.0
Wnb	Width Dependence of N0	um/V	0.0
Nd	Sens. of N0 to Drain Bias	1/V	0.0
Lnd	Length Dependence of N0	um/V	0.0
Wnd	Width Dependence of N0	um/V	0.0
Tox	oxide thickness	um	0.02
Cj	Zero-bias Bulk Junction Capacitance	F/m	0.0
Mj	Junction grading coefficient	None	0.5
Cjsw	Zero-bias Bulk Junction Sidewall Cap	F/m	0.0
Mjsw	Junction Sidewall grading coefficient	None	1/3
Pb	Bulk Junction Potential	V	0.8
Pbsw	Bulk Side Junction Potential	V	1.0
Cgso	gate-source overlap capacitance, per channel width	F/m	0.0
Cgdo	gate-drain overlap capacitance, per channel width	F/m	0.0
Cgbo	gate-bulk overlap capacitance, per channel width	F/m	0.0

Name	Description	Units	Default
Xpart	coefficient of channel charge share	None	1.0
Nlev	Noise model level	None	-1
Gdwnoi	Drain noise parameters for Nlev=3	None	1
Kf	flicker noise coefficient	None	0.0
Af	flicker noise exponent	None	1.0
Ffe	flicker noise frequency exponent	None	1.0
Rg	gate resistance	Ohm	fixed at 0
N	bulk P-N emission coefficient	None	1.0
Imax	explosion current	A	10.0
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 3)	A	defaults to Imax
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvg	gate oxide breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
Acm	Area Calculation Method	None	0
Hdif	Length of heavily doped diffusion (ACM=2,3 only)	m	0.0
Ldif	Length of lightly doped diffusion adjacent to gate (ACM=1,2 only)	m	0.0

Name	Description	Units	Default
Wmlt	Width diffusion layer shrink reduction factor	None	1.0
Lmlt	Gate length shrink factor	None	1.0
Xw	Accounts for masking and etching effects	m	0.0
Rdc	Additional drain resistance due to contact resistance	Ohm	0.0
Rsc	Additional source resistance due to contact resistance	Ohm	0.0
AllParams	DataAccessComponent-based parameters	None	None

- BSIM1, BSIM2, and BSIM3 MOSFET models use the same parameters and parameter definitions as the BSIM models in SPICE3 (University of California-Berkeley).
- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname MOSFET Idsmod=4 [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *MOSFET*. Idsmod=4 is a required parameter that is used to tell the simulator to use the BSIM1 equations. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

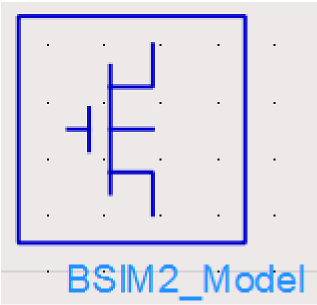
Example

```
model Nch4 MOSFET Idsmod=4 \
Vfb=-0.9 Muz=500 NMOS=yes
```

BSIM2 Model (BSIM2 MOSFET Model)

BSIM2_Model (BSIM2 MOSFET Model)

Symbol



Parameters

Name	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Idsmod	Ids model: 1=LEVEL1 2=LEVEL2 3=LEVEL3 4=BSIM1 5=BSIM2 6=NMOD 8=BSIM3	None	5
Rsh	drain and source diffusion sheet resistance	Ohm/sq	0.0
Js	Gate Saturation Current	A/m^2	0.0
Mu0	Surface Mobility at VDS=0 VGS=VTH	$cm^2/(V \times s)$	600
Dl	shortening of channel	um	0.0
Dw	narrowing of channel	um	0.0
Vdd	Measurement Drain Bias Range	V	5.0

Name	Description	Units	Default
Vgg	Measurement Gate Bias Range	V	5.0
Vbb	Measurement Bulk Bias Range	V	-5.0
Temp	parameter measurement temperature	°C	25
Trise	Temperature rise over ambient	°C	None
Tox	oxide thickness	um	0.02
Cj	Zero-bias Bulk Junction Capacitance	F/m^2	0.0
Mj	Junction grading coefficient	None	0.5
Cjsw	Zero-bias Bulk Junction Sidewall Cap	F/m	0.0
Mjsw	Junction Sidewall grading coefficient	None	1/3
Pb	Bulk Junction Potential	V	0.8
Pbsw	Bulk Side Junction Potential	V	1.0
Cgso	gate-source overlap capacitance, per channel width	F/m	0.0
Cgdo	gate-drain overlap capacitance, per channel width	F/m	0.0
Cgbo	gate-bulk overlap capacitance, per channel width	F/m	0.0
Xpart	coefficient of channel charge share	None	1.0
Vfb	flat-band voltage	V	-0.3
Lvfb	Length Dependence of Vfb	um×V	0.0
Wvfb	Width Dependence of Vfb	um×V	0.0
Phi	surface potential at strong inversion	V	0.6

Name	Description	Units	Default
Lphi	Length Dependence of Phi	um×V	0.0
Wphi	Width Dependence of Phi	um×V	0.0
K1	body effect coefficient	$V^{(1/2)}$	0.5
Lk1	Length Dependence of K1	um×$V^{(1/2)}$	0.0
Wk1	Width Dependence of K1	um×$V^{(1/2)}$	0.0
K2	drain-source depletion charge sharing coefficient	None	0.0
Lk2	Length Dependence of K2	um	0.0
Wk2	Width Dependence of K2	um	0.0
Eta0	Zero-Bias Drain-Induced Barrier Lowering Coefficient	None	0.08
Leta0	Length Dependence of Eta	um	0.0
Weta0	Width Dependence of Eta	um	0.0
Ua0	transverse field mobility degradation coefficient	1/V	670.0
Lua0	Length Dependence of Ua0	um/V	0.0
Wua0	Width Dependence of Ua0	um/V	0.0
U10	zero-bias velocity saturation coefficient	um/V	0.0
Lu10	Length Dependence of U10	um^2/V	0.0
Wu10	Width Dependence of U10	um^2/V	0.0
Mu0b	sensitivity of mobility to substrate bias	$cm^2/(V^2 \times s)$	0.0

Name	Description	Units	Default
Lmu0b	Length Dependence of X2mz	um×cm^2/(V^2×s)	0.0
Wmu0b	Width Dependence of X2mz	um×cm^2/(V^2×s)	0.0
Etab	Sensitivity of of Eta to Substrate Bias	1/V	-0.07
Letab	Length Dependence of X2e	um/V	0.0
Wetab	Width Dependence of X2e	um/V	0.0
Uab	Sensitivity of Ua0 to Substrate Bias	1/V^2	0.0
Luab	Length Dependence of Uab	um/V^2	0.0
Wuab	Width Dependence of Uab	um/V^2	0.0
U1b	Sensitivity of U1 to Substrate Bias	um/V^2	0.0
Lu1b	Length Dependence of U1b	um^2/V^2	0.0
Wu1b	Width Dependence of U1b	um^2/V^2	0.0
U1d	Sensitivity of U1 to Drain Bias	um/V^2	0.0
Lu1d	Length Dependence of U1d	um^2/V^2	0.0
Wu1d	Width Dependence of U1d	um^2/V^2	0.0
Mus0	Mobility at VDS=VDD VGS=VTH	cm^2/(V×s)	600.0
Lmus0	Length Dependence of Mus0	um×cm^2/(V×s)	0.0

Name	Description	Units	Default
Wmus0	Width Dependence of Mus0	um×cm^2/(V×s)	0.0
Musb	Sensitivity of Mus to Substrate Bias	cm^2/(V^2×s)	0.0
Lmusb	Length Dependence of Musb	um×cm^2/(V^2×s)	0.0
Wmusb	Width Dependence of Musb	um×cm^2/(V^2×s)	0.0
N0	Zero-Bias Subthreshold Slope Coefficient	None	None
Ln0	Length Dependence of N0	um	0.0
Wn0	Width Dependence of N0	um	0.0
Nb	Sens. of N0 to Substrate Bias	1/V	None
Lnb	Length Dependence of N0	um/V	0.0
Wnb	Width Dependence of N0	um/V	0.0
Nd	Sens. of N0 to Drain Bias	1/V	None
Lnd	Length Dependence of N0	um/V	0.0
Wnd	Width Dependence of N0	um/V	0.0
Mu20	Empirical Parameter in Beta0 Expression	None	None
Lmu20	Length Dependence of Mu20	um	0.0
Wmu20	Width Dependence of Mu20	um	0.0
Mu2b	Sens. of Mu20 to Substrate Bias	1/V	None

Name	Description	Units	Default
Lmu2b	Length Dependence of Mu2b	um/V	0.0
Wmu2b	Width Dependence of Mu2b	um/V	0.0
Mu2g	Sens. of Mu20 to Gate Bias	1/V	None
Lmu2g	Length Dependence of Mu2g	um/V	0.0
Wmu2g	Width Dependence of Mu2g	um/V	0.0
Mu30	Linear Empirical Parameter in Beta0 Expression	$cm^2/(V^2 \times s)$	None
Lmu30	Length Dependence of Mu30	$um \times cm^2/(V^2 \times s)$	0.0
Wmu30	Width Dependence of Mu30	$um \times cm^2/(V^2 \times s)$	0.0
Mu3g	Sens. of Mu3 to Gate Bias	$cm^2/(V^3 \times s)$	0.0
Lmu3g	Length Dependence of Mu3g	$um \times cm^2/(V^3 \times s)$	0.0
Wmu3g	Width Dependence of Mu3g	$um \times cm^2/(V^3 \times s)$	0.0
Mu40	Quadratic Empirical Parameter in Beta0 Expression	$cm^2/(V^3 \times s)$	0.0
Lmu40	Length Dependence of Mu40	$um \times cm^2/(V^3 \times s)$	0.0
Wmu40	Width Dependence of Mu40	$um \times cm^2/(V^3 \times s)$	0.0

Name	Description	Units	Default
Mu4b	Sens. of Mu4 to Substrate Bias	cm^2/ (V^4×s)	0.0
Lmu4b	Length Dependence of Mu4b	um×cm^2/ (V^4×s)	0.0
Wmu4b	Width Dependence of Mu4b	um×cm^2/ (V^4×s)	0.0
Mu4g	Sens. of Mu4 to Gate Bias	cm^2/ (V^4×s)	0.0
Lmu4g	Length Dependence of Mu4g	um×cm^2/ (V^4×s)	0.0
Wmu4g	Width Dependence of Mu4g	um×cm^2/ (V^4×s)	0.0
Ub0	Mobility Reduction to Vertical Field at Vbs=0	1/V^2	None
Lub0	Length Dependence of Ub0	um/V^2	0.0
Wub0	Width Dependence of Ub0	um/V^2	0.0
Ubb	Sens. of Ub to Substrate Bias	1/V^3	None
Lubb	Length Dependence of Ubb	um/V^3	0.0
Wubb	Width Dependence of Ubb	um/V^3	0.0
Vof0	Threshold Voltage Offset in the Subthreshold Region	V	0.0
Lvof0	Length Dependence of Vof0	um×V	0.0
Wvof0	Width Dependence ofVof0	um×V	0.0

Name	Description	Units	Default
Vob	Sens. of Vof to Substrate Bias	None	0.0
Lvob	Length Dependence of Vob	um	0.0
Wvob	Width Dependence of Vob	um	0.0
Vofd	Sens. of Vof to Substrate Bias	None	0.0
Lvofd	Length Dependence of Vofd	um	0.0
Wvofd	Width Dependence of Vofd	um	0.0
Ai0	Hot-Electron-Induced Rout Degradation Coeff.	None	0.0
Lai0	Length Dependence of Ai0	um	0.0
Wai0	Width Dependence of Ai0	um	0.0
Aib	Sens. of Ai to Substrate Bias	1/V	0.0
Laib	Length Dependence of Aib	um/V	0.0
Waib	Width Dependence of Aib	um/V	0.0
Bi0	Exponential Parameter of Rout Degradation	V	0.0
Lbi0	Length Dependence of Bi0	um×V	0.0
Wbi0	Width Dependence of Bi0	um×V	0.0
Bib	Sens. of Bi to Substrate Bias	None	0.0
Lbib	Length Dependence of Bib	um	0.0
Wbib	Width Dependence of Bib	um	0.0
Vghigh	Upper Bound for the Transition Region	V	0.15

Name	Description	Units	Default
Lvghigh	Length Dependence of Vghigh	um×V	0.0
Wvghigh	Width Dependence of Vghigh	um×V	0.0
Vglow	Upper Bound for the Transition Region	V	-0.15
Lvglow	Length Dependence of Vglow	um×V	0.0
Wvglow	Width Dependence of Vglow	um×V	0.0
Nlev	Noise model level	None	-1
Gdwnoi	Drain noise parameters for Nlev=3	None	1
Kf	flicker noise coefficient	None	0.0
Af	flicker noise exponent	None	1.0
Ffe	flicker noise frequency exponent	None	1.0
Rg	gate resistance	Ohm	fixed at 0
N	bulk P-N emission coefficient	None	1.0
Imax	explosion current	A	10.0
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 3)	A	defaults to Imax
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvg	gate oxide breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None

Name	Description	Units	Default
wPmax	maximum power dissipation (warning)	W	None
Acm	Area Calculation Method	None	0
Hdif	Length of heavily doped diffusion (ACM=2,3 only)	m	0.0
Ldif	Length of lightly doped diffusion adjacent to gate (ACM=1,2 only)	m	0.0
Wmlt	Width diffusion layer shrink reduction factor	None	1.0
Lmlt	Gate length shrink factor	None	1.0
Xw	Accounts for masking and etching effects	m	0.0
Rdc	Additional drain resistance due to contact resistance	Ohm	0.0
Rsc	Additional source resistance due to contact resistance	Ohm	0.0
AllParams	DataAccessComponent-based parameters	None	None

- BSIM1, BSIM2, and BSIM3 MOSFET models use the same parameters and parameter definitions as the BSIM models in SPICE3 (University of California-Berkeley).
- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to ataAccessComponent (Data Access Component)). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname MOSFET Idsmod=5 [parm=value]*
```

The model statement starts with the required keyword *model* . It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *MOSFET* . Idsmod=5 is a required parameter that is used to tell the simulator to use the BSIM2 equations. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

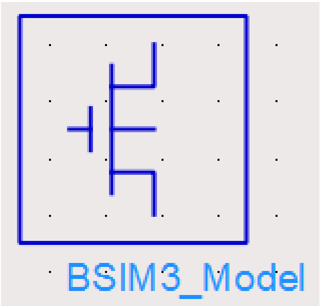
Example

```
model Nch5 MOSFET Idsmod=5 \
Vfb=-0.9 Mu0=500 NMOS=yes
```

BSIM3 Model (BSIM3 MOSFET Model)

BSIM3_Model (BSIM3 MOSFET Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Idsmod	Ids model: 1=LEVEL1 2=LEVEL2 3=LEVEL3 4=BSIM1 5=BSIM2 6=NMOD 8=BSIM3	None	8
Version	model version	None	3.30
Mobmod	mobility model selector	None	1
Capmod	capacitance model selector	None	3 (v3.2+), 2 (v3.1)
Noimod	noise model selector	None	1
Paramchk	model parameter checking selector	None	0
Binunit	bin unit selector	None	1
Rg	gate resistance	Ohm	fixed at 0
Rsh	drain and source diffusion sheet resistance	Ohm/sq	0.0
Nj	bulk P-N emission coefficient	None	1.0
Xti	junction current temp. exponent	None	3.0
Js	gate saturation current	A/m^2	1.0e-4

Jsw	sidewall junction reverse saturation current; defaults to Js	A/m^2	defaults to Js
Lintnoi	Lint offset for noise calculation	m	0.0
Lint †	length offset fitting parameter	m	0.0
Ll	Length Reduction Parameter	None	0.0
Lln	Length Reduction Parameter	None	1.0
Lw	Length Reduction Parameter	None	0.0
Lwn	Length Reduction Parameter	None	1.0
Lwl	Length Reduction Parameter	None	0.0
Wint	Width Reduction Parameter	None	0.0
Wl	Width Reduction Parameter	None	0.0
Wln	Width Reduction Parameter	None	1.0
Ww	Width Reduction Parameter	None	0.0
Wwn	Width Reduction Parameter	None	1.0
Wwl	Width Reduction Parameter	None	0.0
Tnom	parameter measurement temp.	°C	25
Trise	temperature rise above ambient	°C	None
Tox	oxide thickness	m	1.5e-8
Cj	zero-bias bulk junction bottom capacitance	F/m^2	5.0e-4
Mj	bulk junction bottom grading coefficient	None	0.5
Cjsw	zero-bias bulk junction sidewall capacitance	F/m	5.0e-10
Mjsw	bulk junction sidewall grading coefficient	None	1/3
Pb	bulk junction potential	V	1.0
Pbsw	bulk sidewall junction potential	V	1.0
Cjswg	S/D (gate side) sidewall junction capacitance; defaults to Cjsw	F/m	defaults to Cjsw
Mjswg	S/D (gate side) sidewall junction grading coefficient; defaults to Mjsw	None	defaults to Mjsw
Pbswg	S/D (gate side) sidewall junction built-in potential; defaults to Pbsw	V	defaults to Pbsw
Cgso	gate-source overlap capacitance, per channel width	F/m	Calculated
Cgdo	gate-drain overlap capacitance, per channel width	F/m	Calculated

Cgbo	gate-bulk overlap capacitance, per channel length	F/m	Calculated
Xpart	Coefficient of Channel Charge Share	None	0.0
Dwg †	coefficient of Weff's gate dependence	m/V	0.0
Ldwg	Length Dependence of Dwg	None	0.0
Wdwg	Width Dependence of Dwg	None	0.0
Pdwg	Cross Dependence of Dwg	None	0.0
Dwb †	coefficient of Weff's body dependence	$m/V^{(1/2)}$	0.0
Ldwb	Length Dependence of Dwb	None	0.0
Wdwb	Width Dependence of Dwb	None	0.0
Pdwb	Cross Dependence of Dwb	None	0.0
Nch	channel doping concentration	$1/cm^3$	1.7e17
Lnch	Length Dependence of Nch	None	0.0
Wnch	Width Dependence of Nch	None	0.0
Pnch	Cross Dependence of Nch	None	0.0
Nsub	substrate doping concentration	$1/cm^3$	6.0e+16
Lnsub	Length Dependence of Nsub	None	0.0
Wnsub	Width Dependence of Nsub	None	0.0
Pnsub	Cross Dependence of Nsub	None	0.0
Ngate	Gate Doping Concentration	$1/cm^3$	Calculated
Lngate	Length Dependence of Ngate	None	0.0
Wngate	Width Dependence of Ngate	None	0.0
Pngate	Cross Dependence of Ngate	None	0.0
Gamma1	body effect coefficient near interface	$V^{(1/2)}$	Calculated
Lgamma1	Length Dependence of Gamma1	None	0.0
Wgamma1	Width Dependence of Gamma1	None	0.0
Pgamma1	Cross Dependence of Gamma1	None	0.0
Gamma2	body effect coefficient in the bulk	$V^{(1/2)}$	Calculated
Lgamma2	Length Dependence of Gamma2	None	0.0
Wgamma2	Width Dependence of Gamma2	None	0.0
Pgamma2	Cross Dependence of Gamma2	None	0.0
Xt	doping depth	m	1.55e-7

Lxt	Length Dependence of Xt	None	0.0
Wxt	Width Dependence of Xt	None	0.0
Pxt	Cross Dependence of Xt	None	0.0
Vbm	Maximum Body Voltage	V	3.0
Lbm	Length Dependence of Vbm	None	0.0
Wbm	Width Dependence of Vbm	None	0.0
Pbm	Cross Dependence of Vbm	None	0.0
Vbx	Vth transition body voltage	V	calculated
Lbx	Length Dependence of Vbx	None	0.0
Wbx	Width Dependence of Vbx	None	0.0
Pbx	Cross Dependence of Vbx	None	0.0
Xj	metallurgical junction depth	m	0.15e-6
Lxj	Length Dependence of Xj	None	0.0
Wxj	Width Dependence of Xj	None	0.0
Pxj	Cross Dependence of Xj	None	0.0
U0 †	low-field mobility at T=Tnom	cm^2 /V×s	670.0 (NMOS) 250.0 (PMOS)
L	Length Dependence of U0	None	0.0
W	Width Dependence of U0	None	0.0
P	Cross Dependence of U0	None	0.0
Vth0 †	zero-bias threshold voltage	V	0.7 (NMOS) -0.7 (PMOS)
Lvth0	Length Dependence of Vth0	None	0.0
Wvth0	Width Dependence of Vth0	None	0.0
Pvth0	Cross Dependence of Vth0	None	0.0
K1	first order body effect coefficient †	$V^{(1/2)}$	0.5
Lk1	Length Dependence of K1	None	0.0
Wk1	Width Dependence of K1	None	0.0
Pk1	Cross Dependence of K1	None	0.0
K2	second order body effect coefficient †	None	-0.0186
Lk2	Length Dependence of K2	None	0.0
Wk2	Width Dependence of K2	None	0.0
Pk2	Cross Dependence of K2	None	0.0

K3	narrow width effect coefficient †	None	80.0
Lk3	Length Dependence of K3	None	0.0
Wk3	Width Dependence of K3	None	0.0
Pk3	Cross Dependence of K3	None	0.0
K3b	Narrow Width Effect Coefficient †	1/V	0.0
Lk3b	Length Dependence of K3b	None	0.0
Wk3b	Width Dependence of K3b	None	0.0
Pk3b	Cross Dependence of K3b	None	0.0
W0 †	narrow width effect W offset	m	2.5e-6
Lw0	Length Dependence of W0	None	0.0
Ww0	Width Dependence of W0	None	0.0
Pw0	Cross Dependence of W0	None	0.0
Nlx	Lateral Non-Uniform Doping Coeff.	m	1.74e-7
Lnlx	Length Dependence of Nlx	None	0.0
Wnlx	Width Dependence of Nlx	None	0.0
Pnlx	Cross Dependence of Nlx	None	0.0
Dvt0 †	First Coeff. of Short-Channel Effect on Vth	None	2.2
Ldvt0	Length Dependence of Dvt0	None	0.0
Wdvt0	Width Dependence of Dvt0	None	0.0
Pdvt0	Cross Dependence of Dvt0	None	0.0
Dvt1 †	Second Coeff. of Short-Channel Effect on Vth	None	0.53
Ldvt1	Length Dependence of Dvt1	None	0.0
Wdvt1	Width Dependence of Dvt1	None	0.0
Pdvt1	Cross Dependence of Dvt1	None	0.0
Dvt2 †	Body-Bias Coeff. of Short-Channel Effect on Vth	1/V	-0.032
Ldvt2	Length Dependence of Dvt2	None	0.0
Wdvt2	Width Dependence of Dvt2	None	0.0
Pdvt2	Cross Dependence of Dvt2	None	0.0
Dvt0w †	First Coeff. of Narrow-Width Effect on Vth	None	0.0
Ldvt0w	Length Dependence of Dvt0w	None	0.0
Wdvt0w	Width Dependence of Dvt0w	None	0.0
Pdvt0w	Cross Dependence of Dvt0w	None	0.0

Dvt1w †	Second Coeff. of Narrow-Width Effect on Vth	None	5.3e6
Ldvt1w	Length Dependence of Dvt1w	None	0.0
Wdvt1w	Width Dependence of Dvt1w	None	0.0
Pdvt1w	Cross Dependence of Dvt1w	None	0.0
Dvt2w †	Body-Bias Coeff. of Narrow-Width Effect on Vth	1/V	-0.032
Ldvt2w	Length Dependence of Dvt2w	None	0.0
Wdvt2w	Width Dependence of Dvt2w	None	0.0
Pdvt2w	Cross Dependence of Dvt2w	None	0.0
Ua †	First Order Mobility Degradation Coeff.	m/V	2.25e-9
Lua	Length Dependence of Ua	None	0.0
Wua	Width Dependence of Ua	None	0.0
Pua	Cross Dependence of Ua	None	0.0
Ub †	Second Order Mobility Degradation Coeff.	$(m/V)^2$	5.87e-19
Lub	Length Dependence of Ub	None	0.0
Wub	Width Dependence of Ub	None	0.0
Pub	Cross Dependence of Ub	None	0.0
Uc †	Body-Bias Mobility Degradation Coeff.	m/V^2 (1/V)	-0.0465 (Modmod=3), -0.0465e-9 (Mobmod=1,2)
Luc	Length Dependence of Uc	None	0.0
Wuc	Width Dependence of Uc	None	0.0
Puc	Cross Dependence of Uc	None	0.0
Delta †	effective Vds parameter	V	0.01
Ldelta	Length Dependence of Delta	None	0.0
Wdelta	Width Dependence of Delta	None	0.0
Pdelta	Cross Dependence of Delta	None	0.0
Rdsw †	Parasitic Resistance per Unit Width	Ohm×um	0.0
Lrdsw	Length Dependence of Rdsw	None	0.0
Wrdsw	Width Dependence of Rdsw	None	0.0
Prdsw	Cross Dependence of Rdsw	None	0.0
Prwg †	Gate-Bias Effect on Parasitic Resistance	1/V	0.0
Lprwg	Length Dependence of Prwg	None	0.0

Wprwg	Width Dependence of Prwg	None	0.0
Pprwg	Cross Dependence of Prwg	None	0.0
Prwb †	Body Effect on Parasitic Resistance	$1/V^{(1/2)}$	0.0
Lprwb	Length Dependence of Prwb	None	0.0
Wprwb	Width Dependence of Prwb	None	0.0
Pprwb	Cross Dependence of Prwb	None	0.0
Wr †	width dependence of Rds	None	1.0
Lwr	Length Dependence of Wr	None	0.0
Wwr	Width Dependence of Wr	None	0.0
Pwr	Cross Dependence of Wr	None	0.0
Vsat †	Saturation Velocity at Tnom	m/s	8.0e4
Lvsat	Length Dependence of Vsat	None	0.0
Wvsat	Width Dependence of Vsat	None	0.0
Pvsat	Cross Dependence of Vsat	None	0.0
A0 †	Bulk Charge Effect Coeff.	None	1.0
La0	Length Dependence of A0	None	0.0
Wa0	Width Dependence of A0	None	0.0
Pa0	Cross Dependence of A0	None	0.0
Keta †	Body-Bias Coeff. of the Bulk Charge Effect	1/V	-0.047
Lketa	Length Dependence of Keta	None	0.0
Wketa	Width Dependence of Keta	None	0.0
Pketa	Cross Dependence of Keta	None	0.0
Ags †	Gate Bias Coeff. of Abulk	1/V	0.0
Lags	Length Dependence of Ags	None	0.0
Wags	Width Dependence of Ags	None	0.0
Pags	Cross Dependence of Ags	None	0.0
A1 †	First Non-Saturation Factor	1/V	0.0
La1	Length Dependence of A1	None	0.0
Wa1	Width Dependence of A1	None	0.0
Pa1	Cross Dependence of A1	None	0.0
A2 †	Second Non-Saturation Factor	None	1.0
La2	Length Dependence of A2	None	0.0

Wa2	Width Dependence of A2	None	0.0
Pa2	Cross Dependence of A2	None	0.0
B0 †	Bulk Charge Effect Coeff. for Channel Width	m	0.0
Lb0	Length Dependence of B0	None	0.0
Wb0	Width Dependence of B0	None	0.0
Pb0	Cross Dependence of B0	None	0.0
B1 †	Bulk Charge Effect Width Offset	m	0.0
Lb1	Length Dependence of B1	None	0.0
Wb1	Width Dependence of B1	None	0.0
Pb1	Cross Dependence of B1	None	0.0
Alpha0 †	First Parameter of Impact Ionization Current	m/V	0.0
Lalpha0	Length Dependence of Alpha0	None	0.0
Walpha0	Width Dependence of Alpha0	None	0.0
Palpha0	Cross Dependence of Alpha0	None	0.0
Beta0 †	First Parameter of Impact Ionization Current	m/V	30.0
Lbeta0	Length Dependence of Beta0	None	0.0
Wbeta0	Width Dependence of Beta0	None	0.0
Pbeta0	Cross Dependence of Beta0	None	0.0
Voff †	Offset Voltage in Subthreshold Region	V	-0.08
Lvoff	Length Dependence of Voff	None	0.0
Wvoff	Width Dependence of Voff	None	0.0
Pvoff	Cross Dependence of Voff	None	0.0
Nfactor †	Subthreshold Swing Factor	None	1.0
Lnfactor	Length Dependence of Nfactor	None	0.0
Wnfactor	Width Dependence of Nfactor	None	0.0
Pnfactor	Cross Dependence of Nfactor	None	0.0
Cdsc †	Drain/Source and Channel Coupling Capacitance	F/m^2	2.4e-4
Lcdsc	Length Dependence of Cdsc	None	0.0
Wcdsc	Width Dependence of Cdsc	None	0.0
Pcdsc	Cross Dependence of Cdsc	None	0.0

Cdscb †	Body-Bias Dependence of Cdsc	F/ (V×m^2)	0.0
Lcdscb	Length Dependence of Cdscb	None	0.0
Wcdscb	Width Dependence of Cdscb	None	0.0
Pcdscb	Cross Dependence of Cdscb	None	0.0
Cdscd †	Drain-Bias Dependence of Cdsc	F/ (V×m^2)	0.0
Lcdscd	Length Dependence of Cdscd	None	0.0
Wcdscd	Width Dependence of Cdscd	None	0.0
Pcdscd	Cross Dependence of Cdscd	None	0.0
Cit †	Capacitance due to Interface Charge	F/m^2	0.0
Lcit	Length Dependence of Cit	None	0.0
Wcit	Width Dependence of Cit	None	0.0
Pcit	Cross Dependence of Cit	None	0.0
Eta0 †	Subthreshold Region DIBL Coeff.	None	0.08
Leta0	Length Dependence of Eta0	None	0.0
Weta0	Width Dependence of Eta0	None	0.0
Peta0	Cross Dependence of Eta0	None	0.0
Etab †	Subthreshold Region DIBL Coeff.	None	-0.07
Letab	Length Dependence of Peta0	None	0.0
Wetab	Width Dependence of Peta0	None	0.0
Petab	Cross Dependence of Peta0	None	0.0
Dsub †	DIBL Coeff. in Subthreshold Region; defaults to Drout	None	defaults to Drout
Ldsub	Length Dependence of Dsub	None	0.0
Wdsub	Width Dependence of Dsub	None	0.0
Pdsub	Cross Dependence of Dsub	None	0.0
Drout †	DIBL Coeff. of Output Resistance	None	0.56
Ldrout	Length Dependence of Drout	None	0.0
Wdrout	Width Dependence of Drout	None	0.0
Pdrout	Cross Dependence of Drout	None	0.0
Pclm †	Channel Length Modulation Coeff.	None	1.3
Lpclm	Length Dependence of Pclm	None	0.0

Wpclm	Width Dependence of Pclm	None	0.0
Ppclm	Cross Dependence of Pclm	None	0.0
Pdiblc1	Drain Induced Barrier Lowering Effect Coeff. 1	None	0.39
Lpdiblc1	Length Dependence of Pdiblc1	None	0.0
Wpdiblc1	Width Dependence of Pdiblc1	None	0.0
Ppdiblc1	Cross Dependence of Pdiblc1	None	0.0
Pdiblc2	Drain Induced Barrier Lowering Effect Coeff. 2	None	0.0086
Lpdiblc2	Length Dependence of Pdiblc2	None	0.0
Wpdiblc2	Width Dependence of Pdiblc2	None	0.0
Ppdiblc2	Cross Dependence of Pdiblc2	None	0.0
Pdiblcb	Body-Effect on Drain Induced Barrier Lowering	1/V	0.0
Lpdiblcb	Length Dependence of Pdiblcb	None	0.0
Wpdiblcb	Width Dependence of Pdiblcb	None	0.0
Ppdiblcb	Cross Dependence of Pdiblcb	None	0.0
Pscbe1	Substrate Current Body-Effect Coeff. 1	V/m	4.24e8
Lpscbe1	Length Dependence of Pscbe1	None	0.0
Wpscbe1	Width Dependence of Pscbe1	None	0.0
Ppscbe1	Cross Dependence of Pscbe1	None	0.0
Pscbe2	Substrate Current Body-Effect Coeff. 2	m/V	1.0e-5
Lpscbe2	Length Dependence of Pscbe2	None	0.0
Wpscbe2	Width Dependence of Pscbe2	None	0.0
Ppscbe2	Cross Dependence of Pscbe2	None	0.0
Pvag	Gate voltage dependence of Rout	None	0.0
Lpvag	Length Dependence of Pvag	None	0.0
Wpvag	Width Dependence of Pvag	None	0.0
Ppvag	Cross Dependence of Pvag	None	0.0
Ute	Mobility Temperature Exponent	None	-1.5
Lute	Length Dependence of Ute	None	0.0
Wute	Width Dependence of Ute	None	0.0
Pute	Cross Dependence of Ute	None	0.0
At	Temperature Coefficient of Vsat	m/s	3.3e4
Lat	Length Dependence of At	None	0.0

Wat	Width Dependence of At	None	0.0
Pat	Cross Dependence of At	None	0.0
Ua1	Temperature Coefficient of Ua	m/V	4.31e-9
Lua1	Length Dependence of Ua1	None	0.0
Wua1	Width Dependence of Ua1	None	0.0
Pua1	Cross Dependence of Ua1	None	0.0
Ub1	Temperature Coefficient of Ub	$(m/V)^2$	-7.61e-18
Lub1	Length Dependence of Ub1	None	0.0
Wub1	Width Dependence of Ub1	None	0.0
Pub1	Cross Dependence of Ub1	None	0.0
Uc1	Temperature Coefficient of Uc	1/V	-0.056 (Mobmod=3), -0.056e-9 (Mobmod=1,2)
Luc1	Length Dependence of Uc1	None	0.0
Wuc1	Width Dependence of Uc1	None	0.0
Puc1	Cross Dependence of Uc1	None	0.0
Kt1	Temperature Coefficient of Vth	V	-0.11
Lkt1	Length Dependence of Kt1	None	0.0
Wkt1	Width Dependence of Kt1	None	0.0
Pkt1	Cross Dependence of Kt1	None	0.0
Kt1l	Channel Length Sensitivity of Kt1	V×m	0.0
Lkt1l	Length Dependence oKt1l 1	None	0.0
Wkt1l	Width Dependence of Kt1l	None	0.0
Pkt1l	Cross Dependence of Kt1l	None	0.0
Kt2	Body Coefficient of Kt1	None	0.022
Lkt2	Length Dependence of Kt2	None	0.0
Wkt2	Width Dependence of Kt2	None	0.0
Pkt2	Cross Dependence of Kt2	None	0.0
Prt	Temperature Coefficient of Rdsw	Ohm × um	0.0
Lprt	Length Dependence of Prt	None	0.0
Wprt	Width Dependence of Prt	None	0.0
Pprt	Cross Dependence of Prt	None	0.0
Cgsl	Light Doped Source-Gate Overlap Capacitance	F/m	0.0

Lcgsl	Length Dependence of Cgsl	None	0.0
Wcgsl	Width Dependence of Cgsl	None	0.0
Pcgsl	Cross Dependence of Cgsl	None	0.0
Cgdl	Light Doped Drain-Gate Overlap Capacitance	F/m	0.0
Lcgdl	Length Dependence of Cgdl	None	0.0
Wcgdl	Width Dependence of Cgdl	None	0.0
Pcgdl	Cross Dependence of Cgdl	None	0.0
Ckappa	Coeff. for Light Doped Overlap Capacitance	F/m	0.6
Lckappa	Length Dependence of Ckappa	None	0.0
Wckappa	Width Dependence of Ckappa	None	0.0
Pckappa	Cross Dependence of Ckappa	None	0.0
Cf	Fringing Field Capacitance	F/m	calculated
Lcf	Length Dependence of Cf	None	0.0
Wcf	Width Dependence of Cf	None	0.0
Pcf	Cross Dependence of Cf	None	0.0
Clc	Constant Term for the Short Channel C-V Model	m	0.1e-6
Lclc	Length Dependence of Clc	None	0.0
Wclc	Width Dependence of Clc	None	0.0
Pclc	Cross Dependence of Clc	None	0.0
Cle	Exponential Term for the Short Channel C-V Model	None	0.6
Lcle	Length Dependence of Cle	None	0.0
Wcle	Width Dependence of Cle	None	0.0
Pcle	Cross Dependence of Cle	None	0.0
Dlc	Length Offset Fitting Parameter from C-V Model; defaults to Lint	m	defaults to Lint
Dwc	Width Offset Fitting Parameter from C-V Model; defaults to Wint	m	defaults to Wint
Vfbcv	flat-band voltage parameter for capmod=0 only	V	-1.0
Lvfbcv	Length Dependence of Vfbcv	None	0.0
Wvfbcv	Width Dependence of Vfbcv	None	0.0
Pvfbcv	Cross Dependence of Vfbcv	None	0.0
Toxm	gate oxide thickness tox value at which parameters are extracted; defaults to tox	m	defaults to tox

Vfb	DC flat-band voltage	V	calculated
Lvfb	Length Dependence of Vfb	None	0.0
Wvfb	Width Dependence of Vfb	None	0.0
Pvfb	Cross Dependence of Vfb	None	0.0
Noff	CV Turn on/off	None	1.0
Lnoff	Length Dependence of Noff	None	0.0
Wnoff	Width Dependence of Noff	None	0.0
Pnoff	Cross Dependence of Noff	None	0.0
Voffcv	CV Lateral Shift Parameter	V	0.0
Lvoffcv	Length Dependence of Voffcv	None	0.0
Wvoffcv	Width Dependence of Voffcv	None	0.0
Pvoffcv	Cross Dependence of Voffcv	None	0.0
Ijth	diode limiting current	None	0.1
Alpha1	substrate current	1/V	0.0
Lalpha1	Length Dependence of Alpha1	None	0.0
Walpha1	Width Dependence of Alpha1	None	0.0
Palpha1	Cross Dependence of Alpha1	None	0.0
Acde †	Exponential Coefficient for Finite Charge Thickness	m/V	1.0
Lacde	Length Dependence of Acde	None	0.0
Wacde	Width Dependence of Acde	None	0.0
Pacde	Cross Dependence of Acde	None	0.0
Moin †	coefficient for the gate-bias dependent surface potential	$V^{(1/2)}$	15.0
Lmoin	Length Dependence of Moin	None	0.0
Wmoin	Width Dependence of Moin	None	0.0
Pmoin	Cross Dependence of Moin	None	0.0
Tpb	Temperature Coefficient of Pb	V/K	0.0
Tpbsw	Temperature Coefficient of Pbsw	V/K	0.0
Tpbswg	Temperature Coefficient of Pbswg	V/K	0.0
Tcj	Temperature Coefficient of Cj	1/K	0.0
Tcjsw	Temperature Coefficient of Cjsw	1/K	0.0
Tcjswg	Temperature Coefficient of Cjswg	1/K	0.0

Llc	Length Reduction Parameter for CV; defaults to Ll	None	defaults to Ll
Lwc	Length Reduction Parameter for CV; defaults to Lw	None	defaults to Lw
Lwlc	Length Reduction Parameter for CV; defaults to Lwl	None	defaults to Lwl
Wlc	Width Reduction Parameter for CVt; defaults to Wl	None	defaults to Wl
Wwc	Width Reduction Parameter for CV; defaults to Ww	None	defaults to Ww
Wwlc	Width Reduction Parameter for CV; defaults to Wwl	None	defaults to Wwl
Elm	Non-Quasi Static Elmore Constant	None	5.0
Lelm	Length Dependence of Elm	None	0.0
Welm	Width Dependence of Elm	None	0.0
Pelm	Cross Dependence of Elm	None	0.0
Nlev	Noise model level	None	-1
Gdwnoi	Drain noise parameters for Nlev=3	None	1
Kf	Flicker Noise Coefficient	None	0.0
Af	Flicker Noise Coefficient	None	1.0
Ef	Flicker Noise Frequency Exponent	None	1.0
Em	Flicker Noise	V/m	4.1e7
Noia	noise parameter A	None	1.0e20 (NMOS), 9.9e18 (PMOS)
Noib	noise parameter B	None	5.0e4 (NMOS), 2.4e3 (PMOS)
Noic	noise parameter C	None	-1.4e-12 (NMOS), 1.4e-12 (PMOS)
Imax	explosion current	A	10.0
Imelt	explosion current similar to Imax; defaults to Imax	A	defaults to Imax
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvg	gate oxide breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None

wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
Acm	area calculation method	None	-1
Hdif	length of heavily doped diffusion (ACM=2,3 only)	m	0.0
Ldif	length of lightly doped diffusion adjacent to gate (ACM=1,2)	m	0.0
Wmlt	width diffusion layer shrink reduction factor	None	1.0
Lmlt	Gate length shrink factor	None	1.0
Xw	accounts for masking and etching effects	m	0.0
Rdc	additional drain resistance due to contact resistance	Ohm	0.0
Rsc	additional source resistance due to contact resistance	Ohm	0.0
AllParams	DataAccessComponent-based parameters	None	None
B3qmod	BSIM3 charge model (0 for Berkeley, 1 for Hspice Capmod=0)	None	0
Calcacm	flag to use Acm when Acm=12	None	0
Xl	accounts for masking and etching effects	m	0.0
Is	bulk junction saturation current	A	1.0e-14
Rd	drain resistance	Ohm	0.0
Rs	source resistance	Ohm	0.0
Flkmod	flicker noise model selector	None	0
Tlev	temperature equation selector (0/1/2/3)	None	0
Tlevc	temperature equation selector for capacitance (0/1/2/3)	None	0
Eg	band gap	eV	1.16
Gap1	energy gap temperature coefficient alpha	V/°C	7.04e-4
Gap2	energy gap temperature coefficient beta	K	1108
Cta	Cj linear temperature coefficient	1/°C	0
Ctp	Cjsw linear temperature coefficient	1/°C	0
Pta	Vj linear temperature coefficnet	1/°C	0
Ptp	Vjsw linear temperature coefficient	1/°C	0
Trd	Rd linear temperature coefficient	1/°C	0

Trs	Rs linear temperature coefficient	1/°C	0
Wmin	binning minimum width (not used for binning; use BinModel)	m	0.0
Wmax	binning maximum width (not used for binning; use BinModel)	m	1.0
Lmin	binning minimum length (not used for binning; use BinModel)	m	0.0
Lmax	binning maximum length (not used for binning; use BinModel)	m	1.0
Lgcd	Gate-to-contact length of drain side	m	0.0
Lgcs	Gate-to-contact length of source side	m	0.0
Rdd	Scalable drain resistance,	Ohm × m	0.0
Rss	Scalable source resistance	Ohm × m	0.0
Sc	Spacing between contacts	m	infinity
W	Channel width	m	None
L	Channel length	m	None
Ad	Drain Area	m^2	None
As	Source Area	m^2	None
Pd	Drain Perimeter	m	None
Ps	Source Perimeter	m	None
Nrd	Drain Squares	None	None
Nrs	Source Squares	None	None
Dtoxcv	Delta oxide thickness	m	0.0
Vfbflag	Select Vfb for Capmod=0	None	0
Stimod	LOD stress effect model selector	None	0
Sa0	Reference distance between OD edge to poly of one side	m	1.0e-6
Sb0	Reference distance between OD edge to poly of the other side	m	1.0e-6
Wlod	Length parameter for stress effect	None	0.0
Ku0	Mobility degradation/enhancement coefficient for LOD	None	0.0
Kvsat	Saturation velocity degradation/enhancement coefficient for LOD	None	0.0

Kvth0	Threshold degradation/enhancement parameter for LOD	None	0.0
Tku0	Temperature coefficient of Ku0	None	0.0
Llodku0	Length parameter for U0 LOD effect	None	0.0
Wlodku0	Width parameter for U0 LOD effect	None	0.0
Llodvth	Length parameter for Vth LOD effect	None	0.0
Wlodvth	Width parameter for Vth LOD effect	None	0.0
Lku0	Length dependence of Ku0	None	0.0
Wku0	Width dependence of Ku0	None	0.0
Pku0	Cross-term dependence of Ku0	None	0.0
Lkvth0	Length dependence of Kvth0	None	0.0
Wkvth0	Width dependence of Kvth0	None	0.0
Pkvth0	Cross-term dependence of Kvth0	None	0.0
Stk2	K2 shift factor related to stress effect on Vth	None	0.0
Lodk2	K2 shift modification factor for stress effect	None	1.0
Steta0	Eta0 shift factor related to stress effect on Vth	None	0.0
Lodeta0	Eta0 shift modification factor for stress effect	None	1.0
Nqsmod	non-quasi-static model selector	None	0
Acnqsmod	AC non-quasi static model option: 1=on or 0=off	None	0
† binning parameter; see Note 5			

- More information about this model is available at: http://www-device.eecs.berkeley.edu/bsim3
- BSIM1, BSIM2, and BSIM3 MOSFET models use the same parameters and parameter definitions as the BSIM models in SPICE3 (University of California-Berkeley).
- The K1 parameter's default value is calculated except when K2 is present. When K2 is present, 0.5 is used as the default value of K1.
- Several DC, AC, and capacitance parameters can be binned; these parameters follow this implementation:

$$P = P_0 + \frac{P_L}{L_{eff}} + \frac{P_w}{W_{eff}} + \frac{P_p}{L_{eff} \times W_{eff}}$$

For example, for the K1 parameter, the following relationships exist: P_0=k1, P_L=lk1, P_W=wk1, P_P=pk1. The Binunit parameter is a binning unit selector. If Binunit=1, the units of L_{eff} and W_{eff} used in the preceding binning equation have the units of microns, otherwise in meters. For example, for a device with L_{eff}=0.5mm and W_{eff}=10mm, if Binunit=1, parameter values are le5, le4, 2e4, and 3e4 for Vsat, Lvsat, Wvsat, and Pvsat, respectively, Therefore, the effective value of Vsat for this device is:

> *Vsat = 1e5 + 1e4/0.5 + 2e4/10 + 3e4/(0.5 × 10) = 1.28e5*

To get the same effective value of Vsat for Binunit=0, values of Vsat, Lvsat, Wvsat, and Pvsat would be 1e5, le2, 2e2, 3e8, respectively. Thus:

> *Vsat = 1e5 + 1e-2/0.5e6 + 2e2/10e6 + 3e 8/(0.5e-6 × 10e6) = 1.28e5*

- The nonquasi-static (NQS) charge model is supported in versions 3.2 and later.
- Model parameter U0 can be entered in meters or centimeters. U0 is converted to m2/V sec as follows: if U0 > 1, it is multiplied by 10^{-4}.
- Nqsmod is also supported as an instance parameter. For simulation, only the Nqsmod instance parameter is used (the Nqsmod model parameter is not used). This is the way Berkeley defined Nqsmod in BSIM3v3.2. Hspice supports Nqsmod only as a model parameter.
- Imelt and Ijth Parameters
  Imelt and Ijth specify the diode limiting current (also known as P-N junction explosion current). Imelt and Ijth can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Ijth value, the Imelt value is increased to the Ijth value.
  If Imelt is specified (in the model or in Options) diode limiting current = Imelt; otherwise, if Ijth is specified (in the model or in Options) diode limiting current = Ijth; otherwise, diode limiting current = model Imelt default value (which is the same as the model Ijth default value).
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.
- DC operating point data is generated for this model. If a DC simulation is performed, device operating point data can be viewed for a component. The procedure for viewing device operating point data for a component is in Using Circuit Simulators. The device operating point information displayed for the BSIM3 model is:

> *Gmb: small-signal Vbs to Ids transconductance, in Siemens*
> *Gds: small-signal drain source conductance, in Siemens*
> *Vdsat: saturation voltage, in volts*
> *Capbd: small-signal bulk drain capacitance, in farads*
> *Capbs: small-signal bulk source capacitance, in farads*
> *CgdM: small-signal gate drain Meyer capacitance, in farads*
> *CgbM: small-signal gate bulk Meyer capacitance, in farads*
> *CgsM: small-signal gate source Meyer capacitance, in farads*
> *DqgDvgb: small-signal transcapacitance dQg/dVg, in farads*
> *DqgDvdb: small-signal transcapacitance dQg/dVd, in farads*
> *DqgDvsb: small-signal transcapacitance dQg/dVs, in farads*
> *DqbDvgb: small-signal transcapacitance dQb/dVg, in farads*
> *DqbDvdb: small-signal transcapacitance dQb/dVd, in farads*
> *DqbDvsb: small-signal transcapacitance dQb/dVs, in farads*
> *DqdDvgb: small-signal transcapacitance dQd/dVg, in farads*
> *DqdDvdb: small-signal transcapacitance dQd/dVd, in farads*
> *DqdDvsb: small-signal transcapacitance dQd/dVs, in farads*

- The model parameter Dtoxcv has been added to the BSIM3 model for Version ≥ 3.2. The implementation is taken from a recent enhancement to the B3soiPD made by U. C. Berkeley. This parameter allows a different effective gate oxide thickness to be used in the I-V and C-V calculations.

The value Tox-Dtoxcv is used in the calculation of Vfbzb instead of Tox. In the Capmod=3 code, the effective oxide thickness is now Tox-Dtoxcv instead of Tox.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname MOSFET Idsmod=8 [parm=value]*
```

The model statement starts with the required keyword *model* . It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *MOSFET* . Idsmod=8 is a required parameter that tells the simulator to use the BSIM3v3 equations. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example

```
model Nch6 MOSFET Idsmod=8 \
Vtho=0.7 Cj=3e-
```

Temperature Scaling

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device Temp parameter. (Temperatures in the following equations are in Kelvin.)

The energy bandgap E_G varies as:

$$E_G(T) = 1.16 - \frac{7.02 \times 10^{-4} T^2}{T + 1108}$$ *Tlev = 0, 1, 3*

$$E_G(T) = Eg - \frac{Gap1 T^2}{T + Gap2}$$ *Tlev = 2*

The intrinsic carrier concentration n_i for silicon varies as:

$$n_i(T) = 1.45 \times 10^{10} \left(\frac{T}{300.15}\right)^{3/2} \exp\left(\frac{E_G(300.15)}{2k\,300.15/q} - \frac{E_G(T)}{2kT/q}\right)$$

The saturation currents Js and Jsw scale as:

$$Js^{NEW} = Js \exp\left[\frac{E_G(Tnom)}{NkTnom/q} - \frac{E_G(Temp)}{NkTemp/q} + \frac{Xti}{N} \ln\left(\frac{Temp}{Tnom}\right)\right]$$

$$Jsw^{NEW} = Jsw \exp\left[\frac{E_G(Tnom)}{NkTnom/q} - \frac{E_G(Temp)}{NkTemp/q} + \frac{Xti}{N} \ln\left(\frac{Temp}{Tnom}\right)\right]$$

The series resistances Rs and Rd scale as:

$$Rs^{NEW} = Rs[1 + Trs(Temp - Tnom)]$$

$$Rd^{NEW} = Rd[1 + Trd(Temp - Tnom)]$$

The junction potentials Pb, Pbsw, and Pbswg and the junction capacitances Cj, Cjsw, and Cjswg scale as:

if Version ≥ 3.2 and ACM ≥ 10

$$Pb^{NEW} = Pb - Tpb(Temp - Tnom)$$

$$Pbsw^{NEW} = Pbsw - Tpbsw(Temp - Tnom)$$

$$Pbswg^{NEW} = Pbswg - Tpbswg(Temp - Tnom)$$

$$Cj^{NEW} = Cj(1 + Tcj(Temp - Tnom))$$

$$Cjsw^{NEW} = Cjsw(1 + Tcjsw(Temp - Tnom))$$

$$Cjswg^{NEW} = Cjswg(1 + Tcjswg(Temp - Tnom))$$

else if ACM <10

if Tlevc = 0

$$Pb^{NEW} = Pb\frac{Temp}{Tnom} + \frac{2kTemp}{q}\ln\left(\frac{n_i(Tnom)}{n_i(Temp)}\right)$$

$$Pbsw^{NEW} = Pbsw\frac{Temp}{Tnom} + \frac{2kTemp}{q}\ln\left(\frac{n_i(Tnom)}{n_i(Temp)}\right)$$

$$Pbswg^{NEW} = Pbswg\frac{Temp}{Tnom} + \frac{2kTemp}{q}\ln\left(\frac{n_i(Tnom)}{n_i(Temp)}\right)$$

$$Cj^{NEW} = Cj\left(1 + Mj\left[1 + 4 \times 10^{-4}(Temp - Tnom) - \frac{Pb^{NEW}}{Pb}\right]\right)$$

$$Cjsw^{NEW} = Cjsw\left(1 + Mjsw\left[1 + 4 \times 10^{-4}(Temp - Tnom) - \frac{Pbsw^{NEW}}{Pbsw}\right]\right)$$

$$Cjswg^{NEW} = Cjswg\left(1 + Mjswg\left[1 + 4 \times 10^{-4}(Temp - Tnom) - \frac{Pbswg^{NEW}}{Pbswg}\right]\right)$$

if Tlevc = 1

$$Pb^{NEW} = Pb - Pta(Temp - Tnom)$$

$$Pbsw^{NEW} = Pbsw - Ptp(Temp - Tnom)$$

$$Pbswg^{NEW} = Pbswg - Ptp(Temp - Tnom)$$

$$Cj^{NEW} = Cj[1 + Cta(Temp - Tnom)]$$

$$Cjsw^{NEW} = Cjsw[1 + Ctp(Temp - Tnom)]$$

$$Cjswg^{NEW} = Cjswg[1 + Ctp(Temp - Tnom)]$$

if Tlevc = 2

$$Pb^{NEW} = Pb - Pta(Temp - Tnom)$$

$$Pbsw^{NEW} = Pbsw - Ptp(Temp - Tnom)$$

$$Pbswg^{NEW} = Pbswg - Ptp(Temp - Tnom)$$

$$Cj^{NEW} = Cj\left(\frac{Pb}{Pb^{NEW}}\right)^{Mj}$$

$$Cjsw^{NEW} = Cjsw\left(\frac{Pbsw}{Pbsw^{NEW}}\right)^{Mjsw}$$

$$Cjswg^{NEW} = Cjswg\left(\frac{Pbswg}{Pbswg^{NEW}}\right)^{Mjswg}$$

if Tlevc = 3

if Tlev = 0, 1, 3

$$dPbdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (1.16 - E_G(Tnom))\frac{Tnom + 2\times 1108}{Tnom + 1108} - Pb\right)\frac{1}{Tnom}$$

$$dPbswdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (1.16 - E_G(Tnom))\frac{Tnom + 2\times 1108}{Tnom + 1108} - Pbsw\right)\frac{1}{Tnom}$$

$$dPbswdgdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (1.16 - E_G(Tnom))\frac{Tnom + 2\times 1108}{Tnom + 1108} - Pbswg\right)\frac{1}{Tnom}$$

if Tlev = 2

$$dPbdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (Eg - E_G(Tnom))\frac{Tnom + 2Gap2}{Tnom + Gap2} - Pb\right)\frac{1}{Tnom}$$

$$dPbswdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (Eg - E_G(Tnom))\frac{Tnom + 2Gap2}{Tnom + Gap2} - Pbsw\right)\frac{1}{Tnom}$$

$$dPbswdgT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (Eg - E_G(Tnom))\frac{Tnom + 2Gap2}{Tnom + Gap2} - Pbswg\right)\frac{1}{Tnom}$$

$$Pb^{NEW} = Pb + dPbdT(Temp - Tnom)$$

$$Pbsw^{NEW} = Pbsw + dPbswdT(Temp - Tnom)$$

$$Pbswg^{NEW} = Pbswg + dPbswgT(Temp - Tnom)$$

$$Cj^{NEW} = Ce\left(1 - \frac{dPbdT(Temp - Tnom)}{2Pb}\right)$$

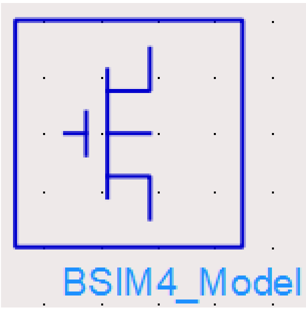
$$Cjsw^{NEW} = Cjsw\left(1 - \frac{dPbswdT(Temp - Tnom)}{2Pbsw}\right)$$

$$Cjswg^{NEW} = Cjswg\left(1 - \frac{dPbswgdT(Temp - Tnom)}{2Pbswg}\right)$$

BSIM4 Model (BSIM4 MOSFET Model)

BSIM4_Model (BSIM4 MOSFET Model)

Symbol



Description

BSIM4 was developed by the Device Research Group of the Department of Electrical Engineering and Computer Science, University of California, Berkeley and copyrighted by the University of California. More information about this model is available at:

> http://bsim.berkeley.edu/models/bsim4

Parameters

Name	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Capmod	Capacitance model selector	None	2
Diomod	Diode IV model selector	None	1
Rdsmod	Bias-dependent S/D resistance model selector	None	0
Trnqsmod	Transient NQS model selector	None	0
Acnqsmod	AC NQS model selector	None	0

Name	Description	Units	Default
Mobmod	Mobility model selector	None	0
Rbodymod	Distributed body R model selector	None	0
Rgatemod	Gate R model selector	None	0
Permod	Pd and Ps model selector	None	1
Geomod	Geometry dependent parasitics model selector	None	0
Rgeomod	S/D resistance and contact model selector	None	0
Fnoimod	Flicker noise model selector	None	1
Tnoimod	Thermal noise model selector	None	0
Igcmod	Gate-to-channel Ig model selector	None	0
Igbmod	Gate-to-body Ig model selector	None	0
Tempmod	Temperature model selector	None	0
Paramchk	Model parameter checking selector	None	1
Nf	Number of fingers	None	1.0
Binunit	Bin unit selector	None	1
Version	Parameter for model version	None	4.81
Toxe	Electrical gate oxide thickness in meters	None	30.0e-10
Toxp	Physical gate oxide thickness in meters; defaults to Toxe	None	defaults to Toxe
Toxm	Gate oxide thickness at which parameters are extracted; defaults to Toxe	None	defaults to Toxe
Toxref	Target Tox value	None	30.0e-10

Name	Description	Units	Default
Dtox	Defined as (Toxe - Toxp)	None	0.0
Epsrox	Dielectric constant of the gate oxide relative to vacuum	None	3.9
Cdsc	Drain/Source and channel coupling capacitance	$F/(V \times m^2)$	2.4e-4
Cdscb	Body-bias dependence of Cdsc	$F/(V \times m^2)$	0.0
Cdscd	Drain-bias dependence of Cdsc	$F/(V \times m^2)$	0.0
Cit	Interface state capacitance	$F/(V \times m^2)$	0.0
Nfactor	Subthreshold swing coefficient	None	1.0
Xj	Junction depth in meters	m	1.5e-7
Vsat	Saturation velocity at Tnom	m/s	8.0e4
At	Temperature coefficient of Vsat	m/s	3.3e4
A0	Non-uniform depletion width effect coefficient	None	1.0
Ags	Gate bias coefficient of Abulk	V^{-1}	0.0
A1	First non-saturation effect coefficient	V^{-1}	0.0
A2	Second non-saturation effect coefficient	None	1.0
Keta	Body-bias coefficient of non-uniform depletion width effect	V^{-1}	-0.047
Nsub	Substrate doping concentration	cm^{-3}	6.0e16
Ndep	Channel doping concentration at the depletion edge	cm^{-3}	1.7e17
Nsd	S/D doping concentration	cm^{-3}	1.0e20

Name	Description	Units	Default
Phin	Adjusting parameter for surface potential due to non-uniform vertical doping	V	0.0
Ngate	Poly-gate doping concentration	cm^{-3}	0.0
Gamma1	Vth body coefficient	$V^{(1/2)}$	calculated
Gamma2	Vth body coefficient	$V^{(1/2)}$	calculated
Vbx	Vth transition body voltage	V	calculated
Vbm	Maximum body voltage	V	-3.0
Xt	Doping depth	m	1.55e-7
K1	Bulk effect coefficient 1	$V^{(1/2)}$	0.53
Kt1	Temperature coefficient of Vth	V	-0.11
Kt1l	Temperature coefficient of Vth	V×m	0.0
Kt2	Body coefficient of Kt1	None	0.022
K2	Bulk effect coefficient 2	None	-0.0186
K3	Narrow width effect coefficient	None	80.0
K3b	Body effect coefficient of K3	V^{-1}	0.0
W0	Narrow width effect parameter	m	2.5e-6
Dvtp0	First parameter for Vth shift due to pocket	m	0.0
Dvtp1	Second parameter for Vth shift due to pocket	V^{-1}	0.0
Lpe0	Equivalent length of pocket region at zero bias	m	1.74e-7

Name	Description	Units	Default
Lpeb	Equivalent length of pocket region accounting for body bias	m	0.0
Dvt0	Short channel effect coefficient 0	None	2.2
Dvt1	Short channel effect coefficient 1	None	0.53
Dvt2	Short channel effect coefficient 2	V^{-1}	-0.032
Dvt0w	Narrow Width coefficient 0	None	0.0
Dvt1w	Narrow Width effect coefficient 1	m^{-1}	5.3e6
Dvt2w	Narrow Width effect coefficient 2	V^{-1}	-0.032
Drout	DIBL coefficient of output resistance	None	0.56
Dsub	DIBL coefficient in the subthreshold region	None	fixed by Drout
Vth0	Threshold voltage	V	0.7 (NMOS)
Ua	Linear gate dependence of mobility	None	1.0e-15 (Mobmod=2),
Ua1	Temperature coefficient of Ua	m/V	1.0e-9
Ub	Quadratic gate dependence of mobility	(m/V^2)	1.0e-19
Ub1	Temperature coefficient of Ub	(m/V^2)	-1.0e-18
Uc	Body-bias dependence of mobility	V^{-1}	-0.0465 (Mobmod=1), -0.0465e-9 (Mobmod=0,2)
Uc1	Temperature coefficient of Uc	V^{-1}	-0.056 (Mobmod=1), -0.056e-9 (Mobmod=0,2)
U0	Low-field mobility at Tnom	$m^2/(V \times s)$	0.067 (NMOS),

Name	Description	Units	Default
Eu	Mobility exponent	None	1.67 (NMOS)
Ute	Temperature coefficient of mobility	None	-1.5
Voff	Threshold voltage offset	V	-0.08
Minv	Fitting parameter for moderate inversion in Vgsteff	None	0.0
Voffl	Length dependence parameter for Vth offset	V×m	0.0
Tnom	Parameter measurement temperature	°C	25
Trise	temperature rise above ambient	°C	0
Cgso	Gate-source overlap capacitance per width	F/m	calculated
Cgdo	Gate-drain overlap capacitance per width	F/m	calculated
Cgbo	Gate-bulk overlap capacitance per length	F/m	0.0
Xpart	Channel charge partitioning	None	0.0
Delta	Effective Vds parameter	V	0.01
Rsh	Source-drain sheet resistance	Ohm/sq	0.0
Rdsw	Source-drain resistance per width	Ohm×um	200.0
Rdswmin	Source-drain resistance per width at high Vg	Ohm×um	0.0
Rsw	Source resistance per width	Ohm×um	100.0
Rdw	Drain resistance per width	Ohm×um	100.0
Rdwmin	Drain resistance per width at high Vg	Ohm×um	0.0
Rswmin	Source resistance per width at high Vg	Ohm×um	0.0

Name	Description	Units	Default
Prwg	Gate-bias effect on parasitic resistance	V^{-1}	1.0
Prwb	Body-effect on parasitic resistance	$V^{(-1/2)}$	0.0
Prt	Temperature coefficient of parasitic resistance	Ohm×um	0.0
Eta0	Subthreshold region DIBL coefficient	None	0.08
Etab	Subthreshold region DIBL coefficient	V^{-1}	-0.07
Pclm	Channel length modulation coefficient	None	1.3
Pdiblc1	Drain-induced barrier lowering coefficient	None	0.39
Pdiblc2	Drain-induced barrier lowering coefficient	None	0.0086
Pdiblcb	Body-effect on drain-induced barrier lowering	V^{-1}	0.0
Fprout	Rout degradation coefficient for pocket devices	$V/m^{(1/2)}$	0.0
Pdits	Coefficient for drain-induced Vth shifts	V^{-1}	0.0
Pditsl	Length dependence of drain-induced Vth shifts	m^{-1}	0.0
Pditsd	Vds dependence of drain-induced Vth shifts	V^{-1}	0.0
Pscbe1	Substrate current body-effect coefficient	V/m	4.24e8
Pscbe2	Substrate current body-effect coefficient	m/V	1.0e-5
Pvag	Gate dependence of output resistance parameter	None	0.0
Jss	Bottom source junction reverse saturation current density	A/m^2	1.0e-4

Name	Description	Units	Default
Jsws	Isolation edge sidewall source junction reverse saturation current density	A/m	0.0
Jswgs	Gate edge source junction reverse saturation current density	A/m	0.0
Pbs	Source junction built-in potential	V	1.0
Njs	Source junction emission coefficient	None	1.0
Xtis	Source junction current temperature exponent	None	3.0
Mjs	Source bottom junction capacitance grading coefficient	None	0.5
Pbsws	Source sidewall junction capacitance built-in potential	V	1.0
Mjsws	Source sidewall junction capacitance grading coefficient	None	0.33
Pbswgs	Source gate side sidewall junction capacitance built-in potential; defaults to Pbsws	V	defaults to Pbsws
Mjswgs	Source gate side sidewall junction capacitance grading coefficient; defaults to Mjsws	None	defaults to Mjsws
Cjs	Source bottom junction capacitance per unit area	F/m^2	5.0e-4
Cjsws	Source sidewall junction capacitance per unit periphery	F/m	5.0e-10
Cjswgs	Source gate side sidewall junction capacitance per unit width; defaults to Cjsws	F/m	defaults to Cjsws
Jsd	Bottom drain junction reverse saturation current density; defaults to Jss	A/m^2	defaults to Jss
Jswd	Isolation edge sidewall drain junction reverse saturation current density; defaults to Jsws	A/m	defaults to Jsws
Jswgd	Gate edge drain junction reverse saturation current density; defaults to Jswgs	None	defaults to Jswgs

Name	Description	Units	Default
Pbd	Drain junction built-in potential; defaults to Pbs	V	None
Njd	Drain junction emission coefficient; defaults to Njs	None	defaults to Njs
Xtid	Drain junction current temperature exponent; defaults to Xtis	None	defaults to Xtis
Mjd	Drain bottom junction capacitance grading coefficient; defaults to Mjs	None	defaults to Mjs
Pbswd	Drain sidewall junction capacitance built-in potential; defaults to Pbsws	V	defaults to Pbsws
Mjswd	Drain sidewall junction capacitance grading coefficient; defaults to Mjsws	None	None
Pbswgd	Drain gate side sidewall junction capacitance built-in potential; defaults to Pbswgs	V	None
Mjswgd	Drain gate side sidewall junction capacitance grading coefficient; defaults to Mjswgs	None	None
Cjd	Drain bottom junction capacitance per unit area; defaults to Cjs	F/m^2	None
Cjswd	Drain sidewall junction capacitance per unit periphery; defaults to Cjsws	F/m	None
Cjswgd	Drain gate side sidewall junction capacitance per unit width; defaults to Cjswg	F/m	None
Vfbcv	Flat Band Voltage parameter for capmod	V	-1.0
Vfb	Flat Band Voltage	V	-1.0
Tpb	Temperature coefficient of pb	V/K	0.0
Tcj	Temperature coefficient of cj	K^{-1}	0.0
Tpbsw	Temperature coefficient of pbsw	V/K	0.0

Name	Description	Units	Default
Tcjsw	Temperature coefficient of cjsw	K^{-1}	0.0
Tpbswg	Temperature coefficient of pbswg	V/K	0.0
Tcjswg	Temperature coefficient of cjswg	K^{-1}	0.0
Acde	Exponential coefficient for finite charge thickness	m/V	1.0
Moin	Coefficient for gate-bias dependent surface potential	None	15.0
Noff	C-V turn-on/off parameter	None	1.0
Voffcv	C-V lateral-shift parameter	V	0.0
Dmcg	Distance of Mid-Contact to Gate edge	m	0.0
Dmci	Distance of Mid-Contact to Isolation; defaults to Dmcg	m	defaults to Dmcg
Dmdg	Distance of Mid-Diffusion to Gate edge	m	0.0
Dmcgt	Distance of Mid-Contact to Gate edge in Test structures	m	0.0
Xgw	Distance from gate contact center to device edge	m	0.0
Xgl	Variation in Ldrawn	m	0.0
Rshg	Gate sheet resistance	Ohm/sq	0.1
Ngcon	Number of gate contacts	None	1.0
Xrcrg1	First fitting parameter the bias-dependent Rg	None	12.0
Xrcrg2	Second fitting parameter the bias-dependent Rg	None	1.0
Xw	W offset for channel width due to mask/etch effect	m	None
Xl	L offset for channel width due to mask/etch effect	m	None

Name	Description	Units	Default
Lambda	Velocity overshoot parameter	$m^3/(V \times s)$	0.0
Vtl	Thermal velocity	m/s	2.0e5
Lc	Velocity back scattering parameter	m	5.0e-9
Xn	Velocity back scattering coefficient	None	3.0
Vfbsdoff	S/D flatband voltage offset	V	0.0
Lintnoi	Lint offset for noise calculation	m	0.0
Lint	Length reduction parameter	m	0.0
Ll	Length reduction parameter	m	0.0
Llc	Length reduction parameter for CV	m	0.0
Lln	Length reduction parameter	None	1.0
Lw	Length reduction parameter	m	0.0
Lwc	Length reduction parameter for CV; defaults to Lw	m	defaults to Lw
Lwn	Length reduction parameter	None	1.0
Lwl	Length reduction parameter	m	0.0
Lwlc	Length reduction parameter for CV; defaults to Lwl	m	defaults to Lwl
Lmin	Minimum length for the model	m	0.0
Lmax	Maximum length for the model	m	1.0
Wr	Width dependence of rds	None	1.0
Wint	Width reduction parameter	m	0.0

Name	Description	Units	Default
Dwg	Width reduction parameter	m/V	0.0
Dwb	Width reduction parameter	$m/V^{(1/2)}$	0.0
Wl	Width reduction parameter	m	0.0
Wlc	Width reduction parameter for CV; defaults to WI	m	defaults to WI
Wln	Width reduction parameter	None	1.0
Ww	Width reduction parameter	m	0.0
Wwc	Width reduction parameter for CV; defaults to Ww	m	defaults to Ww
Wwn	Width reduction parameter	None	1.0
Wwl	Width reduction parameter	m	0.0
Wwlc	Width reduction parameter for CV; defaults to Wwl	m	defaults to Wwl
Wmin	Minimum width for the model	m	0.0
Wmax	Maximum width for the model	m	1.0
B0	A bulk narrow width parameter	m	0.0
B1	A bulk narrow width parameter	m	0.0
Cgsl	New C-V model parameter	F/m	0.0
Cgdl	New C-V model parameter	F/m	0.0
Ckappas	S/G overlap C-V parameter	V	0.6
Ckappad	D/G overlap C-V parameter; defaults to Ckappas	V	defaults to Ckappas
Cf	Fringe capacitance parameter	F/m	calculated

Name	Description	Units	Default
Clc	Vdsat parameter for C-V model	m	1.0e-7
Cle	Vdsat parameter for C-V model	None	0.6
Dwc	Delta W for C-V model; defaults to Wint	m	defaults to Win
Dlc	Delta L for C-V model; defaults to Lint	m	defaults to Lint
Dlcig	Delta L for Ig model; defaults to Lint	m	defaults to Lint
Dwj	Delta W for S/D junctions; defaults to Dwc	None	defaults to Dwc
Alpha0	substrate current model parameter	A×m/V	0.0
Alpha1	substrate current model parameter	A/V	0.0
Beta0	substrate current model parameter	V	0.0 (for version ≥ 4.50), 30.0 (otherwise)
Agidl	Pre-exponential constant for GIDL	Ohm^{-1}	0.0
Bgidl	Exponential constant for GIDL	V/m	2.3e9
Cgidl	Parameter for body-bias dependence of GIDL	V^3	0.5
Egidl	Fitting parameter for bandbending	V	0.8
Aigc	Parameter for Igc	None	0.43 (NMOS)
Bigc	Parameter for Igc	None	0.054 (NMOS)
Cigc	Parameter for Igc	V^{-1}	0.075 (NMOS)
Aigsd	Parameter for Igs,d	None	0.043 (NMOS)
Bigsd	Parameter for Igs,d	None	0.054 (NMOS)

Name	Description	Units	Default
Cigsd	Parameter for Igs,d	V^{-1}	0.075 (NMOS)
Aigbacc	Parameter for Igb	None	1.36e-2 (for version ≥ 4.50), 0.43 (otherwise)
Bigbacc	Parameter for Igb	None	1.71e-3 (for version ≥ 4.50), 0.054 (otherwise)
Cigbacc	Parameter for Igb	V^{-1}	0.075
Aigbinv	Parameter for Igb	None	1.11e-2 (for version ≥ 4.50), 0.35 (otherwise)
Bigbinv	Parameter for Igb	None	9.49e-4 (for version ≥ 4.50), 0.03 (otherwise)
Cigbinv	Parameter for Igb	V^{-1}	0.006
Nigc	Parameter for Igc slope	None	1.0
Nigbinv	Parameter for Igbinv slope	None	3.0
Nigbacc	Parameter for Igbacc slope	None	1.0
Ntox	Exponent for Tox ratio	None	1.0
Eigbinv	Parameter for the Si bandgap for Igbinv	V	1.1
Pigcd	Parameter for Igc partition	None	1.0
Poxedge	Factor for the gate edge Tox	None	1.0
Ijthdfwd	Forward drain diode forward limiting current; defaults to Ijthsfwd	A	defaults to Ijthsfwd
Ijthsfwd	Forward source diode forward limiting current	A	0.1
Ijthdrev	Reverse drain diode forward limiting current; defaults to Ijthsrev	A	defaults to Ijthsrev

Name	Description	Units	Default
Ijthsrev	Reverse source diode forward limiting current	A	0.1
Xjbvd	Fitting parameter for drain diode breakdown current; defaults to Xjbvs	None	defaults to Xjbvs
Xjbvs	Fitting parameter for source diode breakdown current	None	1.0
Bvd	Drain diode breakdown voltage; defaults to Bvs	V	defaults to Bvs
Bvs	Source diode breakdown voltage	V	10.0
Gbmin	Minimum body conductance	Ohm^{-1}	1.0e-12
Jtss	Source bottom trap-assisted saturation current density	None	0.0
Jtsd	Drain bottom trap-assisted saturation current density	None	0.0
Jtssws	Source STI sidewall trap-assisted saturation current density	None	0.0
Jtsswd	Drain STI sidewall trap-assisted saturation current density	None	0.0
Jtsswgs	Source gate-edge sidewall trap-assisted saturation current density	None	0.0
Jtsswgd	Drain gate-edge sidewall trap-assisted saturation current density	None	0.0
Njts	Non-ideality factor for bottom junction	None	20.0
Njtssw	Non-ideality factor for STI sidewall junction	None	20.0
Njtsswg	Non-ideality factor for gate-edge sidewall junction	None	20.0
Xtss	Power dependence of Jtss on temperature	None	0.02
Xtsd	Power dependence of Jtsd on temperature	None	0.02

Name	Description	Units	Default
Xtssws	Power dependence of Jtssws on temperature	None	0.02
Xtsswd	Power dependence of Jtsswd on temperature	None	0.02
Xtsswgs	Power dependence of Jtsswgs on temperature	None	0.02
Xtsswgd	Power dependence of Jtsswgd on temperature	None	0.02
Tnjts	Temperature coefficient for Njts	None	0.0
Tnjtssw	Temperature coefficient for Njtssw	None	0.0
Tnjtsswg	Temperature coefficient for Njtsswg	None	0.0
Vtss	Source bottom trap-assisted voltage dependent parameter	None	10.0
Vtsd	Drain bottom trap-assisted voltage dependent parameter	None	10.0
Vtssws	Source STI sidewall trap-assisted voltage dependent parameter	None	10.0
Vtsswd	Drain STI sidewall trap-assisted voltage dependent parameter	None	10.0
Vtsswgs	Source gate-edge sidewall trap-assisted voltage dependent parameter	None	10.0
Vtsswgd	Drain gate-edge sidewall trap-assisted voltage dependent parameter	None	10.0
Rbdb	Resistance between bNode and dbNode	Ohm	50.0
Rbpb	Resistance between bNodePrime and bNode	Ohm	50.0
Rbsb	Resistance between bNode and sbNode	Ohm	50.0
Rbps	Resistance between bNodePrime and sbNode	Ohm	50.0

Name	Description	Units	Default
Rbpd	Resistance between bNodePrime and bNode	Ohm	50.0
Lcdsc	Length dependence of cdsc	None	0.0
Lcdscb	Length dependence of cdscb	None	0.0
Lcdscd	Length dependence of cdscd	None	0.0
Lcit	Length dependence of cit	None	0.0
Lnfactor	Length dependence of nfactor	None	0.0
Lxj	Length dependence of xj	None	0.0
Lvsat	Length dependence of vsat	None	0.0
Lat	Length dependence of at	None	0.0
La0	Length dependence of a0	None	0.0
Lags	Length dependence of ags	None	0.0
La1	Length dependence of a1	None	0.0
La2	Length dependence of a2	None	0.0
Lketa	Length dependence of keta	None	0.0
Lnsub	Length dependence of nsub	None	0.0
Lndep	Length dependence of ndep	None	0.0
Lnsd	Length dependence of nsd	None	0.0
Lphin	Length dependence of phin	None	0.0
Lngate	Length dependence of ngate	None	0.0

Name	Description	Units	Default
Lgamma1	Length dependence of gamma1	None	0.0
Lgamma2	Length dependence of gamma2	None	0.0
Lvbx	Length dependence of vbx	None	0.0
Lvbm	Length dependence of vbm	None	0.0
Lxt	Length dependence of xt	None	0.0
Lk1	Length dependence of k1	None	0.0
Lkt1	Length dependence of kt1	None	0.0
Lkt1l	Length dependence of kt1l	None	0.0
Lkt2	Length dependence of kt2	None	0.0
Lk2	Length dependence of k2	None	0.0
Lk3	Length dependence of k3	None	0.0
Lk3b	Length dependence of k3b	None	0.0
Lw0	Length dependence of w0	None	0.0
Ldvtp0	Length dependence of dvtp0	None	0.0
Ldvtp1	Length dependence of dvtp1	None	0.0
Llpe0	Length dependence of lpe0	None	0.0
Llpeb	Length dependence of lpeb	None	0.0
Ldvt0	Length dependence of dvt0	None	0.0
Ldvt1	Length dependence of dvt1	None	0.0

Name	Description	Units	Default
Ldvt2	Length dependence of dvt2	None	0.0
Ldvt0w	Length dependence of dvt0w	None	0.0
Ldvt1w	Length dependence of dvt1w	None	0.0
Ldvt2w	Length dependence of dvt2w	None	0.0
Ldrout	Length dependence of drout	None	0.0
Ldsub	Length dependence of dsub	None	0.0
Lvth0	Length dependence of vto	None	0.0
Lua	Length dependence of ua	None	0.0
Lua1	Length dependence of ua1	None	0.0
Lub	Length dependence of ub	None	0.0
Lub1	Length dependence of ub1	None	0.0
Luc	Length dependence of uc	None	0.0
Luc1	Length dependence of uc1	None	0.0
Lu0	Length dependence of u0	None	0.0
Lute	Length dependence of ute	None	0.0
Lvoff	Length dependence of voff	None	0.0
Lminv	Length dependence of minv	None	0.0
Ldelta	Length dependence of delta	None	0.0
Lrdsw	Length dependence of rdsw	None	0.0

Name	Description	Units	Default
Lrsw	Length dependence of rsw	None	0.0
Lrdw	Length dependence of rdw	None	0.0
Lprwg	Length dependence of prwg	None	0.0
Lprwb	Length dependence of prwb	None	0.0
Lprt	Length dependence of prt	None	0.0
Leta0	Length dependence of eta0	None	0.0
Letab	Length dependence of etab	None	0.0
Lpclm	Length dependence of pclm	None	0.0
Lpdiblc1	Length dependence of pdiblc1	None	0.0
Lpdiblc2	Length dependence of pdiblc2	None	0.0
Lpdiblcb	Length dependence of pdiblcb	None	0.0
Lfprout	Length dependence of pdiblcb	None	0.0
Lpdits	Length dependence of pdits	None	0.0
Lpditsd	Length dependence of pditsd	None	0.0
Lpscbe1	Length dependence of pscbe1	None	0.0
Lpscbe2	Length dependence of pscbe2	None	0.0
Lpvag	Length dependence of pvag	None	0.0
Lwr	Length dependence of wr	None	0.0
Ldwg	Length dependence of dwg	None	0.0

Name	Description	Units	Default
Ldwb	Length dependence of dwb	None	0.0
Lb0	Length dependence of b0	None	0.0
Lb1	Length dependence of b1	None	0.0
Lcgsl	Length dependence of cgsl	None	0.0
Lcgdl	Length dependence of cgdl	None	0.0
Lckappas	Length dependence of ckappas	None	0.0
Lckappad	Length dependence of ckappad	None	0.0
Lcf	Length dependence of cf	None	0.0
Lclc	Length dependence of clc	None	0.0
Lcle	Length dependence of cle	None	0.0
Lalpha0	Length dependence of alpha0	None	0.0
Lalpha1	Length dependence of alpha1	None	0.0
Lbeta0	Length dependence of beta0	None	0.0
Lagidl	Length dependence of agidl	None	0.0
Lbgidl	Length dependence of bgidl	None	0.0
Lcgidl	Length dependence of cgidl	None	0.0
Legidl	Length dependence of egidl	None	0.0
Laigc	Length dependence of aigc	None	0.0
Lbigc	Length dependence of bigc	None	0.0

Name	Description	Units	Default
Lcigc	Length dependence of cigc	None	0.0
Laigsd	Length dependence of aigsd	None	0.0
Lbigsd	Length dependence of bigsd	None	0.0
Lcigsd	Length dependence of cigsd	None	0.0
Laigbacc	Length dependence of aigbacc	None	0.0
Lbigbacc	Length dependence of bigbacc	None	0.0
Lcigbacc	Length dependence of cigbacc	None	0.0
Laigbinv	Length dependence of aigbinv	None	0.0
Lbigbinv	Length dependence of bigbinv	None	0.0
Lcigbinv	Length dependence of cigbinv	None	0.0
Lnigc	Length dependence of nigc	None	0.0
Lnigbinv	Length dependence of nigbinv	None	0.0
Lnigbacc	Length dependence of nigbacc	None	0.0
Lntox	Length dependence of ntox	None	0.0
Leigbinv	Length dependence for eigbinv	None	0.0
Lpigcd	Length dependence for pigcd	None	0.0
Lpoxedge	Length dependence for poxedge	None	0.0
Lvfbcv	Length dependence of vfbcv	None	0.0
Lvfb	Length dependence of vfb	None	0.0

Name	Description	Units	Default
Lacde	Length dependence of acde	None	0.0
Lmoin	Length dependence of moin	None	0.0
Lnoff	Length dependence of noff	None	0.0
Lvoffcv	Length dependence of voffcv	None	0.0
Lxrcrg1	Length dependence of xrcrg1	None	0.0
Lxrcrg2	Length dependence of xrcrg2	None	0.0
Llambda	Length dependence of Lambda	None	0.0
Lvtl	Length dependence of Vtl	None	0.0
Lxn	Length dependence of Xn	None	0.0
Leu	Length dependence of eu	None	0.0
Lvfbsdoff	Length dependence of Vfbsdoff	None	0.0
Wcdsc	Width dependence of cdsc	None	0.0
Wcdscb	Width dependence of cdscb	None	0.0
Wcdscd	Width dependence of cdscd	None	0.0
Wcit	Width dependence of cit	None	0.0
Wnfactor	Width dependence of nfactor	None	0.0
Wxj	Width dependence of xj	None	0.0
Wvsat	Width dependence of vsat	None	0.0
Wat	Width dependence of at	None	0.0

Name	Description	Units	Default
Wa0	Width dependence of a0	None	0.0
Wags	Width dependence of ags	None	0.0
Wa1	Width dependence of a1	None	0.0
Wa2	Width dependence of a2	None	0.0
Wketa	Width dependence of keta	None	0.0
Wnsub	Width dependence of nsub	None	0.0
Wndep	Width dependence of ndep	None	0.0
Wnsd	Width dependence of nsd	None	0.0
Wphin	Width dependence of phin	None	0.0
Wngate	Width dependence of ngate	None	0.0
Wgamma1	Width dependence of gamma1	None	0.0
Wgamma2	Width dependence of gamma2	None	0.0
Wvbx	Width dependence of vbx	None	0.0
Wvbm	Width dependence of vbm	None	0.0
Wxt	Width dependence of xt	None	0.0
Wk1	Width dependence of k1	None	0.0
Wkt1	Width dependence of kt1	None	0.0
Wkt1l	Width dependence of kt1l	None	0.0
Wkt2	Width dependence of kt2	None	0.0

Name	Description	Units	Default
Wk2	Width dependence of k2	None	0.0
Wk3	Width dependence of k3	None	0.0
Wk3b	Width dependence of k3b	None	0.0
Ww0	Width dependence of w0	None	0.0
Wdvtp0	Width dependence of dvtp0	None	0.0
Wdvtp1	Width dependence of dvtp1	None	0.0
Wlpe0	Width dependence of lpe0	None	0.0
Wlpeb	Width dependence of lpeb	None	0.0
Wdvt0	Width dependence of dvt0	None	0.0
Wdvt1	Width dependence of dvt1	None	0.0
Wdvt2	Width dependence of dvt2	None	0.0
Wdvt0w	Width dependence of dvt0w	None	0.0
Wdvt1w	Width dependence of dvt1w	None	0.0
Wdvt2w	Width dependence of dvt2w	None	0.0
Wdrout	Width dependence of drout	None	0.0
Wdsub	Width dependence of dsub	None	0.0
Wvth0	Width dependence of vto	None	0.0
Wua	Width dependence of ua	None	0.0
Wua1	Width dependence of ua1	None	0.0

Name	Description	Units	Default
Wub	Width dependence of ub	None	0.0
Wub1	Width dependence of ub1	None	0.0
Wuc	Width dependence of uc	None	0.0
Wuc1	Width dependence of uc1	None	0.0
Wu0	Width dependence of u0	None	0.0
Wute	Width dependence of ute	None	0.0
Wvoff	Width dependence of voff	None	0.0
Wminv	Width dependence of minv	None	0.0
Wdelta	Width dependence of delta	None	0.0
Wrdsw	Width dependence of rdsw	None	0.0
Wrsw	Width dependence of rsw	None	0.0
Wrdw	Width dependence of rdw	None	0.0
Wprwg	Width dependence of prwg	None	0.0
Wprwb	Width dependence of prwb	None	0.0
Wprt	Width dependence of prt	None	0.0
Weta0	Width dependence of eta0	None	0.0
Wetab	Width dependence of etab	None	0.0
Wpclm	Width dependence of pclm	None	0.0
Wpdiblc1	Width dependence of pdiblc1	None	0.0

Name	Description	Units	Default
Wpdiblc2	Width dependence of pdiblc2	None	0.0
Wpdiblcb	Width dependence of pdiblcb	None	0.0
Wfprout	Width dependence of pdiblcb	None	0.0
Wpdits	Width dependence of pdits	None	0.0
Wpditsd	Width dependence of pditsd	None	0.0
Wpscbe1	Width dependence of pscbe1	None	0.0
Wpscbe2	Width dependence of pscbe2	None	0.0
Wpvag	Width dependence of pvag	None	0.0
Wwr	Width dependence of wr	None	0.0
Wdwg	Width dependence of dwg	None	0.0
Wdwb	Width dependence of dwb	None	0.0
Wb0	Width dependence of b0	None	0.0
Wb1	Width dependence of b1	None	0.0
Wcgsl	Width dependence of cgsl	None	0.0
Wcgdl	Width dependence of cgdl	None	0.0
Wckappas	Width dependence of ckappas	None	0.0
Wckappad	Width dependence of ckappad	None	0.0
Wcf	Width dependence of cf	None	0.0
Wclc	Width dependence of clc	None	0.0

Name	Description	Units	Default
Wcle	Width dependence of cle	None	0.0
Walpha0	Width dependence of alpha0	None	0.0
Walpha1	Width dependence of alpha1	None	0.0
Wbeta0	Width dependence of beta0	None	0.0
Wagidl	Width dependence of agidl	None	0.0
Wbgidl	Width dependence of bgidl	None	0.0
Wcgidl	Width dependence of cgidl	None	0.0
Wegidl	Width dependence of egidl	None	0.0
Waigc	Width dependence of aigc	None	0.0
Wbigc	Width dependence of bigc	None	0.0
Wcigc	Width dependence of cigc	None	0.0
Waigsd	Width dependence of aigsd	None	0.0
Wbigsd	Width dependence of bigsd	None	0.0
Wcigsd	Width dependence of cigsd	None	0.0
Waigbacc	Width dependence of aigbacc	None	0.0
Wbigbacc	Width dependence of bigbacc	None	0.0
Wcigbacc	Width dependence of cigbacc	None	0.0
Waigbinv	Width dependence of aigbinv	None	0.0
Wbigbinv	Width dependence of bigbinv	None	0.0

Name	Description	Units	Default
Wcigbinv	Width dependence of cigbinv	None	0.0
Wnigc	Width dependence of nigc	None	0.0
Wnigbinv	Width dependence of nigbinv	None	0.0
Wnigbacc	Width dependence of nigbacc	None	0.0
Wntox	Width dependence of ntox	None	0.0
Weigbinv	Width dependence for eigbinv	None	0.0
Wpigcd	Width dependence for pigcd	None	0.0
Wpoxedge	Width dependence for poxedge	None	0.0
Wvfbcv	Width dependence of vfbcv	None	0.0
Wvfb	Width dependence of vfb	None	0.0
Wacde	Width dependence of acde	None	0.0
Wmoin	Width dependence of moin	None	0.0
Wnoff	Width dependence of noff	None	0.0
Wvoffcv	Width dependence of voffcv	None	0.0
Wxrcrg1	Width dependence of xrcrg1	None	0.0
Wxrcrg2	Width dependence of xrcrg2	None	0.0
Wlambda	Width dependence of Lambda	None	0.0
Wvtl	Width dependence of Vtl	None	0.0
Wxn	Width dependence of Xn	None	0.0

Name	Description	Units	Default
Weu	Width dependence of eu	None	0.0
Wvfbsdoff	Width dependence of Vfbsdoff	None	0.0
Pcdsc	Cross-term dependence of cdsc	None	0.0
Pcdscb	Cross-term dependence of cdscb	None	0.0
Pcdscd	Cross-term dependence of cdscd	None	0.0
Pcit	Cross-term dependence of cit	None	0.0
Pnfactor	Cross-term dependence of nfactor	None	0.0
Pxj	Cross-term dependence of xj	None	0.0
Pvsat	Cross-term dependence of vsat	None	0.0
Pat	Cross-term dependence of at	None	0.0
Pa0	Cross-term dependence of a0	None	0.0
Pags	Cross-term dependence of ags	None	0.0
Pa1	Cross-term dependence of a1	None	0.0
Pa2	Cross-term dependence of a2	None	0.0
Pketa	Cross-term dependence of keta	None	0.0
Pnsub	Cross-term dependence of nsub	None	0.0
Pndep	Cross-term dependence of ndep	None	0.0
Pnsd	Cross-term dependence of nsd	None	0.0
Pphin	Cross-term dependence of phin	None	0.0

Name	Description	Units	Default
Pngate	Cross-term dependence of ngate	None	0.0
Pgamma1	Cross-term dependence of gamma1	None	0.0
Pgamma2	Cross-term dependence of gamma2	None	0.0
Pvbx	Cross-term dependence of vbx	None	0.0
Pvbm	Cross-term dependence of vbm	None	0.0
Pxt	Cross-term dependence of xt	None	0.0
Pk1	Cross-term dependence of k1	None	0.0
Pkt1	Cross-term dependence of kt1	None	0.0
Pkt1l	Cross-term dependence of kt1l	None	0.0
Pkt2	Cross-term dependence of kt2	None	0.0
Pk2	Cross-term dependence of k2	None	0.0
Pk3	Cross-term dependence of k3	None	0.0
Pk3b	Cross-term dependence of k3b	None	0.0
Pw0	Cross-term dependence of w0	None	0.0
Pdvtp0	Cross-term dependence of dvtp0	None	0.0
Pdvtp1	Cross-term dependence of dvtp1	None	0.0
Plpe0	Cross-term dependence of lpe0	None	0.0
Plpeb	Cross-term dependence of lpeb	None	0.0
Pdvt0	Cross-term dependence of dvt0	None	0.0

Name	Description	Units	Default
Pdvt1	Cross-term dependence of dvt1	None	0.0
Pdvt2	Cross-term dependence of dvt2	None	0.0
Pdvt0w	Cross-term dependence of dvt0w	None	0.0
Pdvt1w	Cross-term dependence of dvt1w	None	0.0
Pdvt2w	Cross-term dependence of dvt2w	None	0.0
Pdrout	Cross-term dependence of drout	None	0.0
Pdsub	Cross-term dependence of dsub	None	0.0
Pvth0	Cross-term dependence of vto	None	0.0
Pua	Cross-term dependence of ua	None	0.0
Pua1	Cross-term dependence of ua1	None	0.0
Pub	Cross-term dependence of ub	None	0.0
Pub1	Cross-term dependence of ub1	None	0.0
Puc	Cross-term dependence of uc	None	0.0
Puc1	Cross-term dependence of uc1	None	0.0
Pu0	Cross-term dependence of u0	None	0.0
Pute	Cross-term dependence of ute	None	0.0
Pvoff	Cross-term dependence of voff	None	0.0
Pminv	Cross-term dependence of minv	None	0.0
Pdelta	Cross-term dependence of delta	None	0.0

Name	Description	Units	Default
Prdsw	Cross-term dependence of rdsw	None	0.0
Prsw	Cross-term dependence of rsw	None	0.0
Prdw	Cross-term dependence of rdw	None	0.0
Pprwg	Cross-term dependence of prwg	None	0.0
Pprwb	Cross-term dependence of prwb	None	0.0
Pprt	Cross-term dependence of prt	None	0.0
Peta0	Cross-term dependence of eta0	None	0.0
Petab	Cross-term dependence of etab	None	0.0
Ppclm	Cross-term dependence of pclm	None	0.0
Ppdiblc1	Cross-term dependence of pdiblc1	None	0.0
Ppdiblc2	Cross-term dependence of pdiblc2	None	0.0
Ppdiblcb	Cross-term dependence of pdiblcb	None	0.0
Pfprout	Cross-term dependence of pdiblcb	None	0.0
Ppdits	Cross-term dependence of pdits	None	0.0
Ppditsd	Cross-term dependence of pditsd	None	0.0
Ppscbe1	Cross-term dependence of pscbe1	None	0.0
Ppscbe2	Cross-term dependence of pscbe2	None	0.0
Ppvag	Cross-term dependence of pvag	None	0.0
Pwr	Cross-term dependence of wr	None	0.0

Name	Description	Units	Default
Pdwg	Cross-term dependence of dwg	None	0.0
Pdwb	Cross-term dependence of dwb	None	0.0
Pb0	Cross-term dependence of b0	None	0.0
Pb1	Cross-term dependence of b1	None	0.0
Pcgsl	Cross-term dependence of cgsl	None	0.0
Pcgdl	Cross-term dependence of cgdl	None	0.0
Pckappas	Cross-term dependence of ckappas	None	0.0
Pckappad	Cross-term dependence of ckappad	None	0.0
Pcf	Cross-term dependence of cf	None	0.0
Pclc	Cross-term dependence of clc	None	0.0
Pcle	Cross-term dependence of cle	None	0.0
Palpha0	Cross-term dependence of alpha0	None	0.0
Palpha1	Cross-term dependence of alpha1	None	0.0
Pbeta0	Cross-term dependence of beta0	None	0.0
Pagidl	Cross-term dependence of agidl	None	0.0
Pbgidl	Cross-term dependence of bgidl	None	0.0
Pcgidl	Cross-term dependence of cgidl	None	0.0
Pegidl	Cross-term dependence of egidl	None	0.0
Paigc	Cross-term dependence of aigc	None	0.0

Name	Description	Units	Default
Pbigc	Cross-term dependence of bigc	None	0.0
Pcigc	Cross-term dependence of cigc	None	0.0
Paigsd	Cross-term dependence of aigsd	None	0.0
Pbigsd	Cross-term dependence of bigsd	None	0.0
Pcigsd	Cross-term dependence of cigsd	None	0.0
Paigbacc	Cross-term dependence of aigbacc	None	0.0
Pbigbacc	Cross-term dependence of bigbacc	None	0.0
Pcigbacc	Cross-term dependence of cigbacc	None	0.0
Paigbinv	Cross-term dependence of aigbinv	None	0.0
Pbigbinv	Cross-term dependence of bigbinv	None	0.0
Pcigbinv	Cross-term dependence of cigbinv	None	0.0
Pnigc	Cross-term dependence of nigc	None	0.0
Pnigbinv	Cross-term dependence of nigbinv	None	0.0
Pnigbacc	Cross-term dependence of nigbacc	None	0.0
Pntox	Cross-term dependence of ntox	None	0.0
Peigbinv	Cross-term dependence for eigbinv	None	0.0
Ppigcd	Cross-term dependence for pigcd	None	0.0
Ppoxedge	Cross-term dependence for poxedge	None	0.0
Pvfbcv	Cross-term dependence of vfbcv	None	0.0

Name	Description	Units	Default
Pvfb	Cross-term dependence of vfb	None	0.0
Pacde	Cross-term dependence of acde	None	0.0
Pmoin	Cross-term dependence of moin	None	0.0
Pnoff	Cross-term dependence of noff	None	0.0
Pvoffcv	Cross-term dependence of voffcv	None	0.0
Pxrcrg1	Cross-term dependence of xrcrg1	None	0.0
Pxrcrg2	Cross-term dependence of xrcrg2	None	0.0
Plambda	Cross-term dependence of Lambda	None	0.0
Pvtl	Cross-term dependence of Vtl	None	0.0
Pxn	Cross-term dependence of Xn	None	0.0
Peu	Cross-term dependence of eu	None	0.0
Pvfbsdoff	Cross-term dependence of Vfbsdoff	None	0.0
Saref	Reference distance between OD edge to poly of one side	m	1.0e-6
Sbref	Reference distance between OD edge to poly of the other side	m	1.0e-6
Wlod	Width parameter for stress effect	m	0.0
Ku0	Mobility degradation/enhancement coefficient for LOD	m	0.0
Kvsat	Saturation velocity degradation/enhancement parameter for LOD	m	0.0
Kvth0	Threshold shift parameter for LOD	V×m	0.0

Name	Description	Units	Default
Tku0	Temperature coefficient of Ku0	None	0.0
Llodku0	Length parameter for U0 LOD effect	None	0.0
Wlodku0	Width parameter for U0 LOD effect	None	0.0
Llodvth	Length parameter for Vth LOD effect	None	0.0
Wlodvth	Width parameter for Vth LOD effect	None	0.0
Lku0	Length dependence of Ku0	None	0.0
Wku0	Width dependence of Ku0	None	0.0
Pku0	Cross-term dependence of Ku0	None	0.0
Lkvth0	Length dependence of Kvth0	None	0.0
Wkvth0	Width dependence of Kvth0	None	0.0
Pkvth0	Cross-term dependence of Kvth0	None	0.0
Stk2	K2 shift factor related to stress effect on Vth	m	0.0
Lodk2	K2 shift modification factor for stress effect	None	1.0
Steta0	Eta0 shift factor related to stress effect on Vth	m	0.0
Lodeta0	Eta0 shift modification factor for stress effect	None	1.0
Noia	Flicker noise parameter	None	6.25e41 (NMOS),
Noib	Flicker noise parameter	None	3.125e26 (NMOS),
Noic	Flicker noise parameter	None	8.75e9
Tnoia	Thermal noise parameter	None	1.5

Name	Description	Units	Default
Tnoib	Thermal noise parameter	None	3.5
Rnoia	Thermal noise coefficient	None	0.577
Rnoib	Thermal noise coefficient	None	0.5164
Ntnoi	Thermal noise parameter	None	1.0
Em	Flicker noise parameter	V/m	4.1e7
Ef	Flicker noise frequency exponent	None	1.0
Af	Flicker noise exponent	None	1.0
Kf	Flicker noise coefficient	None	0.0
Tlev	Temperature equation selector (0/1/2/3)		0
Tlevc	Temperature equation selector for capacitance (0/1/2/3)		1
Eg	Band Gap	eV	1.16
Gap1	Energy gap temperature coefficient alpha	V/°C	7.04e-4
Gap2	Energy gap temperature coefficient beta	K	1108
L	Channel length	m	None
W	Channel width	m	None
Ad	Drain area	m^2	None
As	Source area	m^2	None
Pd	Drain perimeter	m	None
Ps	Source perimeter	m	None

Name	Description	Units	Default
Nrd	Drain squares	None	None
Nrs	Source squares	None	None
Imelt	Explosion current similar to Imax; defaults to Imax (refer to note 13)	A	defaults to Imax
wBvsub	substrate junction reverse breakdown voltage warning	V	None
wBvds	gate oxide breakdown voltage warning	V	None
wBvds	drain-source breakdown voltage warning	V	None
wIdsmax	maximum drain-source current warning	A	None
wPmax	maximum power dissipation warning	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None
Ud	Mobility Coulumb scattering coefficient	m^{-2}	0.0 for version ≥4.61, 1e14 otherwise
Ud1	Temperature coefficient for Ud	m^{-2}	0.0
Up	Mobility channel length coefficient	m^{-2}	0
Lp	Mobility channel length exponential coefficient	m	1e-8
Tvoff	Temperature coefficient of Voff	K^{-1}	0.0
Tvfbsdoff	Temperature coefficient of Vfbsdoff	K^{-1}	0.0
Lud	Length dependence of Ud	None	0.0
Lud1	Length dependence of Ud1	None	0.0
Lup	Length dependence of Up	None	0.0

Name	Description	Units	Default
L1p	Length dependence of Lp	None	0.0
Ltvoff	Length dependence of Tvoff	None	0.0
Ltvfbsdoff	Length dependence of Tvfbsdoff	None	0.0
Wud	Width dependence of Ud	None	0.0
Wud1	Width dependence of Ud1	None	0.0
Wup	Width dependence of Up	None	0.0
Wip	Width dependence of Lp	None	0.0
Wtvoff	Width dependence of Tvoff	None	0.0
Wtvfbsdoff	Width dependence of Tvfbsdoff	None	0.0
Pud	Cross-term dependence of Ud	None	0.0
Pud1	Cross-term dependence of Ud1	None	0.0
Pup	Cross-term dependence of Up	None	0.0
P1p	Cross-term dependence of Lp	None	0.0
Ptvoff	Cross-term dependence of Tvoff	None	0.0
Ptvfbsdoff	Cross-term dependence of Tvfbsdoff	None	0.0
Rbps0	Scaling prefactor for Rbps	Ohm	50
Rbps1	Length Scaling parameter for Rbps	None	0.0
Rbpsw	Width Scaling parameter for Rbps	None	0.0
Rbpsnf	Number of fingers Scaling parameter for Rbps	None	0.0

Name	Description	Units	Default
Rbpd0	Scaling prefactor for Rbpd	Ohm	50
Rbpd1	Length Scaling parameter for Rbpd	None	0.0
Rbpdw	Width Scaling parameter for Rbpd	None	0.0
Rbpdnf	Number of fingers Scaling parameter for Rbpd	None	0.0
Rbpbx0	Scaling prefactor for Rbpbx	Ohm	100
Rbpbx1	Length Scaling parameter for Rbpbx	None	0.0
Rbpbxw	Width Scaling parameter for Rbpbx	None	0.0
Rbpbxnf	Number of fingers Scaling parameter for Rbpbx	None	0.0
Rbpby0	Scaling prefactor for Rbpby	Ohm	100
Rbpby1	Length Scaling parameter for Rbpby	None	0.0
Rbpbyw	Width Scaling parameter for Rbpby	None	0.0
Rbpbynf	Number of fingers Scaling parameter for Rbpby	None	0.0
Rbsbx0	Scaling prefactor for Rbsbx	Ohm	100
Rbsby0	Scaling prefactor for Rbsby	Ohm	100
Rbdbx0	Scaling prefactor for Rbdbx	Ohm	100
Rbdby0	Scaling prefactor for Rbdby	Ohm	100
Rbsdbx1	Length Scaling parameter for Rbsbx and Rbdbx	None	0.0
Rbsdbxw	Width Scaling parameter for Rbsbx and Rbdbx	None	0.0
Rbsdbxnf	Number of fingers Scaling parameter for Rbsbx and Rbdbx	None	0.0

Name	Description	Units	Default
Rbsdby1	Length Scaling parameter for Rbsby and Rbdby	None	0.0
Rbsdbyw	Width Scaling parameter for Rbsby and Rbdby	None	0.0
Rbsdbynf	Number of fingers Scaling parameter for Rbsby and Rbdby	None	0.0
Wpemod	Flag for well proximity effect model (Wpemod=1 to activate this model)	None	0
Web	Coefficient for Scb	None	0.0
Wec	Coefficient for Scc	None	0.0
Ktvh0we	Threshold shift factor for well proximity effect	None	0.0
K2we	K2 shift factor for well proximity effect	None	0.0
Ku0we	Mobility degradation factor for well proximity effect	None	0.0
Scref	Reference distance to calculate Sca, Scb and Scc	m	1e-6
Lkvth0we	Length dependence of Kvth0we	None	0.0
Lk2we	Length dependence of K2we	None	0.0
Lku0we	Length dependence of Ku0we	None	0.0
Wkvth0we	Width dependence of Kvth0we	None	0.0
Wk2we	Width dependence of K2we	None	0.0
Wku0we	Width dependence of Ku0we	None	0.0
Pkvth0we	Cross-term dependence of Kvth0we	None	0.0
Pk2we	Cross-term dependence of K2we	None	0.0

Name	Description	Units	Default
Pku0we	Cross-term dependence of Ku0we	None	0.0
Cvchargemod	Threshold voltage for C-V model selector	None	0
Mtrlmod	New material model selector	None	0
Eot	Equivalent gate oxide thickness	m	1.5e-9
Vddeot	Gate voltage at which EOT is measured	V	1.5 (NMOS), -1.5 (PMOS)
Ados	Density of states parameter to control charge centroid	None	1
Bdos	Density of states parameter to control charge centroid	None	1
Phig	Work function of gate	None	4.05
Epsrgate	Dielectric constant of gate relative to vacuum	None	11.7
Easub	Electron affinity of substrate	eV	4.05
Epsrsub	Dielectric constant of substrate relative to vacuum	None	11.7
Ni0sub	Intrinsic carrier concentration of substrate at 300.15K	cm^{-3}	1.45e10
Bg0sub	Band-gap of substrate at T=0K	eV	1.16
Tbgasub	First parameter of band-gap change due to temperature	eV/K	7.02e-4
Tbgbsub	Second parameter of band-gap change due to temperature	K	1108.0
Minvcv	Fitting parameter for moderate inversion in Vgsteffcv	None	0
Voffcvl	Length dependence parameter for Vth offset in CV	None	0
Dlcigd	Delta L for Ig model drain side	m	default to Dlcig

Name	Description	Units	Default
Agisl	Pre-exponential constant for GISL	Ohm^{-1}	default to Agidl
Bgisl	Exponential constant for GISL	V/m	default to Bgidl
Cgisl	Parameter for body-bias dependence of GISL	V^3	default to Cgidl
Egisl	Fitting parameter for Bandbending	V	default to Egidl
Aigs	Parameter for Igs	None	1.36e-2 (NMOS), 9.8e-3 (PMOS)
Bigs	Parameter for Igs	None	1.71e-3 (NMOS), 7.59e-4 (PMOS)
Cigs	Parameter for Igs	None	0.075 (NMOS), 0.03 (PMOS)
Aigd	Parameter for Igd	None	1.36e-2 (NMOS), 9.8e-3 (PMOS)
Bigd	Parameter for Igd	None	1.71e-3 (NMOS), 7.59e-4 (PMOS)
Cigd	Parameter for Igd	None	0.075 (NMOS), 0.03 (PMOS)
Njtsd	Non-ideality factor for bottom junction drain side	None	default to Njts
Njtsswd	Non-ideality factor for STI sidewall junction drain side	None	default to Njtssw
Njtsswgd	Non-ideality factor for gate-edge sidewall junction drain side	None	default to Njtsswg
Tnjtsd	Temperature coefficient for Njtsd	None	default to Tnjts
Tnjtsswd	Temperature coefficient for Njtsswd	None	default to Tnjtssw
Tnjtsswgd	Temperature coefficient for Njtsswgd	None	default to Tnjtsswg

Name	Description	Units	Default
Lminvcv	Length dependence of Minvcv	None	0
Lagisl	Length dependence of Agisl	None	0
Lbgisl	Length dependence of Bgisl	None	0
Lcgisl	Length dependence of Cgisl	None	0
Legisl	Length dependence of Egisl	None	0
Laigs	Length dependence of Aigs	None	0
Lbigs	Length dependence of Bigs	None	0
Lcigs	Length dependence of Cigs	None	0
Laigd	Length dependence of Aigd	None	0
Lbigd	Length dependence of Bigd	None	0
Lcigd	Length dependence of Cigd	None	0
Wminvcv	Width dependence of Minvcv	None	0
Wagisl	Width dependence of Agisl	None	0
Wbgisl	Width dependence of Bgisl	None	0
Wcgisl	Width dependence of Cgisl	None	0
Wegisl	Width dependence of Egisl	None	0
Waigs	Width dependence of Aigs	None	0
Wbigs	Width dependence of Bigs	None	0
Wcigs	Width dependence of Cigs	None	0

Name	Description	Units	Default
Waigd	Width dependence of Aigd	None	0
Wbigd	Width dependence of Bigd	None	0
Wcigd	Width dependence of Cigd	None	0
Pminvcv	Cross-term dependence of Minvcv	None	0
Pagisl	Cross-term dependence of Agisl	None	0
Pbgisl	Cross-term dependence of Bgisl	None	0
Pcgisl	Cross-term dependence of Cgisl	None	0
Pegisl	Cross-term dependence of Egisl	None	0
Paigs	Cross-term dependence of Aigs	None	0
Pbigs	Cross-term dependence of Bigs	None	0
Pcigs	Cross-term dependence of Cigs	None	0
Paigd	Cross-term dependence of Aigd	None	0
Pbigd	Cross-term dependence of Bigd	None	0
Pcigd	Cross-term dependence of Cigd	None	0
Tempeot	Temperature for extraction of EOT	Kelvin	300.15
Leffeot	Effective length for extraction of EOT	um	1.0
Weffeot	Effective width for extraction of EOT	um	10.0
Ucs	Colombic scattering exponent	None	1.67 (NMOS), 1.0 (PMOS)
Ucste	Temperature coefficient of colombic mobility	None	-4.775e-3

Name	Description	Units	Default
Jtweff	TAT current width dependance	None	0.0
Lucste	Length dependence of ucste	None	0.0
Lucs	Length dependence of ucs	None	0.0
Wucste	Width dependence of ucste	None	0.0
Wucs	Width dependence of ucs	None	0.0
Pucste	Cross-term dependence of ucste	None	0.0
Pucs	Cross-term dependence of ucs	None	0.0

- Several DC, AC, and capacitance parameters can be binned as described in the parameters table; these parameters follow this implementation:

  $$P = P_0 + \frac{P_L}{L_{eff}} + \frac{P_w}{W_{eff}} + \frac{P_p}{L_{eff} \times W_{eff}}$$

  For example, for the parameter K1, the following relationships exist: P_0=k1, P_L=lk1, P_W=wk1, P_P=pk1. The Binunit parameter is a binning unit selector. If Binunit=1, the units of L_{eff} and W_{eff} used in the preceding binning equation have units of microns, otherwise meters. For example, for a device with L_{eff}=0.5mm and W_{eff}=10mm, if Binunit=1, parameter values are le5, le4, 2e4, and 3e4 for Vsat, Lvsat, Wvsat, and Pvsat, respectively, Therefore, the effective value of Vsat for this device is:

  > *Vsat = 1e5 + 1e4/0.5 + 2e4/10 + 3e4/(0.5 × 10) = 1.28e5*

  To get the same effective value of Vsat for Binunit=0, values of Vsat, Lvsat, Wvsat, and Pvsat would be 1e5, le2, 2e2, 3e8, respectively. Thus:

  > *Vsat = 1e5 + 1e-2/0.5e6 + 2e2/10e6 + 3e 8/(0.5e-6 × 10e6) = 1.28e5*

- DC operating point data is generated for this model. If a DC simulation is performed, device operating point data can be viewed for a component. The procedure for viewing device operating point data for a component is in Using Circuit Simulators. The device operating point information that is displayed for the BSIM4 model is:

> *Gm: small-signal Vgs to Ids transconductance, in Siemens*
> *Gmb: small-signal Vbs to Ids transconductance, in Siemens*
> *Gds: small-signal drain source conductance, in Siemens*
> *Vth: threshold voltage, in volts*
> *Vdsat: saturation voltage, in volts*
> *DqgDvgb: small-signal transcapacitance dQg/dVg, in farads*
> *DqgDvdb: small-signal transcapacitance dQg/dVd, in farads*
> *DqgDvsb: small-signal transcapacitance dQg/dVs, in farads*
> *DqbDvgb: small-signal transcapacitance dQb/dVg, in farads*
> *DqbDvdb: small-signal transcapacitance dQb/dVd, in farads*
> *DqbDvsb: small-signal transcapacitance dQb/dVs, in farads*
> *DqdDvgb: small-signal transcapacitance dQd/dVg, in farads*
> *DqdDvdb: small-signal transcapacitance dQd/dVd, in farads*
> *DqdDvsb: small-signal transcapacitance dQd/dVs, in farads*

- If 1 is not given, it is calculated by

$$\gamma_1 = \frac{\sqrt{2q\varepsilon_{si}NDEP}}{C_{oxe}}$$

If 2 is not given, it is calculated by

$$\gamma_2 = \frac{\sqrt{2q\varepsilon_{si}NSUB}}{C_{oxe}}$$

- If *NDEP* is not given and 1 is given, *NDEP*is calculated from

$$NDEP = \frac{\gamma_1^2 C_{oxe}}{2q\varepsilon_{si}}^2$$

If both 1 and *NDEP* are not given, *NDEP* defaults to 1.7e17cm^{-3} and is calculated from *NDEP*
- If *VBX* is not given, it is calculated by

$$\frac{qNDEP \times XT^2}{2\varepsilon_{si}} = (\Phi_s - VBX)$$

- If *VTH*0 is not given it is calculated by

$$VTH0 = VFB + \Phi_s + K1\sqrt{\Phi_s} - V_{bs}$$

where *VFB* = -1.0
If *VTH* 0 is given, *VFB*defaults to

$$VFB = VTH0 - \Phi_s - K1\sqrt{\Phi_s - V_{bs}}$$

- If K_1 and $K_2$are not given, they are calculated by

$$K1 = \gamma_2 - 2K2\sqrt{\Phi_s - VBM}$$

$$K2 = \frac{(\gamma_1 - \gamma_2)(\sqrt{\Phi_s - VBX} - \sqrt{\Phi_s})}{2\sqrt{\Phi_s}(\sqrt{\Phi_s - VBM} - \sqrt{\Phi_s}) + VBM}$$

- If *Cgso* is not given, it is calculated by:
  If *DLC*is given and > 0.0

  Cgso = DLC × C oxe - CGSL
  if Cgso < 0.0, CGSO = 0.0

  Else

  CGSO = 0.6 × XJ × C oxe

  If *CGDO* is not given, it is calculated by:
  If *DLC*is given and > 0.0

  CGDO = DLC × C oxe - CGDL
  if CGDO < 0.0, CGDO = 0.0

  Else

  CGDO = 0.6 × XJ × C oxe

  If *CGBO*is not given, it is calculated by:

  CGBO = 2 × DWC × C oxe
- If *CF*is not given, it is calculated by

$$CF = \frac{2 \times EPSROX \times \varepsilon_0}{\pi} \times \log\left(1 + \frac{4.0e-7}{TOXE}\right)$$

- For dioMod = 0, if Xjbvs < 0.0, it is reset to 1.0
  For dioMod = 2, if Xjbvs 0.0, it is reset to 1.0
  For dioMod = 0, if Xjbvd < 0.0, it is reset to 1.0
  For dioMod = 2, if Xjbvd 0.0, it is reset to 1.0
- Imelt, Ijth, Ijthsfwd, Ijthsrev, Ijthdfwd, and Ijthdrev Parameters
  Imelt, Ijth, Ijthsfwd, Ijthsrev, Ijthdfwd, and Ijthdrev are used to determine the different diode limiting currents (also known as P-N junction explosion current).
  Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value. Ijth can be specified only in the Options component.
  If Ijthsfwd is not specified and Ijth is specified, Ijthsfwd = Ijth.
  If Ijthsrev is not specified and Ijth is specified, Ijthsrev = Ijth.
  If Ijthdfwd is not specified and Ijth is specified, Ijthdfwd = Ijth.
  If Ijthdrev is not specified and Ijth is specified, Ijthdrev = Ijth.
  If the Imelt value is less than the maximum value of Ijthsfwd, Ijthsrev, Ijthdfwd, and Ijthdrev, the Imelt value is increased to the maximum value.
  If Imelt is specified (in the model or in Options) all diode limiting currents (Ijthsfwd, Ijthsrev, Ijthdfwd, and Ijthdrev) = Imelt; otherwise, each diode limiting current is used to limit its own diode current.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to DataAccessComponent (Data Access Component)). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model  modelname  BSIM4 \[parm=value\]\*
```

The model statement starts with the required keyword *model* . It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *BSIM4* . Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

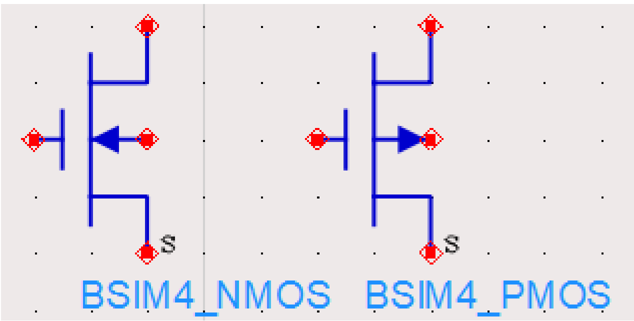
Example

```
model Nch7 BSIM4 \
Vtho=0.7 Cjs=3e-4 NMOS=yes
```

BSIM4 NMOS, BSIM4 PMOS (BSIM4 Transistor, NMOS, PMOS)

BSIM4_NMOS, BSIM4_PMOS (BSIM4 Transistor, NMOS, PMOS)

Symbol



Parameters

Model parameters must be specified in SI units

Name	Description	Units	Default
Model	model instance name	None	BSIM4M1
Length †	channel length	m	5.0e-6
Width †	channel width	m	5.0e-6
Nf	number of fingers	None	1.0
Sa †	distance between outer diameter edge to poly of one side	m	0.0
Sb †	distance between outer diameter edge to poly of the other side	m	0.0
Sd †	distance between neighboring fingers	m	0.0
Min	minimize either D or S	None	0
Ad †	Drain area	m^2	0.0
As †	Source area	m^2	0.0
Pd †	Drain perimeter	m	0.0
Ps †	Source perimeter	m	0.0

Nrd	number of squares in drain	None	1.0
Nrs	number of squares in source	None	1.0
Off	device is initially off	None	0.0
Rbdb	body resistance; defaults to Rbdb model	None	defaults to Rbdb model
Rbsb	body resistance; defaults to Rbsb model	None	defaults to Rbsb model
Rbpb	body resistance; defaults to Rbpb model	None	defaults to Rbpb model
Rbps	body resistance; defaults to Rbps model	None	defaults to Rbps model
Rbpd	body resistance; defaults to Rbpd model	None	defaults to Rbpd model
Trnqsmod	transient NQS model selector; defaults to Trnqsmod model	None	defaults to Trnqsmod model
Acnqsmod	AC NQS model selector; defaults to Acnqsmod model	None	defaults to Acnqsmod model
Rbodymod	distributed model R model selector; defaults to Rbodymod model	None	defaults to Rbodymod model
Rgatemod	gate resistance model selector; defaults to Rgatemod model	None	defaults to Rgatemod model
Geomod	geometry dependent parasitics model selector; defaults to Geomod model	None	defaults to Geomod model
Rgeomod	source/drain resistance and contact model selector; defaults to Rgeomod model	None	defaults to Rgeomod model
Temp	device operating temperature	°C	25
Mode	simulation mode: Nonlinear, Linear, Standard (refer to note 1)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
_M	number of devices in parallel	None	1
Sc	Distance to a single well edge	m	0.0
Sca	Integral of the first distribution function for scattered well dopant	None	0.0
Scb	Integral of the second distribution function for scattered well dopant	None	0.0
Scc	Integral of the third distribution function for scattered well dopant	None	0.0

Xgw	Distance from the gate contact to the channel edge	m	model Xgw
Ngcon	Number of gate contacts	None	model Ngcon
† Each instance parameter whose dimension contains a power of meter will be multiplied by the Scale to the same power. For example, a parameter with a dimension of *m* will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. Note that only parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains *cm* instead of meter is not scaled.			

- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Ib	Bulk current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gmb	Backgate transconductance (dIds/dVbs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Vth	Threshold voltage	volts
Vdsat	Drain-source saturation voltage	volts
DqgDvgb	(dQg/dVgb)	farads

Name	Description	Units
DqgDvdb	(dQg/dVdb)	farads
DqgDvsb	(dQg/dVsb)	farads
DqbDvgb	(dQb/dVgb)	farads
DqbDvdb	(dQb/dVdb)	farads
DqbDvsb	(dQb/dVsb)	farads
DqdDvgb	(dQd/dVgb)	farads
DqdDvdb	(dQd/dVdb)	farads
DqdDvsb	(dQd/dVsb)	farads
Vgs	Internal gate-internal source voltage	volts
Vds	Internal drain-internal source voltage	volts
Vbs	Internal bulk-internal source voltage	volts
Vgms	Midgate-source voltage	volts
Vges	External gate-source voltage	volts
Vdbs	Drain body-internal source voltage	volts
Vsbs	Source body-internal source voltage	volts

BSIM6 Model (BSIM6 MOSFET Model and Instance)

BSIM6_Model (BSIM6 MOSFET Model and Instance)

This topic lists the model and instance parameters.

Description

BSIM6 was developed by the Device Research Group of the Department of Electrical Engineering and Computer Science, University of California, Berkeley and copyrighted by the University of California. More information about this model, visit http://bsim.berkeley.edu/models/bsimbulk/.

NOTE This component is not available in the library browser, component palette, or component history. You must use a netlist fragment and include it using the NetlistInclude component. For more information on creating model netlist see, Netlist Format section.

Model Parameters

Name	Description
COVMOD	Bias-independent overlap capacitance:0
RDSMOD	Internal RDS:0
GIDLMOD	Turn off GIDL model:0
IGCMOD	0: Turn off Igc
IGBMOD	0: Turn off Igb
TNOIMOD	Thermal noise model selector
LLONG	Length of extracted long channel device
XL	Channel length offset due to mask/ etch effects
WWIDE	Width of extracted long channel device
XW	Channel width offset due to mask/ etch effects

Name	Description
LINT	Length reduction parameter (dopant diffusion effect
LL	Coefficient of length dependence for length offset
LW	Coefficient of width dependence for length offset
LWL	Coefficient of length and width cross term dependence for length offset
LLN	Power of length dependence for length offset
LWN	Power of width dependence for length offset
WINT	Width reduction parameter (dopant diffusion effect
WL	Coefficient of length dependence for width offset
WW	Coefficient of width dependence for width offset
WWL	Coefficient of length and width cross term dependence for width offset
WLN	Power of length dependence of width offset
WWN	Power of width dependence of width offset
DLC	Length reduction parameter for CV (dopant diffusion effect)
LLC	Coefficient of length dependence for CV channel length offset
LWC	Coefficient of width dependence for CV channel length offset
LWLC	Coefficient of length and width cross-term dependence for CV channel length offset
DWC	Width reduction parameter for CV (dopant diffusion effect)
WLC	Coefficient of length dependence for CV channel width offset
WWC	Coefficient of width dependence for CV channel width offset

Name	Description
WWLC	Coefficient of length and width cross-term dependence for CV channel width offset
TOXE	Effective gate dielectric thickness relative to SiO2
TOXP	Physical gate dielectric thickness
DTOX	Difference between effective dielectric thickness and physical thickness
NDEP	channel (body)
NDEPL1	Length dependence coefficient of NDEP
NDEPLEXP1	Length dependence exponent coefficient of NDEP
NDEPL2	Length dependence of NDEP - For Short Channel Devices
NDEPLEXP2	Length dependence exponent coefficient of NDEP
NDEPW	Width dependence coefficient of NDEP
NDEPWEXP	Width-Length dependence coefficient of NDEP
NDEPWL	Width-Length dependence coefficient of NDEP
NDEPWLEXP	Width-Length dependence exponent coefficient of NDEP
LNDEP	Length-dependence of NDEP
WNDEP	Width-dependence of NDEP
PNDEP	Cross-term dependence of NDEP
NDEPCV	channel (body)
NDEPCVL1	Length dependence coefficient of NDEPCV
NDEPCVLEXP1	Length dependence exponent coefficient of NDEPCV

Name	Description
NDEPCVL2	Length dependence coefficient of NDEPCV - For Short Channel Devices
NDEPCVLEXP2	Length dependence exponent coefficient of NDEPCV
NDEPCVW	Width dependence coefficient of NDEPCV
NDEPCVWEXP	Width dependence exponent coefficient of NDEPCV
NDEPCVWL	Width-Length dependence coefficient of NDEPCV
NDEPCVWLEXP	Width-Length dependence exponent coefficient of NDEPCV
LNDEPCV	Length-dependence of NDEPCV
WNDEPCV	Width-dependence of NDEPCV
PNDEPCV	Cross-term-dependence of NDEPCV
NGATE	Gate Doping Concentration
LNGATE	Length-dependence of NGATE
WNGATE	Width-dependence of NGATE
PNGATE	Cross-term-dependence of NGATE
EASUB	Electron affinity of substrate
NI0SUB	intrinsic carrier concentration of channel at 300.15K
BG0SUB	Band gap of substrate at 300.15K
EPSRSUB	relative dielectric constant of the channel material
EPSROX	relative dielectric constant of the gate insulator
XJ	S/D junction depth

Name	Description
LXJ	Length-dependence of XJ
WXJ	Width-dependence of XJ
PXJ	Cross-term-dependence of XJ
VFB	Flat band Voltage
LVFB	Length-dependence of VFB
WVFB	Width-dependence of VFB
PVFB	Cross-term-dependence of VFB
VFBCV	Flat band voltage for CV
LVFBCV	Length-dependence of VFBCV
WVFBCV	Width-dependence of VFBCV
PVFBCV	NULL
VFBCVL	Length dependence coefficient of VFBCV
VFBCVLEXP	Length dependence exponent coefficient of VFBCV
VFBCVW	Width dependence coefficient of VFBCV
VFBCVWEXP	Width dependence exponent coefficient of VFBCV
VFBCVWL	Width-Length dependence coefficient of VFBCV
VFBCVWLEXP	Width-Length dependence coefficient of VFBCV
PERMOD	Whether PS/PD (when given)
DWJ	Offset of the S/D junction width

Name	Description
VFBSDOFF	Flatband Voltage Offset Parameter
NSD	S/D doping concentration
LNSD	Length-dependence of NSD
WNSD	Width-dependence of NSD
PNSD	Cross-term-dependence of NSD
DVTP0	Coefficient of drain-induced Vth shift for long channel devices with pocket implant
LDVTP0	Length-dependence of DVTP0
WDVTP0	Width-dependence of DVTP0
PDVTP0	Cross-term-dependence of DVTP0
DVTP1	Coefficient of drain-induced Vth shift for long channel devices with pocket implant
LDVTP1	Length-dependence of DVTP1
WDVTP1	Width-dependence of DVTP1
PDVTP1	Cross-term-dependence of DVTP1
DVTP2	Coefficient of drain-induced Vth shift for long channel devices with pocket implant
LDVTP2	Length-dependence of DVTP2
WDVTP2	Width-dependence of DVTP2
PDVTP2	Cross-term-dependence of DVTP2
DVTP3	Coefficient of drain-induced Vth shift for long channel devices with pocket implant

Name	Description
LDVTP3	Length-dependence of DVTP3
WDVTP3	Width-dependence of DVTP3
PDVTP3	Cross-term-dependence of DVTP3
DVTP4	Coefficient of drain-induced Vth shift for long channel devices with pocket implant
LDVTP4	Length-dependence of DVTP4
WDVTP4	Width-dependence of DVTP4
PDVTP4	Cross-term-dependence of DVTP4
DVTP5	Coefficient of drain-induced Vth shift for long channel devices with pocket implant
LDVTP5	Length-dependence of DVTP5
WDVTP5	Width-dependence of DVTP5
PDVTP5	Cross-term-dependence of DVTP5
PHIN	Vertical nonuniform doping effect on surface potential
LPHIN	Length-dependence of PHIN
WPHIN	Width-dependence of PHIN
PPHIN	Cross-term-dependence of PHIN
ETA0	DIBL coefficient
LETA0	Length-dependence of ETA0
WETA0	Width-dependence of ETA0

Name	Description
PETA0	Cross-term-dependence of ETA0
DSUB	DIBL exponent coefficient
ETAB	Body bias sensitivity to DIBL effect
ETABEXP	Exponent coefficient of ETAB
LETAB	Length-dependence of ETAB
WETAB	Width-dependence of ETAB
PETAB	Cross-term-dependence of ETAB
K2	Vth shift due to nonuniform vertical doping.
K2L	Length dependence coefficient of K2
K2LEXP	Length dependence exponent coefficient of K2
K2W	Width dependence coefficient of K2
K2WEXP	Width dependence exponent coefficient of K2
K2WL	Width-Length dependence coefficient of K2
K2WLEXP	Width-Length dependence exponent coefficient of K2
LK2	Length-dependence of K2
WK2	Width-dependence of K2
PK2	Cross-term-dependence of K2
ADOS	Quantum mechanical effect prefactor switch in inversion
BDOS	Charge centroid parameter - slope of CV curve under QME in inversion

Name	Description
QM0	Charge centroid parameter - starting point for QME in inversion
ETAQM	Bulk charge coefficient for charge centroid in inversion
CIT	Interface trap capacitance
LCIT	Length-dependence of CIT
WCIT	Width-dependence of CIT
PCIT	Cross-term-dependence of CIT
NFACTOR	Subthreshold Swing factor
NFACTORL	Length dependence coefficient of NFACTOR
NFACTORLEXP	Length dependence exponent coefficient of NFACTOR
NFACTORW	Width dependence coefficient of NFACTOR
NFACTORWEXP	Width dependence exponent coefficient of NFACTOR
NFACTORWL	Width-Length dependence coefficient of NFACTOR
NFACTORWLEXP	Width-Length dependence exponent coefficient of NFACTOR
LNFACTOR	Length-dependence of NFACTOR
WNFACTOR	Width-dependence of NFACTOR
PNFACTOR	Cross-term-dependence of NFACTOR
CDSCD	Drain-bias sensitivity of Subthreshold Swing
CDSCDL	Length dependence coefficient of CDSCD
CDSCDLEXP	Length dependence exponent coefficient of CDSCD

Name	Description
LCDSCD	Length-dependence of CDSCD
WCDSCD	Width-dependence of CDSCD
PCDSCD	Cross-term-dependence of CDSCD
CDSCB	Body-bias sensitivity of sub-threshold slope
CDSCBL	Length dependence coefficient of CDSCB
CDSCBLEXP	Length dependence exponent coefficient of CDSCB
LCDSCB	Length-dependence of CDSCB
WCDSCB	Width-dependence of CDSCB
PCDSCB	Cross-term-dependence of CDSCB
VSAT	Saturation velocity.
LVSAT	Length-dependence of VSAT
WVSAT	Width-dependence of VSAT
PVSAT	Cross-term-dependence of VSAT
VSATL	Length dependence coefficient of VSAT
VSATLEXP	Length dependence exponent coefficient of VSAT
VSATW	Width dependence coefficient of VSAT
VSATWEXP	Width dependence exponent coefficient of VSAT
VSATWL	Width-Length dependence coefficient of VSAT
VSATWLEXP	Width-Length dependence exponent coefficient of VSAT

Name	Description
DELTA	Smoothing function factor for Vds to Vdsat
LDELTA	Length-dependence of DELTA
WDELTA	Width-dependence of DELTA
PDELTA	Cross-term-dependence of DELTA
DELTAL	Length dependence coefficient of DELTA
DELTALEXP	Length dependence exponent coefficient of DELTA
VSATCV	Saturation velocity for CV.
LVSATCV	Length-dependence of VSATCV
WVSATCV	Width-dependence of VSATCV
PVSATCV	Cross-term-dependence of VSATCV
VSATCVL	Length dependence coefficient of VSATCV
VSATCVLEXP	Length dependence exponent coefficient of of VSATCV
VSATCVW	Width dependence coefficient of VSATCV
VSATCVWEXP	Width dependence exponent coefficient of VSATCV
VSATCVWL	Width-Length dependence coefficient of VSATCV
VSATCVWLEXP	Width-Length dependence exponent coefficient of VSATCV
U0	Low field mobility.
U0L	Length dependence coefficient of U0
U0LEXP	Length dependence exponent coefficient of U0L

Name	Description
LU0	Length-dependence of U0
WU0	Width-dependence of U0
PU0	Cross-term-dependence of U0
ETAMOB	effective field parameter
UA	Mobility reduction coefficient
UAL	Length dependence coefficient of UA
UALEXP	Length dependence exponent coefficient of UA
UAW	Width dependence coefficient of UA
UAWEXP	Width dependence exponent coefficient of UA
UAWL	Width-Length dependence coefficient of UA
UAWLEXP	Width-Length dependence exponent coefficient of UA
LUA	Length-dependence of UA
WUA	Width-dependence of UA
PUA	Cross-term-dependence of UA
EU	Mobility reduction exponent
LEU	Length-dependence of EU
WEU	Width-dependence of EU
PEU	Cross-term-dependence of EU
EUL	Length dependence coefficient of EU

Name	Description
EULEXP	Length dependence exponent coefficient of EU
EUW	Width dependence coefficient of EU
EUWEXP	Width dependence exponent coefficient of EU
EUWL	Width-Length dependence coefficient of EU
EUWLEXP	Width-Length dependence exponent coefficient of EU
UD	Coulombic scattering parameter
UDL	Length dependence coefficient of UD
UDLEXP	Length dependence exponent coefficient of UD
LUD	Length-dependence of UD
WUD	Width-dependence of UD
PUD	Cross-term-dependence of UD
UCS	Coulombic scattering parameter
LUCS	Length-dependence of UCS
WUCS	Width-dependence of UCS
PUCS	Cross-term-dependence of UCS
UC	Body-bias sensitivity on mobility
UCL	Length dependence coefficient of UC
UCLEXP	Length dependence exponent coefficient of UC
UCW	Width dependence coefficient of UC

Name	Description
UCWEXP	Width dependence exponent coefficient of UC
UCWL	Width-Length dependence coefficient of UC
UCWLEXP	Width-Length dependence exponent coefficient of UC
LUC	Length-dependence of UC
WUC	Width-dependence of UC
PUC	Cross-term-dependence of UC
PCLM	Channel Length Modulation (CLM)
PCLML	Length dependence coefficient of PCLM
PCLMLEXP	Length dependence exponent coefficient of PCLM
LPCLM	Length-dependence of PCLM
WPCLM	Width-dependence of PCLM
PPCLM	Cross-term-dependence of PCLM
PCLMG	Gate bias dependent parameter for channel Length Modulation (CLM)
PCLMCV	Channel Length Modulation (CLM)
PCLMCVL	Length dependence coefficient of PCLMCV
PCLMCVLEXP	Length dependence exponent coefficient of PCLMCV
LPCLMCV	Length-dependence of PCLMCV
WPCLMCV	Width-dependence of PCLMCV
PPCLMCV	Cross-term-dependence of PCLMCV

Name	Description
PSCBE1	Substrate current body-effect coefficient
LPSCBE1	Length-dependence of PSCBE1
WPSCBE1	Width-dependence of PSCBE1
PPSCBE1	Cross-term-dependence of PSCBE1
PSCBE2	Substrate current body-effect coefficient
LPSCBE2	Length-dependence of PSCBE2
WPSCBE2	Width-dependence of PSCBE2
PPSCBE2	Cross-term-dependence of PSCBE2
PDITS	Drain-induced Vth shift
LPDITS	Length-dependence of PDITS
WPDITS	Width-dependence of PDITS
PPDITS	Cross-term-dependence of PDITS
PDITSL	L dependence of Drain-induced Vth shift
PDITSD	VDS dependence of Drain-induced Vth shift
LPDITSD	Length-dependence of PDITSD
WPDITSD	Width-dependence of PDITSD
PPDITSD	Cross-term-dependence of PDITSD
RSH	Sheet resistance
PRWG	gate bias dependence of S/D extension resistance

Name	Description
LPRWG	Length-dependence of PRWG
WPRWG	Width-dependence of PRWG
PPRWG	Cross-term-dependence of PRWG
PRWB	body bias dependence of S/D extension resistance
LPRWB	Length-dependence of PRWB
WPRWB	Width-dependence of PRWB
PPRWB	Cross-term-dependence of PRWB
PRWBL	Length dependence coefficient of PRWB
PRWBLEXP	Length dependence exponent coefficient of PRWB
WR	W dependence parameter of S/D extension resistance
LWR	Length-dependence of WR
WWR	Width-dependence of WR
PWR	Cross-term-dependence of WR
RSWMIN	source extension resistance per unit width at high Vgs
LRSWMIN	Length-dependence of RSWMIN
WRSWMIN	Width-dependence of RSWMIN
PRSWMIN	Cross-term-dependence of RSWMIN
RSW	Zero bias source extension resistance per unit width.
LRSW	Length-dependence of RSW

Name	Description
WRSW	Width-dependence of RSW
PRSW	Cross-term-dependence of RSW
RSWL	Geometrical scaling of RSW (RDSMOD=1)
RSWLEXP	Geometrical scaling of RSW (RDSMOD=1)
RDWMIN	Drain extension resistance per unit width at high Vgs
LRDWMIN	Length-dependence of RDWMIN
WRDWMIN	Width-dependence of RDWMIN
PRDWMIN	Cross-term-dependence of RDWMIN
RDW	Zero bias drain extension resistance per unit width.
LRDW	Length-dependence of RDW
WRDW	Width-dependence of RDW
PRDW	Cross-term-dependence of RDW
RDWL	Geometrical scaling of RDW (RDSMOD=1)
RDWLEXP	Geometrical scaling of RDW (RDSMOD=1)
RDSWMIN	LDD resistance per unit width at high Vgs for RDSMOD = 0
LRDSWMIN	Length-dependence of RDSWMIN
WRDSWMIN	Width-dependence of RDSWMIN
PRDSWMIN	Cross-term-dependence of RDSWMIN
RDSW	Zero bias LDD resistance per unit width for RDSMOD=0.

Name	Description
RDSWL	Geometrical scaling of RDSW (RDSMOD=0)
RDSWLEXP	Geometrical scaling of RDSW (RDSMOD=0)
LRDSW	Length-dependence of RDSW
WRDSW	Width-dependence of RDSW
PRDSW	Cross-term-dependence of RDSW
PSAT	Velocity saturation exponent
LPSAT	Length-dependence of PSAT
WPSAT	Width-dependence of PSAT
PPSAT	Cross-term-dependence of PSAT
PSATL	Length dependence coefficient of PSAT
PSATLEXP	Length dependence exponent coefficient of PSAT
PSATB	Velocity saturation exponent for non-zero Vbs
PSATX	Fine tuning of PTWG effect
PTWG	Correction factor for velocity saturation
LPTWG	Length-dependence of PTWG
WPTWG	Width-dependence of PTWG
PPTWG	Cross-term-dependence of PTWG
PTWGL	Length dependence coefficient of PTWG
PTWGLEXP	Length dependence exponent coefficient of PTWG

Name	Description
PDIBLC	DIBL effect on Rout.
PDIBLCL	Length dependence coefficient of PDIBLC
PDIBLCLEXP	Length dependence exponent coefficient of PDIBLC
LPDIBLC	Length-dependence of PDIBLC
WPDIBLC	Width-dependence of PDIBLC
PPDIBLC	Cross-term-dependence of PDIBLC
PDIBLCB	Body-bias sensitivity on DIBL
LPDIBLCB	Length-dependence of PDIBLCB
WPDIBLCB	Width-dependence of PDIBLCB
PPDIBLCB	Cross-term-dependence of PDIBLCB
PVAG	Vgs dependence on early voltage
LPVAG	Length-dependence of PVAG
WPVAG	Width-dependence of PVAG
PPVAG	Cross-term-dependence of PVAG
FPROUT	gds degradation factor due to pocket implant
FPROUTL	Length dependence coefficient of FPROUT
FPROUTLEXP	Length dependence exponent coefficient of FPROUT
LFPROUT	Length-dependence of FPROUT
WFPROUT	Width-dependence of FPROUT

Name	Description
PFPROUT	Cross-term-dependence of FPROUT
ALPHA0	First parameter of impact ionization current.
ALPHA0L	Length dependence coefficient of ALPHA0
ALPHA0LEXP	Length dependence exponent coefficient of ALPHA0
LALPHA0	Length-dependence of ALPHA0
WALPHA0	Width-dependence of ALPHA0
PALPHA0	Cross-term-dependence of ALPHA0
BETA0	First Vds dependent parameter of impact ionization current
LBETA0	Length-dependence of BETA0
WBETA0	Width-dependence of BETA0
PBETA0	Cross-term-dependence of BETA0
AIGBACC	Parameter for Igb
BIGBACC	Parameter for Igb
CIGBACC	Parameter for Igb
NIGBACC	Parameter for Igbacc slope
AIGBINV	Parameter for Igb
BIGBINV	Parameter for Igb
CIGBINV	Parameter for Igb
EIGBINV	Parameter for Igb

Name	Description
NIGBINV	Parameter for Igb
AIGC	Parameter for Igcs and Igcd
BIGC	Parameter for Igcs and Igcd
CIGC	Parameter for Igcs and Igcd
AIGS	Parameter for Igs
BIGS	Parameter for Igs
CIGS	Parameter for Igs
AIGD	Parameter for Igd
BIGD	Parameter for Igd
CIGD	Parameter for Igd
DLCIG	Source/Drain overlap length for Igs
DLCIGD	Source/Drain overlap length for Igd
POXEDGE	Factor for the gate oxide thickness in source/drain overlap regions
NTOX	Exponent for the gate oxide ratio
TOXREF	Nominal gate oxide thickness for gate dielectric tunneling current model only
PIGCD	Vds dependence of Igcs and Igcd
AIGCL	Length dependence coefficient of AIGC
AIGCW	Width dependence coefficient of AIGC
AIGSL	Length dependence coefficient of AIGS

Name	Description
AIGSW	Width dependence coefficient of AIGS
AIGDL	Length dependence coefficient of AIGD
AIGDW	Width dependence coefficient of AIGD
PIGCDL	Length dependence coefficient of PIGCD
LAIGBINV	Length-dependence of AIGBINV
WAIGBINV	Width-dependence of AIGBINV
PAIGBINV	Cross-term-dependence of AIGBINV
LBIGBINV	Length-dependence of BIGBINV
WBIGBINV	Width-dependence of BIGBINV
PBIGBINV	Cross-term-dependence of BIGBINV
LCIGBINV	Length-dependence of CIGBINV
WCIGBINV	Width-dependence of CIGBINV
PCIGBINV	Cross-term-dependence of CIGBINV
LEIGBINV	Length-dependence of EIGBINV
WEIGBINV	Width-dependence of EIGBINV
PEIGBINV	Cross-term-dependence of EIGBINV
LNIGBINV	Length-dependence of NIGBINV
WNIGBINV	Width-dependence of NIGBINV
PNIGBINV	Cross-term-dependence of NIGBINV

Name	Description
LAIGBACC	Length-dependence of AIGBACC
WAIGBACC	Width-dependence of AIGBACC
PAIGBACC	Cross-term-dependence of AIGBACC
LBIGBACC	Length-dependence of BIGBACC
WBIGBACC	Width-dependence of BIGBACC
PBIGBACC	Cross-term-dependence of BIGBACC
LCIGBACC	Length-dependence of CIGBACC
WCIGBACC	Width-dependence of CIGBACC
PCIGBACC	Cross-term-dependence of CIGBACC
LNIGBACC	Length-dependence of NIGBACC
WNIGBACC	Width-dependence of NIGBACC
PNIGBACC	Cross-term-dependence of NIGBACC
LAIGC	Length-dependence of AIGC
WAIGC	Width-dependence of AIGC
PAIGC	Cross-term-dependence of AIGC
LBIGC	Length-dependence of BIGC
WBIGC	Width-dependence of BIGC
PBIGC	Cross-term-dependence of BIGC
LCIGC	Length-dependence of CIGC

Name	Description
WCIGC	Width-dependence of CIGC
PCIGC	Cross-term-dependence of CIGC
LAIGS	Length-dependence of AIGS
WAIGS	Width-dependence of AIGS
PAIGS	Cross-term-dependence of AIGS
LBIGS	Length-dependence of BIGS
WBIGS	Width-dependence of BIGS
PBIGS	Cross-term-dependence of BIGS
LCIGS	Length-dependence of CIGS
WCIGS	Width-dependence of CIGS
PCIGS	Cross-term-dependence of CIGS
LAIGD	Length-dependence of AIGD
WAIGD	Width-dependence of AIGD
PAIGD	Cross-term-dependence of AIGD
LBIGD	Length-dependence of BIGD
WBIGD	Width-dependence of BIGD
PBIGD	Cross-term-dependence of BIGD
LCIGD	Length-dependence of CIGD
WCIGD	Width-dependence of CIGD

Name	Description
PCIGD	Cross-term-dependence of CIGD
LPOXEDGE	Length-dependence of POXEDGE
WPOXEDGE	Width-dependence of POXEDGE
PPOXEDGE	Cross-term-dependence of POXEDGE
LDLCIG	Length-dependence of DLCIG
WDLCIG	Width-dependence of DLCIG
PDLCIG	Cross-term-dependence of DLCIG
LDLCIGD	Length-dependence of DLCIGD
WDLCIGD	Width-dependence of DLCIGD
PDLCIGD	Cross-term-dependence of DLCIGD
LNTOX	Length-dependence of NTOX
WNTOX	Width-dependence of NTOX
PNTOX	Cross-term-dependence of NTOX
AGIDL	Pre-exponential coefficient for GIDL
AGIDLL	Length dependence coefficient of AGIDL
AGIDLW	Width dependence coefficient of AGIDL
LAGIDL	Length-dependence of AGIDL
WAGIDL	Width-dependence of AGIDL
PAGIDL	Cross-term-dependence of AGIDL

Name	Description
BGIDL	exponential coefficient for GIDL
LBGIDL	Length-dependence of BGIDL
WBGIDL	Width-dependence of BGIDL
PBGIDL	Cross-term-dependence of BGIDL
CGIDL	exponential coefficient for GIDL
LCGIDL	Length-dependence of CGIDL
WCGIDL	Width-dependence of CGIDL
PCGIDL	Cross-term-dependence of CGIDL
EGIDL	band bending parameter for GIDL
LEGIDL	Length-dependence of EGIDL
WEGIDL	Width-dependence of EGIDL
PEGIDL	Cross-term-dependence of EGIDL
AGISL	NULL
AGISLL	Pre-exponential coefficient for GISL
AGISLW	NULL
LAGISL	Length-dependence of AGISL
WAGISL	Width-dependence of AGISL
PAGISL	Cross-term-dependence of AGISL
BGISL	exponential coefficient for GISL

Name	Description
LBGISL	Length-dependence of BGISL
WBGISL	Width-dependence of BGISL
PBGISL	Cross-term-dependence of BGISL
CGISL	exponential coefficient for GISL
LCGISL	Length-dependence of CGISL
WCGISL	Width-dependence of CGISL
PCGISL	Cross-term-dependence of CGISL
EGISL	band bending parameter for GISL
LEGISL	Length-dependence of EGISL
WEGISL	Width-dependence of EGISL
PEGISL	Cross-term-dependence of EGISL
CF	Outer fringe cap
LCF	Length-dependence of CF
WCF	Width-dependence of CF
PCF	Cross-term-dependence of CF
CFRCOEFF	Outer fringe cap coefficient
CGSO	Non LDD region source-gate overlap capacitance per unit channel width
CGDO	Non LDD region drain-gate overlap capacitance per unit channel width
CGBO	Gate-substrate overlap capacitance per unit channel length

Name	Description
CGSL	Overlap capacitance between gate and lightly-doped source region
LCGSL	Length-dependence of CGSL
WCGSL	Width-dependence of CGSL
PCGSL	Cross-term-dependence of CGSL
CGDL	Overlap capacitance between gate and lightly-doped drain region
LCGDL	Length-dependence of CGDL
WCGDL	Width-dependence of CGDL
PCGDL	Cross-term-dependence of CGDL
CKAPPAS	Coefficient of bias-dependent overlap capacitance for the source side
LCKAPPAS	Length-dependence of CKAPPAS
WCKAPPAS	Width-dependence of CKAPPAS
PCKAPPAS	Cross-term-dependence of CKAPPAS
CKAPPAD	Coefficient of bias-dependent overlap capacitance for the drain side
LCKAPPAD	Length-dependence of CKAPPAD
WCKAPPAD	Width-dependence of CKAPPAD
PCKAPPAD	Cross-term-dependence of CKAPPAD
DMCG	Distance from S/D contact center to the gate edge
DMCI	Distance from S/D contact center to the isolation edge in the channel-length direction
DMDG	Same as DMCG but for merged device only

Name	Description
DMCGT	DMCG of test structures
XGL	Offset of the gate length due to variations in patterning
RSHG	Gate sheet resistance Ohm
CJS	Bottom junction capacitance per unit area at zero bias
CJD	Bottom junction capacitance per unit area at zero bias
CJSWS	Isolation-edge sidewall junction capacitance per unit area
CJSWD	Isolation-edge sidewall junction capacitance per unit area
CJSWGS	Gate-edge sidewall junction capacitance per unit length
CJSWGD	Gate-edge sidewall junction capacitance per unit length
PBS	Bottom junction built-in potential
PBD	Bottom junction built-in potential
PBSWS	Isolation-edge sidewall junction built-in potential
PBSWD	Isolation-edge sidewall junction built-in potential
PBSWGS	Gate-edge sidewall junction built-in potential
PBSWGD	Gate-edge sidewall junction built-in potential
MJS	Bottom junction capacitance grating coefficient
MJD	Bottom junction capacitance grating coefficient
MJSWS	Isolation-edge sidewall junction capacitance grading coefficient
MJSWD	Isolation-edge sidewall junction capacitance grading coefficient

Name	Description
MJSWGS	Gate-edge sidewall junction capacitance grading coefficient
MJSWGD	Gate-edge sidewall junction capacitance grading coefficient
JSS	Bottom junction reverse saturation current density
JSD	Bottom junction reverse saturation current density
JSWS	Isolation-edge sidewall reverse saturation current density
JSWD	Isolation-edge sidewall reverse saturation current density
JSWGS	Gate-edge sidewall reverse saturation current density
JSWGD	Gate-edge sidewall reverse saturation current density
NJS	Emission coecients of junction for source junction
NJD	Emission coecients of junction for drain junction
IJTHSFWD	Limiting current in forward bias region
IJTHDFWD	Limiting current in forward bias region
IJTHSREV	Limiting current in reverse bias region
IJTHDREV	Limiting current in reverse bias region
BVS	Breakdown voltage
BVD	Breakdown voltage
XJBVS	Fitting parameter for diode breakdown
XJBVD	Fitting parameter for diode breakdown
JTSS	Bottom trap-assisted saturation current density

Name	Description
JTSD	Bottom trap-assisted saturation current density
JTSSWS	STI sidewall trap-assisted saturation current density
JTSSWD	STI sidewall trap-assisted saturation current density
JTSSWGS	Gate-edge sidewall trap-assisted saturation current density
JTSSWGD	Gate-edge sidewall trap-assisted saturation current density
JTWEFF	Trap-assistant tunneling current density width dependence
NJTS	Non-ideality factor for JTSS
NJTSD	Non-ideality factor for JTSD
NJTSSW	Non-ideality factor for JTSSWS
NJTSSWD	Non-ideality factor for JTSSWD
NJTSSWG	Non-ideality factor for JTSSWGS
NJTSSWGD	Non-ideality factor for JTSSWGD
VTSS	Bottom trap-assisted voltage dependent parameter
VTSD	Bottom trap-assisted voltage dependent parameter
VTSSWS	STI sidewall trap-assisted voltage dependent parameter
VTSSWD	STI sidewall trap-assisted voltage dependent parameter
VTSSWGS	Gate-edge sidewall trap-assisted voltage dependent parameter
VTSSWGD	Gate-edge sidewall trap-assisted voltage dependent parameter
XRCRG1	Parameter for distributed channel-resistance effect for both intrinsic-input resistance and charge-defficit NQS models

Name	Description
XRCRG2	Parameter to account for the excess channel diffusion resistance for both intrinsic input resistance and charge-defficit NQS models
GBMIN	Conductance in parallel with each of the five substrate resistances to avoid potential numerical instability due to unreasonably too large a substrate resistance
RBPS0	Scaling prefactor for RBPS
RBPSL	Length Scaling parameter for RBPS
RBPSW	Width Scaling parameter for RBPS
RBPSNF	Number of fingers Scaling parameter for RBPS
RBPD0	Scaling prefactor for RBPD
RBPDL	Length Scaling parameter for RBPD
RBPDW	Width Scaling parameter for RBPD
RBPDNF	Number of fingers Scaling parameter for RBPD
RBPBX0	Scaling prefactor for RBPBX
RBPBXL	Length Scaling parameter for RBPBX
RBPBXW	Width Scaling parameter for RBPBX
RBPBXNF	Number of fingers Scaling parameter for RBPBX
RBPBY0	Scaling prefactor for RBPBY
RBPBYL	Length Scaling parameter for RBPBY
RBPBYW	Width Scaling parameter for RBPBY
RBPBYNF	Number of fingers Scaling parameter for RBPY

Name	Description
RBSBX0	Scaling prefactor for RBSBX
RBSBY0	Scaling prefactor for RBSBY
RBDBX0	Scaling prefactor for RBDBX
RBDBY0	Scaling prefactor for RBDBY
RBSDBXL	Length Scaling parameter for RBSBX and RBDBX
RBSDBXW	Width Scaling parameter for RBSBX and RBDBX
RBSDBXNF	Number of Fingers Scaling parameter for RBSBX and RBDBX
RBSDBYL	Length Scaling parameter for RBSBY and RBDBY
RBSDBYW	Width Scaling parameter for RBSBY and RBDBY
RBSDBYNF	Number of fingers Scaling parameter for RBSBY and RBDBY
EF	Flicker noise frequency exponent
EM	Saturation field
NOIA	Flicker noise parameter A
NOIB	Flicker noise parameter B
NOIC	Flicker noise parameter C
LINTNOI	Length Reduction Parameter Offset
NTNOI	Noise factor for short-channel devices for TNOIMOD=0 only
RNOIA	NULL
RNOIB	NULL

Name	Description
RNOIC	NULL
TNOIA	Coefficient of channel-length dependence of total channel thermal noise
TNOIB	Channel-length dependence parameter for channel thermal noise partitioning
TNOIC	Length dependent parameter for Correlation Coefficient
TBGASUB	Bandgap Temperature Coefficient
TBGBSUB	Bandgap Temperature Coefficient
TNFACTOR	Temperature coefficient of NFACTOR
UTE	Mobility temperature exponent
LUTE	Length-dependence of UTE
WUTE	Width-dependence of UTE
PUTE	Cross-term-dependence of UTE
UTEL	Length Scaling parameter for UTE
UA1	Temperature coefficient for UA
LUA1	Length-dependence of UA1
WUA1	Width-dependence of UA1
PUA1	Cross-term-dependence of UA1
UA1L	Length Scaling parameter for UA1
UC1	Temperature coefficient for UC
LUC1	Length-dependence of UC1

Name	Description
WUC1	Width-dependence of UC1
PUC1	Cross-term-dependence of UC1
UD1	Temperature coefficient for UD
LUD1	Length-dependence of UD1
WUD1	Width-dependence of UD1
PUD1	Cross-term-dependence of UD1
UD1L	Length Scaling parameter for UD1
UCSTE	Temperature coecient of coulombic mobility
LUCSTE	Length-dependence of UCSTE
WUCSTE	Width-dependence of UCSTE
PUCSTE	Cross-term-dependence of UCSTE
TETA0	Temperature coefficient of ETA0
PRT	Temperature coefficient for Rdsw
LPRT	Length-dependence of PRT
WPRT	Width-dependence of PRT
PPRT	Cross-term-dependence of PRT
AT	Temperature coefficient for saturation velocity
LAT	Length-dependence of AT
WAT	Width-dependence of AT

Name	Description
PAT	Cross-term-dependence of AT
ATL	Length Scaling parameter for AT
TDELTA	Temperature coefficient for DELTA
PTWGT	Temperature coefficient for PTWG
LPTWGT	Length-dependence of PTWGT
WPTWGT	Width-dependence of PTWGT
PPTWGT	Cross-term-dependence of PTWGT
PTWGTL	Length Scaling parameter for PTWGT
KT1	Temperature coefficient for threshold voltage
KT1EXP	Temperature exponent for threshold voltage
KT1L	Temperature coefficient for threshold voltage
KT2	Temperature coefficient for threshold voltage
IIT	Temperature coefficient for BETA0
LIIT	Length-dependence of IIT
WIIT	Width-dependence of IIT
PIIT	Cross-term-dependence of IIT
IGT	Gate Current Temperature Dependence
LIGT	Length-dependence of IGT
WIGT	Width-dependence of IGT

Name	Description
PIGT	Cross-term-dependence of IGT
TGIDL	Temperature coefficient for GIDL/GISL
LTGIDL	Length-dependence of TGIDL
WTGIDL	Width-dependence of TGIDL
PTGIDL	Cross-term-dependence of TGIDL
TCJ	Temperature coefficient of CJ
TCJSW	Temperature coefficient of CJSW
TCJSWG	Temperature coefficient of CJSWG
TPB	Temperature coefficient of PB
TPBSW	Temperature coefficient of PBSW
TPBSWG	Temperature coefficient of PBSWG
XTIS	Junction current temperature exponents for source junction
XTID	Junction current temperature exponents for drain junction
XTSS	Power dependence of JTSS on temperature
XTSD	Power dependence of JTSD on temperature
XTSSWS	Power dependence of JTSSWS on temperature
XTSSWD	Power dependence of JTSSWD on temperature
XTSSWGS	Power dependence of JTSSWGS on temperature
XTSSWGD	Power dependence of JTSSWGD on temperature

Name	Description
TNJTS	Temperature coefficient for NJTS
TNJTSD	Temperature coefficient for NJTSD
TNJTSSW	Temperature coefficient for NJTSSW
TNJTSSWD	Temperature coefficient for NJTSSWD
TNJTSSWG	Temperature coefficient for NJTSSWG
TNJTSSWGD	Temperature coefficient for NJTSSWGD
SAREF	Reference distance between OD edge from Poly from one side
SBREF	Reference distance between OD edge from Poly from other side
WLOD	Width parameter for stress effect
KU0	Mobility degradation/enhancement coefficient for stress effect
KVSAT	Saturation velocity degradation/ enhancement parameter for stress effect (kvsat<=1)
TKU0	Temperature coefficient of KU0
LKU0	Length dependence of ku0
WKU0	Width dependence of ku0
PKU0	Cross-term dependence of ku0
LLODKU0	Length parameter for u0 stress effect (>0)
WLODKU0	Width parameter for u0 stress effect (>0)
KVTH0	Threshold shift parameter for stress effect
LKVTH0	Length dependence of kvth0

Name	Description
WKVTH0	Width dependence of kvth0
PKVTH0	Cross-term dependence of kvth0
LLODVTH	Length parameter for Vth stress effect (>0)
WLODVTH	Width parameter for Vth stress effect (>0)
STK2	K2 shift factor related to Vth0 change
LODK2	K2 shift modification factor for stress effect(>0)
STETA0	eta0 shift factor related to Vth0 change
LODETA0	eta0 shift modification factor for stress effect(>0)
WEB	Coefficient for SCB (>0.0)
WEC	Coefficient for SCC (>0.0)
KVTH0WE	Threshold shift factor for well proximity effect
K2WE	K2 shift factor for well proximity effect
KU0WE	Mobility degradation factor for well proximity effect
SCREF	Reference distance to calculate SCA
GMIN	NULL
GEOMOD	Geometry-dependent parasitics model selector - specifying how the end S/D diffusions are connected
RGEOMOD	Bias independent parasitic resistance model selector (same as BSIM4)
RGATEMOD	Gate resistance model selector
RBODYMOD	Substrate resistance network model selector

Name	Description
Version	Model Version

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model  modelname  bsim6 [parm=value]\*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *BSIM6*. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example

```
model Nch6 bsim6 \
Cjs=3e-4 NMOS=yes
```

Instance Parameters

Parameter	Description
GEOMOD	Geometry-dependent parasitics model selector - specifying how the end S/D diffusions are connected
RGEOMOD	Bias independent parasitic resistance model selector (same as BSIM4)
RGATEMOD	Gate resistance model selector
RBODYMOD	Substrate resistance network model selector

Parameter	Description
L	Designed Gate Length
W	Designed Gate Width (per finger)
NF	Number of fingers
AS	Source to Substrate Junction Area
AD	Drain to Substrate Junction Area
PS	Source to Substrate Junction Perimeter
PD	Drain to Substrate Junction Perimeter
NRS	Number of source diffusion squares
NRD	Number of drain diffusion squares
MINZ	Minimize either no. of drain or source ends
XGW	Distance from gate contact center to dev edge
NGCON	Number of gate contacts
RBPB	Resistance between bNodePrime and bNode
RBDB	Resistance between bNodePrime and dbNode
RBSB	Resistance between bNodePrime and sbNode
RBPS	Resistance between sbNode and bNode
RBPD	Resistance between dbNode and bNode
SA	Distance between OD edge from Poly from one side
SB	Distance between OD edge from Poly from other side

Parameter	Description
SD	Distance between neighboring fingers
SCA	Integral of the first distribution function for scatted well dopants
SCB	Integral of the second distribution function for scatted well dopants
SCC	Integral of the third distribution function for scatted well dopants
SC	Distance to a single well edge

DC Operating Point Information

The following table lists the DC operating point parameters that can be sent to the dataset.

Name	Description	Units
QBI	Intrinsic bulk charge	C
QSI	Intrinsic source charge	C
QDI	Intrinsic drain charge	C
QGI	Intrinsic gate charge	C
CGGI	Intrinsic gate capacitance	F
CGBI	Intrinsic gate-bulk transcapacitance	F
CGSI	Intrinsic gate-source transcapacitance	F
CGDI	Intrinsic gate-drain transcapacitance	F
CSGI	Intrinsic source-gate transcapacitance	F
CSBI	Intrinsic source-bulk transcapacitance	F
CSSI	Intrinsic source capacitance	F

Name	Description	Units
CSDI	Intrinsic source-drain transcapacitance	F
CDGI	Intrinsic drain-gate transcapacitance	F
CDBI	Intrinsic drain-bulk transcapacitance	F
CDSI	Intrinsic drain-source transcapacitance	F
CDDI	Intrinsic drain capacitance	F
CBGI	Intrinsic bulk-gate transcapacitance	F
CBBI	Intrinsic bulk capacitance	F
CBSI	Intrinsic bulk-source transcapacitance	F
CBDI	Intrinsic bulk-drain transcapacitance	F
QB	Bulk charge	C
QS	Source charge	C
QD	Drain charge	C
QG	Gate charge	C
CGG	gate capacitance	F
CGB	gate-source transcapacitance	F
CGS	gate-bulk transcapacitance	F
CGD	gate-drain transcapacitance	F
CSG	source-gate transcapacitance	F
CSB	source-bulk transcapacitance	F

Name	Description	Units
CSS	source capacitance	F
CSD	source-drain transcapacitance	F
CDG	drain-gate transcapacitance	F
CDB	drain-bulk transcapacitance	F
CDS	drain-source transcapacitance	F
CDD	drain capacitance	F
CBG	bulk-gate transcapacitance	F
CBB	bulk capacitance	F
CBS	bulk-source transcapacitance	F
CBD	bulk-drain transcapacitance	F
III	Impact-Ionization current	A
IGIDL	GIDL current	A
IGISL	GISL current	A
IGS	Gate-source IGS current	A
IGD	Gate-drain IGD current	A
IGCS	Gate-source IGCS current	A
IGCD	Gate-drain IGCD current	A
IGB	Gate-bulk IGB current	A
CGSEXT	External gate-source capacitance	F

Name	Description	Units
CGDEXT	External gate-drain capacitance	F
CGBOV	Gate-bulk Overlap capacitance	F
CJST	Bulk-source junction capacitance	F
CJDT	Bulk-drain junction capacitance	F
WEFF	Effective width	meter
LEFF	Effective length	meter
WEFFCV	Effective capacitive width	meter
LEFFCV	Effective capacitive length	meter
IDS	Drain-source current	A
IDEFF	Effective drain current	A
ISEFF	Effective source current	A
IGEFF	Effective gate current	A
IJSB	Source-bulk junction current	A
IJDB	Drain-bulk junction current	A
VDS	Drain-to-source voltage	V
VGS	Gate-to-source voltage	V
VSB	Source-to-bulk voltage	V
VDSSAT	Saturation voltage	V
GM	Transconductance	S

Name	Description	Units
GMBS	Bulk-bias transconductance	S
GDS	Output conductance	S

- DC operating point data is generated for this model. If a DC simulation is performed, device operating point data can be viewed for a component. The procedure for viewing device operating point data for a component is in Using Circuit Simulators.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to DataAccessComponent (Data Access Component)). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.

BSIM-BULK Model (BSIM-BULK MOSFET Model and Instance)

BSIM-BULK_Model (BSIM-BULK MOSFET Model and Instance)

This topic lists the model and instance parameters.

Description

BSIM-BULK is the renamed BSIM6 model. It was developed by the Device Research Group of the Department of Electrical Engineering and Computer Science, University of California, Berkeley and copyrighted by the University of California. More information about this model, visit http://bsim.berkeley.edu/models/bsimbulk/.

NOTE This component is not available in the library browser, component palette, or component history. You must use a netlist fragment and include it using the NetlistInclude component. For more information on creating model netlist see, Netlist Format section.

The main changes from version BSIM6 version 6.1.1 are:

- Modified the name of the parameter "MULUO" to "MULU0".
- The flicker noise model can also model the flicker noise trends for Halo transistors.
- The parameter MNUD model parameter was added to increase flexibility in IDS – VDS fitting.
- The gamma behavior in the linear region for TNOIMOD = 1 was improved.
- The thermal noise model to tune noise figure at 50 ohm (NF50) in subthreshold region and to achieve ideal trend of gamma for long channel transistors.
- Clamping was added in IGD and IGS.
- The thermal node is now deactivated when RTH0 or SHMOD are zero.
- Modified Calculations of Geometry-dependent source/drain resistance.
- The operating point VTH expression signs were corrected.
- When SHMOD is set, Weff + WTH0 is limited to positive values.
- Binning parameters for the EDGEFET parameters were added.
- Stress model added to EDGEFET
- Default values of Stress parameters for EDGEFET are set same as main parameters.
- Parameters for EDGEFET to control threshold voltage shift added to KV, THOEDGE, STK2EDGE, and STETA0EDGE while keeping their length and width parameters same as main BSIM-BULK.
- The parameter K2EDGE for VTH shift with body bias for EDGEFET was added.
- The default value of the EDGEFET parameter has changed to "0" from "1".
- The parameters DTEMP, MULU0, DELVTOand IDS0MULT can now be model or instance parameters.
- EDGEFET SCE model made similar to main BSIM6 to avoid convergence at large L.
- Added binning in the EDGEFET parameters.
- Protections on DLCIG and DLCIGD from going negative were added.
- The calculation of VDSX was modified to avoid negative GDS values.
- The clamping of UCR was removed.
- Range protection was added to the parameters: LP1, LP2, NJS, NJD, XJBVS and XJBVD.
- Self-heating output variables were added.
- Parameters EDGEFET and DELV T0 are made instance parameter.
- The calculations of geometry-dependent source/drain resistance were modified.

Model Parameters

Name	Description	Units	Default	Min	Max
TYPE	ntype=1, ptype=-1	-	ntype	-	-
CVMOD	0: Consistent IV-CV, 1: Different IV-CV	-	0	0	1
COVMOD	0: Use Bias-independent Overlap Capacitances, 1: Use Bias-dependent Overlap Capacitances	-	0	0	1
RDSMOD	0: Internal bias dependent and external bias independent s/d resistance model, 1: External s/d resistance model 2: Internal s/d resistance model	-	0	0	2
WPEMOD	Model flag	-	0	0	1
ASYMMOD	0: Asymmetry Model turned off - forward mode parameters used, 1: Asymmetry Model turned on	-	0	0	1
GIDLMOD	0: Turn off GIDL Current, 1: Turn on GIDL Current	-	0	0	1
IGCMOD	0: Turn off Ig	-	0	0	1
IGBMOD	0: Turn off Igb, 1: Turn on Igb	-	0	0	1
TNOIMOD	Thermal noise model selector	-	0	0	1
SHMOD	0 : Self heating model OFF, 1 : Self heating model ON	-	0	0	1
MOBSCALE	Mobility scaling model, 0: Old Model 1: New Model	-	0	0	1
LLONG	L of extracted Long channel device	m	10u	0	inf
LMLT	Length Shrinking Parameter	-	1	0	inf
WMLT	Width Shrinking Parameter	-	1	0	inf
XL	L offset for channel length due to mask/etch effect	m	0	-	-
WWIDE	W of extracted Wide channel device	m	10u	0	inf
XW	W offset for channel width due to mask/etch effect	m	0	-	-
LINT	Delta L for IV	m	0	-	-
LL	Length reduction parameter	m^(1+LLN)	0	-	-
LW	Length reduction parameter	m^(1+LWN)	0	-	-
LWL	Length reduction parameter	m^(1+LLN+LWN)	0	-	-

Name	Description	Units	Default	Min	Max
LLN	Length reduction parameter	-	1	-	-
LWN	Length reduction parameter	-	1	-	-
WINT	Delta W for IV	m	0	-	-
WL	Width reduction parameter	m^(1+WLN)	0	-	-
WW	Width reduction parameter	m^(1+WW N)	0	-	-
WWL	Width reduction parameter	m^(1+WW N+WLN)	0	-	-
WLN	Width reduction parameter	-	1	-	-
WWN	Width reduction parameter	-	1	-	-
DLC	Delta L for CV	m	0	-	-
LLC	Length reduction parameter	m^(1+LLN)	0	-	-
LWC	Length reduction parameter	m^(1+LWN)	0	-	-
LWLC	Length reduction parameter	m^(1+LWN +LLN)	0	-	-
DWC	Delta W for CV	m	0	-	-
WLC	Width reduction parameter	m^(1+WLN)	0	-	-
WWC	Width reduction parameter	m^(1+WW N)	0	-	-
WWLC	Width reduction parameter	m^(1+WW N+WLN)	0	-	-
TOXE	Effective gate dielectric thickness relative to SiO2	m	3.00E-09	0	inf
TOXP	Physical gate dielectric thickness. If not given, TOXP is calculated from TOXE and DTOX	m	TOXE	0	inf
DTOX	Difference between effective dielectric thickness	m	0	-	-
NDEP	Channel Doping Concentration for IV	1/m^3	1.00E+24	-	-
NDEPL1	Length dependence coefficient of NDEP	m	0	-	-
NDEPLEX P1	Length dependence exponent coefficient of NDEP	-	1	0	inf

Name	Description	Units	Default	Min	Max
NDEPL2	Length dependence of NDEP - For Short Channel Devices	m	0	-	-
NDEPLEXP2	Length dependence exponent coefficient of NDEP	-	2	0	inf
NDEPW	Width dependence coefficient of NDEP	m	0	-	-
NDEPWEXP	Width dependence exponent coefficient of NDEP	-	1	0	inf
NDEPWL	Width-Length dependence coefficient of NDEP	m^2	0	-	-
NDEPWLEXP	Width-Length dependence exponent coefficient of NDEP	-	1	0	inf
LNDEP	Length dependence of NDEP	1/m^2	0	-	-
WNDEP	Width dependence of NDEP	1/m^2	0	-	-
PNDEP	Area dependence of NDEP	1/m	0	-	-
NDEPCV	Channel Doping Concentration for CV	1/m^3	NDEP	-	-
NDEPCVL1	Length dependence coefficient of NDEPCV	m	NDEPL1	-	-
NDEPCVLEXP1	Length dependence exponent coefficient of NDEPCV	-	NDEPLEXP1	0	inf
NDEPCVL2	Length dependence coefficient of NDEPCV - For Short Channel Devices	m	NDEPL2	-	-
NDEPCVLEXP2	Length dependence exponent coefficient of NDEPCV	-	NDEPLEXP2	0	inf
NDEPCVW	Width dependence coefficient of NDEPCV	m	NDEPW	-	-
NDEPCVWEXP	Width dependence exponent coefficient of NDEPCV	-	NDEPWEXP	0	inf
NDEPCVWL	Width-Length dependence coefficient of NDEPCV	m^2	NDEPWL	-	-
NDEPCVWLEXP	Width-Length dependence exponent coefficient of NDEPCV	-	NDEPWLEXP	0	inf
LNDEPCV	Length dependence of NDEP for CV	1/m^2	LNDEP	-	-

Name	Description	Units	Default	Min	Max
WNDEPCV	Width dependence of NDEP for CV	1/m^2	WNDEP	-	-
PNDEPCV	Area dependence of NDEP for CV	1/m	PNDEP	-	-
NGATE	Gate Doping Concentration	1/m^3	5.00E+25	-	-
LNGATE	Length dependence of NGATE	1/m^2	0	-	-
WNGATE	Width dependence of NGATE	1/m^2	0	-	-
PNGATE	Area dependence of NGATE	1/m	0	-	-
EASUB	Electron affinity of substrate	eV	4.05	-	-
NI0SUB	Intrinsic carrier concentration of the substrate at 300.15K	1/m^3	1.10E+16	0	inf
BG0SUB	Band gap of substrate at 300.15K	eV	1.17	0	inf
EPSRSUB	Relative dielectric constant of the channel material	-	11.9	0	inf
EPSROX	Relative dielectric constant of the gate dielectric	-	3.9	0	inf
XJ	S/D junction depth	m	1.50E-07	-	-
LXJ	Length dependence of XJ	m^2	0	-	-
WXJ	Width dependence of XJ	m^2	0	-	-
PXJ	Area dependence of XJ	m^3	0	-	-
VFB	Flat band voltage	V	-0.5	-	-
LVFB	Length dependence of VFB	V*m	0	-	-
WVFB	Width dependence of VFB	V*m	0	-	-
PVFB	Area dependence of VFB	V*m^2	0	-	-
VFBCV	Flat band voltage for CV	V	VFB	-	-
LVFBCV	Length dependence of VFBCV	V*m	LVFB	-	-
WVFBCV	Width dependence of VFBCV	V*m	WVFB	-	-
PVFBCV	Area dependence of VFBCV	V*m^2	PVFB	-	-
VFBCVL	Length dependence coefficient of VFBCV	m	0	-	-

Name	Description	Units	Default	Min	Max
VFBCVLEXP	Length dependence exponent coefficient of VFBCV	-	1	0	inf
VFBCVW	Width dependence coefficient of VFBCV	m	0	-	-
VFBCVWEXP	Width dependence exponent coefficient of VFBCV	-	1	0	inf
VFBCVWL	Width-Length dependence coefficient of VFBCV	m^2	0	-	-
VFBCVWLEXP	Width-Length dependence coefficient of VFBCV	-	1	0	inf
PERMOD	Whether PS/PD (when given) include gate-edge perimeter	-	1	0	1
DWJ	delta W for S/D junctions	m	DWC	-	-
NSD	S/D Doping Concentration	1/m^3	1.00E+26	-	-
LNSD	Length dependence of NSD	1/m^2	0	-	-
WNSD	Width dependence of NSD	1/m^2	0	-	-
PNSD	Area dependence of NSD	1/m	0	-	-
DVTP0	DITS	m	0	-	-
LDVTP0	Length dependence of DVTP0	m^2	0	-	-
WDVTP0	Width dependence of DVTP0	m^2	0	-	-
PDVTP0	Area dependence of DVTP0	m^3	0	-	-
DVTP1	DITS	1/V	0	-	-
LDVTP1	Length dependence of DVTP1	m/V	0	-	-
WDVTP1	Width dependence of DVTP1	m/V	0	-	-
PDVTP1	Area dependence of DVTP1	m^2/V	0	-	-
DVTP2	DITS	m*V	0	-	-
LDVTP2	Length dependence of DVTP2	m^2/V	0	-	-
WDVTP2	Width dependence of DVTP2	m^2/V	0	-	-
PDVTP2	Area dependence of DVTP2	m^3/V	0	-	-

Name	Description	Units	Default	Min	Max
DVTP3	DITS	-	0	-	-
LDVTP3	Length dependence of DVTP3	m	0	-	-
WDVTP3	Width dependence of DVTP3	m	0	-	-
PDVTP3	Area dependence of DVTP3	m^2	0	-	-
DVTP4	DITS	1/V	0	-	-
LDVTP4	Length dependence of DVTP4	m/V	0	-	-
WDVTP4	Width dependence of DVTP4	m/V	0	-	-
PDVTP4	Area dependence of DVTP4	m^2/V	0	-	-
DVTP5	DITS	V	0	-	-
LDVTP5	Length dependence of DVTP5	m*V	0	-	-
WDVTP5	Width dependence of DVTP5	m*V	0	-	-
PDVTP5	Area dependence of DVTP5	m^2*V	0	-	-
PHIN	Non-uniform vertical doping effect on surface potential	V	0.045	-	-
LPHIN	Length dependence of PHIN	m*V	0	-	-
WPHIN	Width dependence of PHIN	m*V	0	-	-
PPHIN	Area dependence of PHIN	m^2*V	0	-	-
ETA0	DIBL coefficient	-	0.08	-	-
LETA0	Length dependence of ETA0	m	0	-	-
WETA0	Width dependence of ETA0	m	0	-	-
PETA0	Area dependence of ETA0	m^2	0	-	-
ETA0R	DIBL coefficient	-	ETA0	-	-
LETA0R	Length dependence of ETA0R	m	LETA0	-	-
WETA0R	Width dependence of ETA0R	m	WETA0	-	-
PETA0R	Area dependence of ETA0R	m^2	PETA0	-	-
DSUB	Length scaling exponent for DIBL	-	1	-	-

Name	Description	Units	Default	Min	Max
ETAB	Body bias coefficient for sub-threshold DIBL effect	1/V	-0.07	-	-
ETABEXP	Exponent coefficient of ETAB	-	1	0	inf
LETAB	Length dependence of ETAB	m/V	0	-	-
WETAB	Width dependence of ETAB	m/V	0	-	-
PETAB	Area dependence of ETAB	m^2/V	0	-	-
K1	First-order body-bias Vth shift due to Vertical Non-uniform doping	V^0.5	0	-	-
K1L	length dependence coefficient of K1	-	0	-	-
K1LEXP	Length dependence exponent coefficient of K1	-	1	0	inf
K1W	Width dependence coefficient of K1	-	0	-	-
K1WEXP	Width dependence exponent coefficient of K1	-	1	0	inf
K1WL	Width-Length dependence coefficient of K1	-	0	-	-
K1WLEXP	Width-Length dependence exponent coefficient of K1	-	1	0	inf
LK1	Length dependence of K1	m*V^0.5	0	-	-
WK1	Width dependence of K1	m*V^0.5	0	-	-
PK1	Area dependence of K1	m^2*V^0.5	0	-	-
K2	Vth shift due to Vertical Non-uniform doping	V	0	-	-
K2L	Length dependence coefficient of K2	m^K2LEXP	0	-	-
K2LEXP	Length dependence exponent coefficient of K2	-	1	0	inf
K2W	Width dependence coefficient of K2	m^K2WEXP	0	-	-
K2WEXP	Width dependence exponent coefficient of K2	-	1	0	inf
K2WL	Width-Length dependence coefficient of K2	m^(2*K2WLEXP)	0	-	-
K2WLEXP	Width-Length dependence exponent coefficient of K2	-	1	0	inf
LK2	Length dependence of K2	m	0	-	-
WK2	Width dependence of K2	m	0	-	-

Name	Description	Units	Default	Min	Max
PK2	Area dependence of K2	m^2	0	-	-
ADOS	Quantum mechanical effect pre-factor cum switch in inversion	-	0	0	inf
BDOS	Charge centroid parameter - slope of CV curve under QME in inversion	-	1	0	inf
QM0	Charge centroid parameter - starting point for QME in inversion	-	1.00E-03	0	inf
ETAQM	Bulk charge coefficient for charge centroid in inversion	-	0.54	0	inf
CIT	Parameter for interface trap	F/m^2	0	-	-
LCIT	Length dependence of CIT	F/m	0	-	-
WCIT	Width dependence of CIT	F/m	0	-	-
PCIT	Area dependence of CIT	F	0	-	-
NFACTOR	Sub-threshold slope factor	-	0	-	-
NFACTORL	Length dependence coefficient of NFACTOR	m^NFACTORLEXP	0	-	-
NFACTORLEXP	Length dependence exponent coefficient of NFACTOR	-	1	0	inf
NFACTORW	Width dependence coefficient of NFACTOR	m^NFACTORWEXP	0	-	-
NFACTORWEXP	Width dependence exponent coefficient of NFACTOR	-	1	0	inf
NFACTORWL	Width-Length dependence coefficient of NFACTOR	m^(2*NFACTORWLEXP)	0	-	-
NFACTORWLEXP	Width-Length dependence exponent coefficient of NFACTOR	-	1	0	inf
LNFACTOR	Length dependence of NFACTOR	m	0	-	-
WNFACTOR	Width dependence of NFACTOR	m	0	-	-
PNFACTOR	Area dependence of NFACTOR	m^2	0	-	-

Name	Description	Units	Default	Min	Max
CDSCD	Drain-bias sensitivity of sub-threshold slope	F/m^2/V	1.00E-09	-	-
CDSCDL	Length dependence coefficient of CDSCD	m^CDSCDL EXP	0	-	-
CDSCDLE XP	Length dependence exponent coefficient of CDSCD	-	1	0	inf
LCDSCD	Length dependence of CDSCD	F/m/V	0	-	-
WCDSCD	Width dependence of CDSCD	F/m/V	0	-	-
PCDSCD	Area dependence of CDSCD	F/V	0	-	-
CDSCDR	Drain-bias sensitivity of sub-threshold slope	F/m^2/V	CDSCD	-	-
CDSCDLR	Length dependence coefficient of CDSCD	m^CDSCDL EXP	CDSCDL	-	-
LCDSCDR	Length dependence of CDSCDR	F/m/V	LCDSCD	-	-
WCDSCD R	Width dependence of CDSCDR	F/m/V	WCDSC D	-	-
PCDSCDR	Area dependence of CDSCDR	F/V	PCDSCD	-	-
CDSCB	Body-bias sensitivity of sub-threshold slope	F/m^2/V	0	-	-
CDSCBL	Length dependence coefficient of CDSCB	m^CDSCBL EXP	0	-	-
CDSCBLE XP	Length dependence exponent coefficient of CDSCB	-	1	0	inf
LCDSCB	Length dependence of CDSCB	F/m/V	0	-	-
WCDSCB	Width dependence of CDSCB	F/m/V	0	-	-
PCDSCB	Area dependence of CDSCB	F/V	0	-	-
VSAT	Saturation Velocity	m/s	1.00E+05	-	-
LVSAT	Length dependence of VSAT	m^2/s	0	-	-
WVSAT	Width dependence of VSAT	m^2/s	0	-	-
PVSAT	Area dependence of VSAT	m^3/s	0	-	-
VSATL	Length dependence coefficient of of VSAT	m^VSATLE XP	0	-	-

Name	Description	Units	Default	Min	Max
VSATLEXP	Length dependence exponent coefficient of VSAT	-	1	0	inf
VSATW	Width dependence coefficient of of VSAT	m^VSATWEXP	0	-	-
VSATWEXP	Width dependence exponent coefficient of of VSAT	-	1	0	inf
VSATWL	Width-Length dependence coefficient of of VSAT	m^(2*VSATWLEXP)	0	-	-
VSATWLEXP	Width-Length dependence exponent coefficient of of VSAT	-	1	0	inf
VSATR	Saturation Velocity	m/s	VSAT	-	-
LVSATR	Length dependence of VSATR	m^2/s	LVSAT	-	-
WVSATR	Width dependence of VSATR	m^2/s	WVSAT	-	-
PVSATR	Area dependence of VSATR	m^3/s	PVSAT	-	-
DELTA	Smoothing function factor for Vdsat	-	0.125	-	-
LDELTA	Length dependence of DELTA	m	0	-	-
WDELTA	Width dependence of DELTA	m	0	-	-
PDELTA	Area dependence of DELTA	m^2	0	-	-
DELTAL	Length dependence coefficient of DELTA	m^DELTALEXP	0	-	-
DELTALEXP	Length dependence exponent coefficient of DELTA	-	1	0	inf
VSATCV	VSAT parameter for CV	m/s	VSAT	-	-
LVSATCV	Length dependence of VSATCV	m^2/s	LVSAT	-	-
WVSATCV	Width dependence of VSATCV	m^2/s	WVSAT	-	-
PVSATCV	Area dependence of VSATCV	m^3/s	PVSAT	-	-
VSATCVL	Length dependence coefficient of VSATCV	m^VSATCVLEXP	VSATL	-	-
VSATCVLEXP	Length dependence exponent coefficient of VSATCV	-	VSATLEXP	0	inf

Name	Description	Units	Default	Min	Max
VSATCVW	Width dependence coefficient of VSATCV	m^VSATCV WEXP	VSATW	-	-
VSATCVW EXP	Width dependence exponent coefficient of VSATCV	-	VSATWE XP	0	inf
VSATCVW L	Width-Length dependence coefficient of VSATCV	m^(2*VSAT CVWLEXP)	VSATWL	-	-
VSATCVW LEXP	Width-Length dependence exponent coefficient of VSATCV	-	VSATWL EXP	0	inf
UP1	Mobility channel length coefficient	-	0	-inf	inf
LP1	Mobility channel length exponential coefficient exclude: 0.	m	1.00E-08	-inf	inf
UP2	Mobility channel length coefficient	-	0	-inf	inf
LP2	Mobility channel length exponential coefficient exclude: 0.	m	1.00E-08	-inf	inf
U0	Low Field mobility.	m^2/V/s	6.70E-02	-	-
U0L	Length dependence coefficient of U0L	m^U0LEXP	0	-	-
U0LEXP	Length dependence exponent coefficient of U0L	-	1	0	inf
LU0	Length dependence of U0	m^3/V/s	0	-	-
WU0	Width dependence of U0	m^3/V/s	0	-	-
PU0	Area dependence of U0	m^4/V/s	0	-	-
U0R	Reverse-mode Low Field mobility.	m2/V/s	U0	-	-
LU0R	Length dependence of U0R	m^3/V/s	LU0	-	-
WU0R	Width dependence of U0R	m^3/V/s	WU0	-	-
PU0R	Area dependence of U0R	m^4/V/s	PU0	-	-
ETAMOB	Effective field parameter (should be kept close to 1)	-	1	-	-
UA	Mobility reduction coefficient	(m/V)^EU	0.001	-	-
UAL	Length dependence coefficient of UA	m^UALEXP	0	-	-
UALEXP	Length dependence exponent coefficient of UA	-	1	0	inf

Name	Description	Units	Default	Min	Max
UAW	Width dependence coefficient of UA	m^UAWEXP	0	-	-
UAWEXP	Width dependence exponent coefficient of UA	-	1	0	inf
UAWL	Width-Length dependence coefficient of UA	m^UAWLEXP	0	-	-
UAWLEXP	Width-Length dependence coefficient of UA	-	1	0	inf
LUA	Length dependence of UA	m*(m/V)^EU	0	-	-
WUA	Width dependence of UA	m*(m/V)^EU	0	-	-
PUA	Area dependence of UA	m^2*(m/V)^EU	0	-	-
UAR	Reverse-mode Mobility reduction coefficient	(m/V)^EU	UA	-	-
LUAR	Length dependence of UAR	m*(m/V)^EU	LUA	-	-
WUAR	Width dependence of UAR	m*(m/V)^EU	WUA	-	-
PUAR	Area dependence of UAR	m^2*(m/V)^EU	PUA	-	-
EU	Mobility reduction exponent	-	1.5	-	-
LEU	Length dependence of EU	m	0	-	-
WEU	Width dependence of EU	m	0	-	-
PEU	Area dependence of EU	m^2	0	-	-
EUL	Length dependence coefficient of EU	m^EULEXP	0	-	-
EULEXP	Length dependence exponent coefficient of EU	-	1	0	inf
EUW	Width dependence coefficient of EU	m^EUWEXP	0	-	-
EUWEXP	Width dependence exponent coefficient of EU	-	1	0	inf
EUWL	Width-Length dependence coefficient of EU	m^EUWLEXP	0	-	-
EUWLEXP	Width-Length dependence coefficient of EU	-	1	0	inf

Name	Description	Units	Default	Min	Max
UD	Coulomb scattering parameter	-	0.001	-	-
UDL	Length dependence coefficient of UD	m^UDLEXP	0	-	-
UDLEXP	Length dependence exponent coefficient of UD	-	1	0	inf
LUD	Length dependence of UD	m	0	-	-
WUD	Width dependence of UD	m	0	-	-
PUD	Area dependence of UD	m^2	0	-	-
UDR	Reverse-mode Coulomb scattering parameter	-	UD	-	-
LUDR	Length dependence of UDR	m	LUD	-	-
WUDR	Width dependence of UDR	m	WUD	-	-
PUDR	Area dependence of UDR	m^2	PUD	-	-
UCS	Coulomb scattering parameter	-	2	-	-
LUCS	Length dependence of UCS	m	0	-	-
WUCS	Width dependence of UCS	m	0	-	-
PUCS	Area dependence of UCS	m^2	0	-	-
UCSR	Reverse-mode Coulomb scattering parameter	-	UCS	-	-
LUCSR	Length dependence of UCSR	m	LUCS	-	-
WUCSR	Width dependence of UCSR	m	WUCS	-	-
PUCSR	Area dependence of UCSR	m^2	PUCS	-	-
UC	Mobility reduction with body bias	(m/V)^EU/V	0	-	-
UCL	Length dependence coefficient of UC	m^UCLEXP	0	-	-
UCLEXP	Length dependence exponent coefficient of UC	-	1	0	inf
UCW	Width dependence coefficient of UC	m^UCWEXP	0	-	-
UCWEXP	Width dependence exponent coefficient of UC	-	1	0	inf

Name	Description	Units	Default	Min	Max
UCWL	Width-Length dependence coefficient of UC	m^(2*UCWLEXP)	0	-	-
UCWLEXP	Width-Length dependence exponent coefficient of UC	-	1	0	inf
LUC	Length dependence of UC	m*(m/V)^EU/V	0	-	-
WUC	Width dependence of UC	m*(m/V)^EU/V	0	-	-
PUC	Area dependence of UC	m^2*(m/V)^EU/V	0	-	-
UCR	Reverse-mode Mobility reduction with body bias	(m/V)^EU/V	UC	-	-
LUCR	Length dependence of UCR	m*(m/V)^EU/V	LUC	-	-
WUCR	Width dependence of UCR	m*(m/V)^EU/V	WUC	-	-
PUCR	Area dependence of UCR	m^2*(m/V)^EU/V	PUC	-	-
PCLM	CLM pre-factor	-	0	-	-
PCLML	Length dependence coefficient of PCLM	m^PCLMLEXP	0	-	-
PCLMLEXP	Length dependence exponent coefficient of PCLM	-	1	0	inf
LPCLM	Length dependence of PCLM	m	0	-	-
WPCLM	Width dependence of PCLM	m	0	-	-
PPCLM	Area dependence of PCLM	m^2	0	-	-
PCLMR	Reverse-mode CLM pre-factor	-	PCLM	-	-
LPCLMR	Length dependence of PCLMR	m	LPCLM	-	-
WPCLMR	Width dependence of PCLMR	m	WPCLM	-	-
PPCLMR	Area dependence of PCLMR	m^2	PPCLM	-	-
PCLMG	CLM pre-factor gate voltage dependence	V	0	-	-

Name	Description	Units	Default	Min	Max
PCLMCV	CLM parameter for CV	-	PCLM	-	-
PCLMCVL	Length dependence coefficient of PCLMCV	m^PCLMLEXP	PCLML	-	-
PCLMCVLEXP	Length dependence exponent coefficient of PCLMCV	-	PCLMLEXP	0	inf
LPCLMCV	Length dependence of PCLMCV	m	LPCLM	-	-
WPCLMCV	Width dependence of PCLMCV	m	WPCLM	-	-
PPCLMCV	Area dependence of PCLMCV	m^2	PPCLM	-	-
PSCBE1	Substrate current body-effect coefficient	V/m	4.24E+08	-	-
LPSCBE1	Length dependence of PSCBE1	V	0	-	-
WPSCBE1	Width dependence of PSCBE1	V	0	-	-
PPSCBE1	Area dependence of PSCBE1	V*m	0	-	-
PSCBE2	Substrate current body-effect coefficient	m/V	1.00E-08	-	-
LPSCBE2	Length dependence of PSCBE2	m^2/V	0	-	-
WPSCBE2	Width dependence of PSCBE2	m^2/V	0	-	-
PPSCBE2	Area dependence of PSCBE2	m^3/V	0	-	-
PDITS	Coefficient for drain-induced Vth shift	1/V	0	-	-
LPDITS	Length dependence of PDITS	m/V	0	-	-
WPDITS	Width dependence of PDITS	m/V	0	-	-
PPDITS	Area dependence of PDITS	m^2/V	0	-	-
PDITSL	L dependence of drain-induced Vth shift	1/m	0	0	inf
PDITSD	Vds dependence of drain-induced Vth shift	1/V	0	-	-
LPDITSD	Length dependence of PDITSD	m/V	0	-	-
WPDITSD	Width dependence of PDITSD	m/V	0	-	-
PPDITSD	Area dependence of PDITSD	m^2/V	0	-	-

Name	Description	Units	Default	Min	Max
RSH	Source-drain sheet resistance	ohm/square	0	0	inf
PRWG	Gate bias dependence of S/D extension resistance	1/V	1	-	-
LPRWG	Length dependence of PRWG	m/V	0	-	-
WPRWG	Width dependence of PRWG	m/V	0	-	-
PPRWG	Area dependence of PRWG	m^2/V	0	-	-
PRWB	Body bias dependence of resistance	1/V	0	-	-
LPRWB	Length dependence of PRWB	m/V	0	-	-
WPRWB	Width dependence of PRWB	m/V	0	-	-
PPRWB	Area dependence of PRWB	m^2/V	0	-	-
PRWBL	Length dependence coefficient of PPRWB	m^PRWBLEXP	0	-	-
PRWBLEXP	Length dependence exponent coefficient of PPRWB	-	1	0	inf
WR	W dependence parameter of S/D extension resistance	-	1	-	-
LWR	Length dependence of WR	m	0	-	-
WWR	Width dependence of WR	m	0	-	-
PWR	Area dependence of WR	m^2	0	-	-
RSWMIN	Source Resistance per unit width at high Vgs (RDSMOD=1)	ohm*m^WR	0	-	-
LRSWMIN	Length dependence of RSWMIN	ohm*m^(2*WR)	0	-	-
WRSWMIN	Width dependence of RSWMIN	ohm*m^(2*WR)	0	-	-
PRSWMIN	Area dependence of RSWMIN	ohm*m^(3*WR)	0	-	-
RSW	Zero bias Source Resistance (RDSMOD=1)	ohm*m^WR	10	-	-
LRSW	Length dependence of RSW	ohm*m^(2*WR)	0	-	-

Name	Description	Units	Default	Min	Max
WRSW	Width dependence of RSW	ohm*m^(2*WR)	0	-	-
PRSW	Area dependence of RSW	ohm*m^(3*WR)	0	-	-
RSWL	Geometrical scaling of RSW (RDSMOD=1)	m^RSWLEXP	0	-	-
RSWLEXP	Geometrical scaling of RSW (RDSMOD=1)	-	1	0	inf
RDWMIN	Drain Resistance per unit width at high Vgs (RDSMOD=1)	ohm*m^WR	RSWMIN	-	-
LRDWMIN	Length dependence of RDWMIN	ohm*m^(2*WR)	LRSWMIN	-	-
WRDWMIN	Width dependence of RDWMIN	ohm*m^(2*WR)	WRSWMIN	-	-
PRDWMIN	Area dependence of RDWMIN	ohm*m^(3*WR)	PRSWMIN	-	-
RDW	zero bias Drain Resistance (RDSMOD=1)	ohm*m^WR	RSW	-	-
LRDW	Length dependence of RDW	ohm*m^(2*WR)	LRSW	-	-
WRDW	Width dependence of RDW	ohm*m^(2*WR)	WRSW	-	-
PRDW	Area dependence of RDW	ohm*m^(3*WR)	PRSW	-	-
RDWL	Geometrical scaling of RDW (RDSMOD=1)	m^RDWLEXP	RSWL	-	-
RDWLEXP	Geometrical scaling of RDW (RDSMOD=1)	-	RSWLEXP	0	inf
RDSWMIN	S/D Resistance per unit width at high Vgs (RDSMOD=0 and RDSMOD=2)	ohm*m^WR	0	-	-
LRDSWMIN	Length dependence of RDSWMIN	ohm*m^(2*WR)	0	-	-
WRDSWMIN	Width dependence of RDSWMIN	ohm*m^(2*WR)	0	-	-
PRDSWMIN	Area dependence of RDSWMIN	ohm*m^(3*WR)	0	-	-

Name	Description	Units	Default	Min	Max
RDSW	Zero bias Resistance (RDSMOD=0 and RDSMOD=2)	ohm*um^WR	20	-	-
RDSWL	Geometrical scaling of RDSW (RDSMOD=0 and RDSMOD=2)	m^RDSWLEXP	0	-	-
RDSWLEXP	Geometrical scaling of RDSW (RDSMOD=0 and RDSMOD=2)	-	1	0	inf
LRDSW	Length dependence of RDSW	ohm*m^(2*WR)	0	-	-
WRDSW	Width dependence of RDSW	ohm*m^(2*WR)	0	-	-
PRDSW	Area dependence of RDSW	ohm*m^(3*WR)	0	-	-
PSAT	Gmsat variation with gate bias	-	1	-	-
LPSAT	Length dependence of PSAT	m	0	-	-
WPSAT	Width dependence of PSAT	m	0	-	-
PPSAT	Area dependence of PSAT	m^2	0	-	-
PSATL	Length dependence coefficient of PSATL	m^PSATLEXP	0	-	-
PSATLEXP	Length dependence exponent coefficient of PSATLEXP	-	1	0	inf
PSATB	Body bias effect on Idsat	1/V	0	-	-
PSATR	Reverse-mode Gmsat variation with gate bias	-	PSAT	-	-
LPSATR	Length dependence of PSATR	m	LPSAT	-	-
WPSATR	Width dependence of PSATR	m	WPSAT	-	-
PPSATR	Area dependence of PSATR	m^2	PPSAT	-	-
LPSATB	Length dependence of PSATB	m/V	0	-	-
WPSATB	Width dependence of PSATB	m/V	0	-	-
PPSATB	Area dependence of PSATB	m^2/V	0	-	-
PSATX	Fine tuning of PTWG effect	-	1	0	inf
PTWG	Idsat variation with gate bias	-	0	-	-

Name	Description	Units	Default	Min	Max
LPTWG	Length dependence of PTWG	m	0	-	-
WPTWG	Width dependence of PTWG	m	0	-	-
PPTWG	Area dependence of PTWG	m^2	0	-	-
PTWGL	Length dependence coefficient of PTWG	m^PTWGLE XP	0	-	-
PTWGLEX P	Length dependence exponent coefficient of PTWG	-	1	0	inf
PTWGR	Reverse-mode Idsat variation with gate bias	-	PTWG	-	-
LPTWGR	Length dependence of PTWGR	m	LPTWG	-	-
WPTWGR	Width dependence of PTWGR	m	WPTWG	-	-
PPTWGR	Area dependence of PTWGR	m^2	PPTWG	-	-
PTWGLR	Length dependence coefficient of PTWG	m^PTWGLE XPR	PTWGL	-	-
PTWGLEX PR	Length dependence exponent coefficient of PTWG	-	PTWGLE XP	0	inf
A1	Non-saturation effect parameter for strong inversion region	1/V^2	0	-	-
LA1	Length dependence of A1	m/V^2	0	-	-
WA1	Width dependence of A1	m/V^2	0	-	-
PA1	Area dependence of A1	m^2/V^2	0	-	-
A11	Temperature dependence of A1	-	0	-	-
LA11	Length dependence of A11	m	0	-	-
WA11	Width dependence of A11	m	0	-	-
PA11	Area dependence of A11	m^2	0	-	-
A2	Non-saturation effect parameter for moderate inversion region	1/V	0	-	-
LA2	Length dependence of A2	m/V	0	-	-
WA2	Width dependence of A2	m/V	0	-	-

Name	Description	Units	Default	Min	Max
PA2	Area dependence of A2	m^2/V	0	-	-
A21	Temperature dependence of A2	-	0	-	-
LA21	Length dependence of A21	m	0	-	-
WA21	Width dependence of A21	m	0	-	-
PA21	Area dependence of A21	m^2	0	-	-
PDIBLC	Parameter for DIBL effect on Rout	-	0	-	-
PDIBLCL	Length dependence coefficient of PDIBLC	m^PDIBLCL EXP	0	-	-
PDIBLCLE XP	Length dependence exponent coefficient of PDIBLC	-	1	0	inf
LPDIBLC	Length dependence of PDIBLC	m	0	-	-
WPDIBLC	Width dependence of PDIBLC	m	0	-	-
PPDIBLC	Area dependence of PDIBLC	m^2	0	-	-
PDIBLCR	Reverse-mode Parameter for DIBL effect on Rout	-	PDIBLC	-	-
PDIBLCLR	Length dependence coefficient of PDIBLC	m^PDIBLCL EXPR	PDIBLCL	-	-
PDIBLCLE XPR	Length dependence exponent coefficient of PDIBLC	-	PDIBLCL EXP	0	inf
LPDIBLCR	Length dependence of PDIBLCR	m	LPDIBLC	-	-
WPDIBLC R	Width dependence of PDIBLCR	m	WPDIBL C	-	-
PPDIBLCR	Area dependence of PDIBLCR	m^2	PPDIBLC	-	-
PDIBLCB	Parameter for DIBL effect on Rout	1/V	0	-	-
LPDIBLCB	Length dependence of PDIBLCB	m/V	0	-	-
WPDIBLC B	Width dependence of PDIBLCB	m/V	0	-	-
PPDIBLCB	Area dependence of PDIBLCB	m^2/V	0	-	-
PVAG	Vg dependence of early voltage	-	1	-	-

Name	Description	Units	Default	Min	Max
LPVAG	Length dependence of PVAG	m	0	-	-
WPVAG	Width dependence of PVAG	m	0	-	-
PPVAG	Area dependence of PVAG	m^2	0	-	-
FPROUT	gds degradation factor due to pocket implant.	V/m^0.5	0	-	-
FPROUTL	Length dependence coefficient of FPROUT	m^FPROUT LEXP	0	-	-
FPROUTL EXP	Length dependence exponent coefficient of FPROUT	-	1	0	inf
LFPROUT	Length dependence of FPROUT	V*m^0.5	0	-	-
WFPROU T	Width dependence of FPROUT	V*m^0.5	0	-	-
PFPROUT	Area dependence of FPROUT	V*m^1.5	0	-	-
ALPHA0	First parameter of Iii	m/V	0	-	-
ALPHA0L	Length dependence coefficient of ALPHA0	m^ALPHA0 LEXP	0	-	-
ALPHA0L EXP	Length dependence exponent coefficient of ALPHA0	-	1	0	inf
LALPHA0	Length dependence of ALPHA0	m^2/V	0	-	-
WALPHA0	Width dependence of ALPHA0	m^2/V	0	-	-
PALPHA0	Area dependence of ALPHA0	m^3/V	0	-	-
BETA0	Vds dependent parameter of Iii	1/V	0	-	-
LBETA0	Length dependence of BETA0	m/V	0	-	-
WBETA0	Width dependence of BETA0	m/V	0	-	-
PBETA0	Area dependence of BETA0	m^2/V	0	-	-
AIGBACC	Parameter for Igb	(F*s^2/ g)^0.5/m	1.36E-02	-	-
BIGBACC	Parameter for Igb	(F*s^2/ g)^0.5/m/V	1.71E-03	-	-
CIGBACC	Parameter for Igb	1/V	0.075	-	-

Name	Description	Units	Default	Min	Max
NIGBACC	Parameter for Igbacc slope	-	1	-	-
AIGBINV	Parameter for Igb	(F*s^2/ g)^0.5/m	1.11E-02	-	-
BIGBINV	Parameter for Igb	(F*s^2/ g)^0.5/m/V	9.49E-04	-	-
CIGBINV	Parameter for Igb	1/V	0.006	-	-
EIGBINV	Parameter for the Si band-gap for Igbinv	V	1.1	-	-
NIGBINV	Parameter for Igbinv slope	-	3	-	-
AIGC	Parameter for Igc	(F*s^2/ g)^0.5/m	((TYPE == `ntype) ?	-	-
BIGC	Parameter for Igc	(F*s^2/ g)^0.5/m/V	((TYPE == `ntype) ?	-	-
CIGC	Parameter for Igc	1/V	((TYPE == `ntype) ?	-	-
AIGS	Parameter for Igs d	(F*s^2/ g)^0.5/m	((TYPE == `ntype) ?	-	-
BIGS	Parameter for Igs d	(F*s^2/ g)^0.5/m/V	((TYPE == `ntype) ?	-	-
CIGS	Parameter for Igs d	1/V	((TYPE == `ntype) ?	-	-
AIGD	Parameter for Igs d	(F*s^2/ g)^0.5/m	((TYPE == `ntype) ?	-	-
BIGD	Parameter for Igs d	(F*s^2/ g)^0.5/m/V	((TYPE == `ntype) ?	-	-
CIGD	Parameter for Igs d	1/V	((TYPE == `ntype) ?	-	-
DLCIG	Delta L for Ig model	m	LINT	-	-
DLCIGD	Delta L for Ig model	m	DLCIG	-	-

Name	Description	Units	Default	Min	Max
POXEDGE	Factor for the gate edge Tox	-	1	-	-
NTOX	Exponent for Tox ratio	-	1	-	-
TOXREF	Target tox value	m	3.00E-09	0	inf
PIGCD	Igc, S/D partition parameter	-	1	-50	50
AIGCL	Length dependence coefficient of AIGC	m	0	-	-
AIGCW	Width dependence coefficient of AIGC	m	0	-	-
AIGSL	Length dependence coefficient of AIGS	m	0	-	-
AIGSW	Width dependence coefficient of AIGS	m	0	-	-
AIGDL	Length dependence coefficient of AIGD	m	0	-	-
AIGDW	Width dependence coefficient of AIGD	m	0	-	-
PIGCDL	Length dependence coefficient of PIGCD	m	0	-	-
LAIGBINV	Length dependence of AIGBINV	(F*s^2/ g)^0.5	0	-	-
WAIGBIN V	Width dependence of AIGBINV	(F*s^2/ g)^0.5	0	-	-
PAIGBINV	Area dependence of AIGBINV	m*(F*s^2/ g)^0.5	0	-	-
LBIGBINV	Length dependence of BIGBINV	(F*s^2/ g)^0.5/V	0	-	-
WBIGBIN V	Width dependence of BIGBINV	(F*s^2/ g)^0.5/V	0	-	-
PBIGBINV	Area dependence of BIGBINV	m*(F*s^2/ g)^0.5/V	0	-	-
LCIGBINV	Length dependence of CIGBINV	m/V	0	-	-
WCIGBIN V	Width dependence of CIGBINV	m/V	0	-	-
PCIGBINV	Area dependence of CIGBINV	m^2/V	0	-	-
LEIGBINV	Length dependence of EIGBINV	m*V	0	-	-

Name	Description	Units	Default	Min	Max
WEIGBINV	Width dependence of EIGBINV	m*V	0	-	-
PEIGBINV	Area dependence of EIGBINV	m^2*V	0	-	-
LNIGBINV	Length dependence of NIGBINV	m	0	-	-
WNIGBINV	Width dependence of NIGBINV	m	0	-	-
PNIGBINV	Area dependence of NIGBINV	m^2	0	-	-
LAIGBACC	Length dependence of AIGBACC	(F*s^2/g)^0.5	0	-	-
WAIGBACC	Width dependence of AIGBACC	(F*s^2/g)^0.5	0	-	-
PAIGBACC	Area dependence of AIGBACC	m*(F*s^2/g)^0.5	0	-	-
LBIGBACC	Length dependence of BIGBACC	(F*s^2/g)^0.5/V	0	-	-
WBIGBACC	Width dependence of BIGBACC	(F*s^2/g)^0.5/V	0	-	-
PBIGBACC	Area dependence of BIGBACC	m*(F*s^2/g)^0.5/V	0	-	-
LCIGBACC	Length dependence of CIGBACC	m/V	0	-	-
WCIGBACC	Width dependence of CIGBACC	m/V	0	-	-
PCIGBACC	Area dependence of CIGBACC	m^2/V	0	-	-
LNIGBACC	Length dependence of NIGBACC	m	0	-	-
WNIGBACC	Width dependence of NIGBACC	m	0	-	-
PNIGBACC	Area dependence of NIGBACC	m^2	0	-	-
LAIGC	Length dependence of AIGC	(F*s^2/g)^0.5	0	-	-

Name	Description	Units	Default	Min	Max
WAIGC	Width dependence of AIGC	(F*s^2/ g)^0.5	0	-	-
PAIGC	Area dependence of AIGC	m*(F*s^2/ g)^0.5	0	-	-
LBIGC	Length dependence of BIGC	(F*s^2/ g)^0.5/V	0	-	-
WBIGC	Width dependence of BIGC	(F*s^2/ g)^0.5/V	0	-	-
PBIGC	Area dependence of BIGC	m*(F*s^2/ g)^0.5/V	0	-	-
LCIGC	Length dependence of CIGC	m/V	0	-	-
WCIGC	Width dependence of CIGC	m/V	0	-	-
PCIGC	Area dependence of CIGC	m^2/V	0	-	-
LAIGS	Length dependence of AIGS	(F*s^2/ g)^0.5	0	-	-
WAIGS	Width dependence of AIGS	(F*s^2/ g)^0.5	0	-	-
PAIGS	Area dependence of AIGS	m*(F*s^2/ g)^0.5	0	-	-
LBIGS	Length dependence of BIGS	(F*s^2/ g)^0.5/V	0	-	-
WBIGS	Width dependence of BIGS	(F*s^2/ g)^0.5/V	0	-	-
PBIGS	Area dependence of BIGS	m*(F*s^2/ g)^0.5/V	0	-	-
LCIGS	Length dependence of CIGS	m/V	0	-	-
WCIGS	Width dependence of CIGS	m/V	0	-	-
PCIGS	Area dependence of CIGS	m^2/V	0	-	-
LAIGD	Length dependence of AIGD	(F*s^2/ g)^0.5	0	-	-
WAIGD	Width dependence of AIGD	(F*s^2/ g)^0.5	0	-	-

Name	Description	Units	Default	Min	Max
PAIGD	Area dependence of AIGD	m*(F*s^2/ g)^0.5	0	-	-
LBIGD	Length dependence of BIGD	(F*s^2/ g)^0.5/V	0	-	-
WBIGD	Width dependence of BIGD	(F*s^2/ g)^0.5/V	0	-	-
PBIGD	Area dependence of BIGD	m*(F*s^2/ g)^0.5/V	0	-	-
LCIGD	Length dependence of CIGD	m/V	0	-	-
WCIGD	Width dependence of CIGD	m/V	0	-	-
PCIGD	Area dependence of CIGD	m^2/V	0	-	-
LPOXEDGE	Length dependence of POXEDGE	m	0	-	-
WPOXEDGE	Width dependence of POXEDGE	m	0	-	-
PPOXEDGE	Area dependence of POXEDGE	m^2	0	-	-
LDLCIG	Length dependence of DLCIG	m^2	0	-	-
WDLCIG	Width dependence of DLCIG	m^2	0	-	-
PDLCIG	Area dependence of DLCIG	m^3	0	-	-
LDLCIGD	Length dependence of DLCIGD	m^2	0	-	-
WDLCIGD	Width dependence of DLCIGD	m^2	0	-	-
PDLCIGD	Area dependence of DLCIGD	m^3	0	-	-
LNTOX	Length dependence of NTOX	m	0	-	-
WNTOX	Width dependence of NTOX	m	0	-	-
PNTOX	Area dependence of NTOX	m^2	0	-	-
AGIDL	Pre-exponential coefficient for GIDL	V/m	0	-	-
AGIDLL	Length dependence coefficient of AGIDL	m	0	-	-
AGIDLW	Width dependence coefficient of AGIDL	m	0	-	-

Name	Description	Units	Default	Min	Max
LAGIDL	Length dependence of AGIDL	m^2	0	-	-
WAGIDL	Width dependence of AGIDL	m^2	0	-	-
PAGIDL	Area dependence of AGIDL	m^3	0	-	-
BGIDL	Exponential coefficient for GIDL	V/m	2.30E+09	-	-
LBGIDL	Length dependence of BGIDL	V	0	-	-
WBGIDL	Width dependence of BGIDL	V	0	-	-
PBGIDL	Area dependence of BGIDL	V*m	0	-	-
CGIDL	Exponential coefficient for GIDL	V/m	0.5	-	-
LCGIDL	Length dependence of CGIDL	V	0	-	-
WCGIDL	Width dependence of CGIDL	V	0	-	-
PCGIDL	Area dependence of CGIDL	V*m	0	-	-
EGIDL	Band bending parameter for GIDL	V	0.8	-	-
LEGIDL	Length dependence of EGIDL	V*m	0	-	-
WEGIDL	Width dependence of EGIDL	V*m	0	-	-
PEGIDL	Area dependence of EGIDL	V*m^2	0	-	-
AGISL	Pre-exponential coefficient for GISL	V/m	AGIDL	-	-
AGISLL	Length dependence coefficient of AGISL	m	AGIDLL	-	-
AGISLW	Width dependence coefficient of AGISL	m	AGIDLW	-	-
LAGISL	Length dependence of AGISL	m^2	LAGIDL	-	-
WAGISL	Width dependence of AGISL	m^2	WAGIDL	-	-
PAGISL	Area dependence of AGISL	m^3	PAGIDL	-	-
BGISL	Exponential coefficient for GISL	V/m	BGIDL	-	-
LBGISL	Length dependence of BGISL	V	LBGIDL	-	-
WBGISL	Width dependence of BGISL	V	WBGIDL	-	-
PBGISL	Area dependence of BGISL	V*m	PBGIDL	-	-

Name	Description	Units	Default	Min	Max
CGISL	Exponential coefficient for GISL	V/m	CGIDL	-	-
LCGISL	Length dependence of CGISL	V	LCGIDL	-	-
WCGISL	Width dependence of CGISL	V	WCGIDL	-	-
PCGISL	Area dependence of CGISL	V*m	PCGIDL	-	-
EGISL	Band bending parameter for GISL	V	EGIDL	-	-
LEGISL	Length dependence of EGISL	V*m	LEGIDL	-	-
WEGISL	Width dependence of EGISL	V*m	WEGIDL	-	-
PEGISL	Area dependence of EGISL	V*m^2	PEGIDL	-	-
CF	Outer Fringe capacitance	F/m	0	-	-
LCF	Length dependence of CF	F	0	-	-
WCF	Width dependence of CF	F	0	-	-
PCF	Area dependence of CF	F*m	0	-	-
CFRCOEFF	Coefficient for Outer Fringe capacitance	F/m	1	1	inf
CGSO	Gate - Source overlap capacitance	F/m	0	-	-
CGDO	Gate - Drain overlap capacitance	F/m	0	-	-
CGBO	Gate - Body overlap capacitance	F/m	0	-	-
CGSL	Overlap capacitance between gate and lightly-doped source region	F/m	0	-	-
LCGSL	Length dependence of CGSL	-	0	-	-
WCGSL	Width dependence of CGSL	-	0	-	-
PCGSL	Area dependence of CGSL	-	0	-	-
CGDL	Overlap capacitance between gate and lightly-doped drain region	F/m	0	-	-
LCGDL	Length dependence of CGDL	F	0	-	-
WCGDL	Width dependence of CGDL	F	0	-	-

Name	Description	Units	Default	Min	Max
PCGDL	Area dependence of CGDL	F*m	0	-	-
CKAPPAS	Coefficient of bias-dependent overlap capacitance for the source side	V	0.6	-	-
LCKAPPAS	Length dependence of CKAPPAS	m*V	0	-	-
WCKAPPAS	Width dependence of CKAPPAS	m*V	0	-	-
PCKAPPAS	Area dependence of CKAPPAS	m^2*V	0	-	-
CKAPPAD	Coefficient of bias-dependent overlap capacitance for the drain side	V	0.6	-	-
LCKAPPAD	Length dependence of CKAPPAD	m*V	0	-	-
WCKAPPAD	Width dependence of CKAPPAD	m*V	0	-	-
PCKAPPAD	Area dependence of CKAPPAD	m^2*V	0	-	-
DMCG	Distance of Mid-Contact to Gate edge	m	0	-	-
DMCI	Distance of Mid-Contact to Isolation	m	DMCG	-	-
DMDG	Distance of Mid-Diffusion to Gate edge	m	0	-	-
DMCGT	Distance of Mid-Contact to Gate edge in Test	m	0	-	-
XGL	Variation in Ldrawn	m	0	-inf	L*LMLT+XL
RSHG	Gate sheet resistance	ohm	0.1	0	inf
CJS	Unit area source-side junction capacitance at zero bias	F/m^2	5.00E-04	-	-
CJD	Unit area drain-side junction capacitance at zero bias	F/m^2	CJS	-	-
CJSWS	Unit length source-side side-wall junction capacitance at zero bias	F/m	5.00E-10	-	-
CJSWD	Unit length drain-side side-wall junction capacitance at zero bias	F/m	CJSWS	-	-
CJSWGS	Unit length source-side gate side-wall junction capacitance at zero bias	F/m	0	-	-

Name	Description	Units	Default	Min	Max
CJSWGD	Unit length drain-side gate side-wall junction capacitance at zero bias	F/m	CJSWGS	-	-
PBS	Source-side bulk junction built-in potential	V	1	-	-
PBD	Drain-side bulk junction built-in potential	V	PBS	-	-
PBSWS	Built-in potential for Source-side side-wall junction capacitance	V	1	-	-
PBSWD	Built-in potential for Drain-side side-wall junction capacitance	V	PBSWS	-	-
PBSWGS	Built-in potential for Source-side gate side-wall junction capacitance	V	PBSWS	-	-
PBSWGD	Built-in potential for Drain-side gate side-wall junction capacitance	V	PBSWGS	-	-
MJS	Source bottom junction capacitance grading coefficient	-	0.5	-	-
MJD	Drain bottom junction capacitance grading coefficient	-	MJS	-	-
MJSWS	Source side-wall junction capacitance grading coefficient	-	0.33	-	-
MJSWD	Drain side-wall junction capacitance grading coefficient	-	MJSWS	-	-
MJSWGS	Source-side gate side-wall junction capacitance grading coefficient	-	MJSWS	-	-
MJSWGD	Drain-side gate side-wall junction capacitance grading coefficient	-	MJSWG S	-	-
JSS	Bottom source junction reverse saturation current density	A/m^2	1.00E-04	-	-
JSD	Bottom drain junction reverse saturation current density	A/m^2	JSS	-	-
JSWS	Unit length reverse saturation current for side-wall source junction	A/m	0	-	-
JSWD	Unit length reverse saturation current for side-wall drain junction	A/m	JSWS	-	-
JSWGS	Unit length reverse saturation current for gate-edge side-wall source junction	A/m	0	-	-
JSWGD	Unit length reverse saturation current for gate-edge side-wall drain junction	A/m	JSWGS	-	-

Name	Description	Units	Default	Min	Max
NJS	Source junction emission coefficient	-	1	0	inf
NJD	Drain junction emission coefficient	-	NJS	0	inf
IJTHSFWD	Forward source diode breakdown limiting current	A	0.1	-	-
IJTHDFWD	Forward drain diode breakdown limiting current	A	IJTHSFWD	-	-
IJTHSREV	Reverse source diode breakdown limiting current	A	0.1	-	-
IJTHDREV	Reverse drain diode breakdown limiting current	A	IJTHSREV	-	-
BVS	Source diode breakdown voltage	V	10	-	-
BVD	Drain diode breakdown voltage	V	BVS	-	-
XJBVS	Fitting parameter for source diode breakdown current	-	1	0	inf
XJBVD	Fitting parameter for drain diode breakdown current	-	XJBVS	0	inf
JTSS	Bottom source junction trap-assisted saturation current density	A/m	0	-	-
JTSD	Bottom drain junction trap-assisted saturation current density	A/m	JTSS	-	-
JTSSWS	Unit length trap-assisted saturation current for side-wall source junction	A/m^2	0	-	-
JTSSWD	Unit length trap-assisted saturation current for side-wall drain junction	A/m^2	JTSSWS	-	-
JTSSWGS	Unit length trap-assisted saturation current for gate-edge side-wall source junction	A/m	0	-	-
JTSSWGD	Unit length trap-assisted saturation current for gate-edge side-wall drain junction	A/m	JTSSWGS	-	-
JTWEFF	Trap assisted tunnelling current width dependence	-	0	0	inf
NJTS	Non-ideality factor for JTSS	-	20	-	-
NJTSD	Non-ideality factor for JTSD	-	NJTS	-	-
NJTSSW	Non-ideality factor for JTSSWS	-	20	-	-
NJTSSWD	Non-ideality factor for JTSSWD	-	NJTSSW	-	-

Name	Description	Units	Default	Min	Max
NJTSSWG	Non-ideality factor for JTSSWGS	-	20	-	-
NJTSSWGD	Non-ideality factor for JTSSWGD	-	NJTSSWG	-	-
VTSS	Bottom source junction trap-assisted current voltage dependent parameter	V	10	-	-
VTSD	Bottom drain junction trap-assisted current voltage dependent parameter	V	VTSS	-	-
VTSSWS	Unit length trap-assisted current voltage dependent parameter for side-wall source junction	V	10	-	-
VTSSWD	Unit length trap-assisted current voltage dependent parameter for side-wall drain junction	V	VTSSWS	-	-
VTSSWGS	Unit length trap-assisted current voltage dependent parameter for gate-edge side-wall source junction	V	10	-	-
VTSSWGD	Unit length trap-assisted current voltage dependent parameter for gate-edge side-wall drain junction	V	VTSSWGS	-	-
XRCRG1	1st fitting parameter the bias-dependent Rg	-	12	-	-
XRCRG2	2nd fitting parameter the bias-dependent Rg	-	1	-	-
GBMIN	Minimum body conductance	mho	1.00E-12	0	inf
RBPS0	Scaling pre-factor for RBPS	ohm	50	0	inf
RBPSL	Length Scaling parameter for RBPS	-	0	0	inf
RBPSW	Width Scaling parameter for RBPS	-	0	0	inf
RBPSNF	Number of fingers Scaling parameter for RBPS	-	0	0	inf
RBPD0	Scaling pre-factor for RBPD	ohm	50	0	inf
RBPDL	Length Scaling parameter for RBPD	-	0	0	inf
RBPDW	Width Scaling parameter for RBPD	-	0	0	inf
RBPDNF	Number of fingers Scaling parameter for RBPD	-	0	0	inf
RBPBX0	Scaling pre-factor for RBPBX	ohm	100	0	inf
RBPBXL	Length Scaling parameter for RBPBX	-	0	0	inf

Name	Description	Units	Default	Min	Max
RBPBXW	Width Scaling parameter for RBPBX	-	0	0	inf
RBPBXNF	Number of fingers Scaling parameter for RBPBX	-	0	0	inf
RBPBY0	Scaling pre-factor for RBPBY	ohm	100	0	inf
RBPBYL	Length Scaling parameter for RBPBY	-	0	0	inf
RBPBYW	Width Scaling parameter for RBPBY	-	0	0	inf
RBPBYNF	Number of fingers Scaling parameter for RBPBY	-	0	0	inf
RBSBX0	Scaling pre-factor for RBSBX	ohm	100	0	inf
RBSBY0	Scaling pre-factor for RBSBY	ohm	100	0	inf
RBDBX0	Scaling pre-factor for RBDBX	ohm	100	0	inf
RBDBY0	Scaling pre-factor for RBDBY	ohm	100	0	inf
RBSDBXL	Length Scaling parameter for RBSBX and RBDBX	-	0	0	inf
RBSDBXW	Width Scaling parameter for RBSBX and RBDBX	-	0	0	inf
RBSDBXNF	Number of fingers Scaling parameter for RBSBX and RBDBX	-	0	0	inf
RBSDBYL	Length Scaling parameter for RBSBY and RBDBY	-	0	0	inf
RBSDBYW	Width Scaling parameter for RBSBY and RBDBY	-	0	0	inf
RBSDBYNF	Number of fingers Scaling parameter for RBSBY and RBDBY	-	0	0	inf
EF	Flicker Noise frequency exponent	-	1	0	2
EM	Saturation Field	V/m	4.10E+07	-	-
NOIA	Flicker noise parameter A	s^(1-EF)/(eV)^1/m^3	6.25E+40	-	-
NOIB	Flicker noise parameter B	s^(1-EF)/(eV)^1/m	3.13E+25	-	-
NOIC	Flicker noise parameter C	s^(1-EF)*m/(eV)^1	8.75E+08	-	-

Name	Description	Units	Default	Min	Max
LINTNOI	Length Reduction Parameter Offset	m	0	-	-
NTNOI	Noise factor for short-channel devices for TNOIMOD=0 only	-	1	0	inf
RNOIA	TNOIMOD = 1	-	0.577	-	-
RNOIB	TNOIMOD = 1	-	0.5164	-	-
RNOIC	TNOIMOD = 1	-	0.395	-	-
TNOIA	TNOIMOD = 1	-	0	-inf	inf
TNOIB	TNOIMOD = 1	-	0	-inf	inf
TNOIC	Correlation coefficient	-	0	-inf	inf
BINUNIT	Unit of L and W for Binning, 1 : micro-meter 0 : default	-	1	0	1
DLBIN	Length reduction parameter for binning	-	0	-	-
DWBIN	Width reduction parameter for binning	-	0	-	-
TNOM	Temperature at which the model was extracted	degC	27	-	-
TBGASUB	Band-gap Temperature Coefficient	eV/K	4.73E-04	-	-
TBGBSUB	Band-gap Temperature Coefficient	K	636	-	-
TNFACTOR	Temperature exponent for NFACTOR	-	0	-	-
UTE	Mobility temperature exponent	-	-1.5	-	-
LUTE	Length dependence of UTE	m	0	-	-
WUTE	Width dependence of UTE	m	0	-	-
PUTE	Area dependence of UTE	m^2	0	-	-
UTEL	Length Scaling parameter for UTE	m	0	-	-
UA1	Temperature coefficient for UA	m/V	1.00E-03	-	-
LUA1	Length dependence of UA1	m^2/V	0	-	-
WUA1	Width dependence of UA1	m^2/V	0	-	-
PUA1	Area dependence of UA1	m^3/V	0	-	-

Name	Description	Units	Default	Min	Max
UA1L	Length Scaling parameter for UA1	m	0	-	-
UC1	Temperature coefficient for UC	1/K	5.60E-11	-	-
LUC1	Length dependence of UC1	m/K	0	-	-
WUC1	Width dependence of UC1	m/K	0	-	-
PUC1	Area dependence of UC1	m^2/K	0	-	-
UD1	Temperature coefficient for UD	1/m^2	0	-	-
LUD1	Length dependence of UD1	1/m	0	-	-
WUD1	Width dependence of UD1	1/m	0	-	-
PUD1	Area dependence of UD1	-	0	-	-
UD1L	Length Scaling parameter for UD1	m	0	-	-
UCSTE	Temperature coefficient for UCS	-	-4.78E-03	-	-
LUCSTE	Length dependence of UCSTE	m	0	-	-
WUCSTE	Width dependence of UCSTE	m	0	-	-
PUCSTE	Area dependence of UCSTE	m^2	0	-	-
TETA0	Temperature coefficient for ETA0	-	0	-	-
PRT	Temperature coefficient for resistance	-	0	-	-
LPRT	Length dependence of PRT	m	0	-	-
WPRT	Width dependence of PRT	m	0	-	-
PPRT	Area dependence of PRT	m^2	0	-	-
AT	Temperature coefficient for saturation velocity	m/s	-1.56E-03	-	-
LAT	Length dependence of AT	m^2/s	0	-	-
WAT	Width dependence of AT	m^2/s	0	-	-
PAT	Area dependence of AT	m^3/s	0	-	-
ATL	Length Scaling parameter for AT	m	0	-	-

Name	Description	Units	Default	Min	Max
TDELTA	Temperature coefficient for DELTA	1/K	0	-	-
PTWGT	Temperature coefficient for PTWG	1/K	0	-	-
LPTWGT	Length dependence of PTWGT	m/K	0	-	-
WPTWGT	Width dependence of PTWGT	m/K	0	-	-
PPTWGT	Area dependence of PTWGT	m^2/K	0	-	-
PTWGTL	Length Scaling parameter for PTWGT	m	0	-	-
KT1	Temperature coefficient for Vth	V	-0.11	-	-
KT1EXP	Temperature coefficient for Vth	-	1	0	inf
KT1L	Temperature coefficient for Vth	V*m	0	-	-
LKT1	Length dependence of KT1	V*m	0	-	-
WKT1	Width dependence of KT1	V*m	0	-	-
PKT1	Area dependence of KT1	V*m^2	0	-	-
KT2	Temperature coefficient for Vth	-	0.022	-	-
LKT2	Length dependence of KT2	m	0	-	-
WKT2	Width dependence of KT2	m	0	-	-
PKT2	Area dependence of KT2	m^2	0	-	-
IIT	Temperature coefficient for BETA0	-	0	-	-
LIIT	Length dependence of IIT	m	0	-	-
WIIT	Width dependence of IIT	m	0	-	-
PIIT	Area dependence of IIT	m^2	0	-	-
IGT	Gate Current Temperature Dependence	-	2.5	-	-
LIGT	Length dependence of IGT	m	0	-	-
WIGT	Width dependence of IGT	m	0	-	-
PIGT	Area dependence of IGT	m^2	0	-	-
TGIDL	Temperature coefficient for GIDL/GISL	1/K	0	-	-

Name	Description	Units	Default	Min	Max
LTGIDL	Length dependence of TGIDL	m/K	0	-	-
WTGIDL	Width dependence of TGIDL	m/K	0	-	-
PTGIDL	Area dependence of TGIDL	m^2/K	0	-	-
TCJ	Temperature coefficient for CJS/CJD	1/K	0	-	-
TCJSW	Temperature coefficient for CJSWS/CJSWD	1/K	0	-	-
TCJSWG	Temperature coefficient for CJSWGS/CJSWGD	1/K	0	-	-
TPB	Temperature coefficient for PBS/PBD	V/K	0	-	-
TPBSW	Temperature coefficient for PBSWS/PBSWD	V/K	0	-	-
TPBSWG	Temperature coefficient for PBSWGS/PBSWGD	V/K	0	-	-
XTIS	Source junction current temperature exponent	-	3	-	-
XTID	Drain junction current temperature exponent	-	XTIS	-	-
XTSS	Power dependence of JTSS on temperature	-	0.02	-	-
XTSD	Power dependence of JTSD on temperature	-	XTSS	-	-
XTSSWS	Power dependence of JTSSWS on temperature	-	0.02	-	-
XTSSWD	Power dependence of JTSSWD on temperature	-	XTSSWS	-	-
XTSSWGS	Power dependence of JTSSWGS on temperature	-	0.02	-	-
XTSSWGD	Power dependence of JTSSWGD on temperature	-	XTSSWGS	-	-
TNJTS	Temperature coefficient for NJTS	-	0	-	-
TNJTSD	Temperature coefficient for NJTSD	-	TNJTS	-	-
TNJTSSW	Temperature coefficient for NJTSSW	-	0	-	-
TNJTSSWD	Temperature coefficient for NJTSSWD	-	TNJTSSW	-	-
TNJTSSWG	Temperature coefficient for NJTSSWG	-	0	-	-
TNJTSSWGD	Temperature coefficient for NJTSSWGD	-	TNJTSSWG	-	-

Name	Description	Units	Default	Min	Max
RTH0	Thermal resistance	m*K/W	0	0	inf
CTH0	Thermal capacitance	s*W/(m*K)	1.00E-05	0	inf
WTH0	Width dependence coefficient for Rth and Cth	m	0	-	-
SAREF	Reference distance between OD edge from Poly from one side	m	1.00E-06	0	inf
SBREF	Reference distance between OD edge from Poly from other side	m	1.00E-06	0	inf
WLOD	Width Parameter for Stress Effect	m	0	0	inf
KU0	Mobility degradation/enhancement Parameter for Stress Effect	m	0	-	-
KVSAT	Saturation Velocity degradation/enhancement Parameter for Stress Effect	m	0	-	-
TKU0	Temperature Coefficient for KU0	-	0	-	-
LKU0	Length Dependence of KU0	m^LLODKU0	0	-	-
WKU0	Width Dependence of KU0	m^WLODKU0	0	-	-
PKU0	Cross Term Dependence of KU0	m^(LLODKU0+WLODKU0)	0	-	-
LLODKU0	Length Parameter for U0 stress effect	-	0	-	-
WLODKU0	Width Parameter for U0 stress effect	-	0	-	-
KVTH0	Threshold Shift parameter for stress effect	V*m	0	-	-
LKVTH0	Length dependence of KVTH0	m^LLODKU0	0	-	-
WKVTH0	Width dependence of KVTH0	m^WLODKU0	0	-	-
PKVTH0	Cross-term dependence of KVTH0	m^(LLODKU0+WLODKU0)	0	-	-
LLODVTH	Length Parameter for Vth stress effect	-	0	-	-

Name	Description	Units	Default	Min	Max
WLODVTH	Width Parameter for Vth stress effect	-	0	-	-
STK2	K2 shift factor related to Vth change	m	0	-	-
LODK2	K2 shift modification factor for stress effect	-	0	-	-
STETA0	ETA0 shift related to Vth0 change	m	0	-	-
LODETA0	ETA0 modification factor for stress effect	-	0	-	-
WEB	Coefficient for SCB (>0.0)	-	0	-	-
WEC	Coefficient for SCC (>0.0)	-	0	-	-
KVTH0WE	Threshold shift factor for well proximity effect	-	0	-	-
LKVTH0WE	Length dependence of KVTH0WE	m	0	-	-
WKVTH0WE	Width dependence of KVTH0WE	m	0	-	-
PKVTH0WE	Area dependence of KVTH0WE	m^2	0	-	-
K2WE	K2 shift factor for well proximity effect	-	0	-	-
LK2WE	Length dependence of K2WE	m	0	-	-
WK2WE	Width dependence of K2WE	m	0	-	-
PK2WE	Area dependence of K2WE	m^2	0	-	-
KU0WE	Mobility degradation factor for well proximity effect	-	0	-	-
LKU0WE	Length dependence of KU0WE	m	0	-	-
WKU0WE	Width dependence of KU0WE	m	0	-	-
PKU0WE	Area dependence of KU0WE	m^2	0	-	-
SCREF	Reference distance to calculate SCA, SCB and SCC (<0)	m	1.00E-06	0	inf
SSL0	Temperature- and doping-independent parameter for sub-surface leakage drain current	A/m	4.00E+02	-	-
SSL1	Temperature- and doping-independent parameter for gate length for sub-surface leakage drain current	1/m	3.36E+08	-	-

Name	Description	Units	Default	Min	Max
SSL2	Fitting parameter for sub-surface leakage drain current: barrier height	-	0.185	-	-
SSL3	Fitting parameter for sub-surface leakage drain current: gate voltage effect	V	0.3	-	-
SSL4	Fitting parameter for sub-surface leakage drain current: gate voltage effect	1/V	1.4	-	-
SSLEXP1	Fitting exponent for ssl doping effect	-	0.49	-	-
SSLEXP2	Fitting exponent for ssl temperature	-	1.42	-	-
AVDSX	Smoothing parameter in Vdsx in Vbsx	-	20	5	100
WEDGE	Edge FET Width	m	1.00E-08	1.00 E-09	inf
DGAMMA EDGE	Different in body-bias coefficient between Edge-FET and Main-FET	-	0	-inf	inf
DGAMMA EDGEL	L dependence parameter for DGAMMA	-	0	-inf	inf
DGAMMA EDGELEX P	Exponent of L dependence parameter for DGAMMA	-	1	-inf	inf
DVTEDGE	Vth shift for Edge FET	-	0	-inf	inf
NFACTOR EDGE	NFACTOR for Edge FET	-	NFACTO R	-	-
LNFACTO REDGE	Length dependence of NFACTOREDGE	m	LNFACTO R	-	-
WNFACT OREDGE	Width dependence of NFACTOREDGE	m	WNFACT OR	-	-
PNFACTO REDGE	Area dependence of NFACTOREDGE	m^2	PNFACT OR	-	-
CITEDGE	CIT for Edge FET	F/m^2	CIT	-	-
LCITEDGE	Length dependence of CITEDGE	F/m	LCIT	-	-
WCITEDG E	Width dependence of CITEDGE	F/m	WCIT	-	-
PCITEDGE	Area dependence of CITEDGE	F	PCIT	-	-

Name	Description	Units	Default	Min	Max
CDSCDEDGE	CDSCD for edge FET	F/m^2/V	CDSCD	-	-
LCDSCDEDGE	Length dependence of CDSCDEDGE	F/m/V	LCDSCD	-	-
WCDSCDEDGE	Width dependence of CDSCDEDGE	F/m/V	WCDSCD	-	-
PCDSCDEDGE	Area dependence of CDSCDEDGE	F/V	PCDSCD	-	-
CDSCBEDGE	CDSCB for edge FET	F/m^2/V	CDSCB	-	-
LCDSCBEDGE	Length dependence of CDSCBEDGE	F/m/V	LCDSCB	-	-
WCDSCBEDGE	Width dependence of CDSCBEDGE	F/m/V	WCDSCB	-	-
PCDSCBEDGE	Area dependence of CDSCBEDGE	F/V	PCDSCB	-	-
ETA0EDGE	DIBL parameter for edge FET	-	ETA0	-	-
LETA0EDGE	Length dependence of ETA0EDGE	m	LETA0	-	-
WETA0EDGE	Width dependence of ETA0EDGE	m	WETA0	-	-
PETA0EDGE	Area dependence of ETA0EDGE	m^2	PETA0	-	-
ETABEDGE	ETAB for edge FET	1/V	ETAB	-	-
LETABEDGE	Length dependence of ETABEDGE	m/V	LETAB	-	-
WETABEDGE	Width dependence of ETABEDGE	m/V	WETAB	-	-
PETABEDGE	Area dependence of ETABEDGE	m^2/V	PETAB	-	-
KT1EDGE	Temperature dependence parameter of threshold voltage for edge FET	V	KT1	-	-

Name	Description	Units	Default	Min	Max
LKT1EDGE	Length dependence of KT1EDGE	V*m	LKT1	-	-
WKT1EDGE	Width dependence of KT1EDGE	V*m	WKT1	-	-
PKT1EDGE	Area dependence of KT1EDGE	V*m^2	PKT1	-	-
KT1LEDGE	Temperature dependence parameter of threshold voltage for edge FET	V*m	KT1L	-	-
LKT1LEDGE	Length dependence of KT1LEDGE	V*m^2	0	-	-
WKT1LEDGE	Width dependence of KT1LEDGE	V*m^2	0	-	-
PKT1LEDGE	Area dependence of KT1LEDGE	V*m^3	0	-	-
KT2EDGE	Temperature dependence parameter of threshold voltage for edge FET	-	KT2	-	-
LKT2EDGE	Length dependence of KT2EDGE	m	LKT2	-	-
WKT2EDGE	Width dependence of KT2EDGE	m	WKT2	-	-
PKT2EDGE	Area dependence of KT2EDGE	m^2	PKT2	-	-
KT1EXPEDGE	Temperature dependence parameter of threshold voltage for edge device	-	KT1EXP	-	-
LKT1EXPEDGE	Length dependence of KT1EXPEDGE	m	0	-	-
WKT1EXPEDGE	Width dependence of KT1EXPEDGE	m	0	-	-
PKT1EXPEDGE	Area dependence of KT1EXPEDGE	m^2	0	-	-
TNFACTOREDGE	Temperature dependence parameter of sub-threshold slope factor for edge	-	TNFACTOR	-	-
LTNFACTOREDGE	Length dependence of TNFACTOREDGE	m	0	-	-

Name	Description	Units	Default	Min	Max
WTNFACTOREDGE	Width dependence of TNFACTOREDGE	m	0	-	-
PTNFACTOREDGE	Area dependence of TNFACTOREDGE	m^2	0	-	-
TETA0EDGE	Temperature dependence parameter of DIBL parameter for edge FET	-	TETA0	-	-
LTETA0EDGE	Length dependence of TETA0EDGE	m	0	-	-
WTETA0EDGE	Width dependence of TETA0EDGE	m	0	-	-
PTETA0EDGE	Area dependence of TETA0EDGE	m^2	0	-	-
DVT0EDGE	First coefficient of SCE effect on Vth for Edge FET	-	2.2	-	-
DVT1EDGE	Second coefficient of SCE effect on Vth for Edge FET	-	0.53	-	-
DVT2EDGE	Body-bias coefficient for SCE effect for Edge FET	1/V	0	-	-
K2EDGE	Vth shift due to Vertical Non-uniform doping	V	K2	-	-
LK2EDGE	Length dependence of K2EDGE	m	LK2	-	-
WK2EDGE	Width dependence of K2EDGE	m	WK2	-	-
PK2EDGE	Area dependence of K2EDGE	m^2	PK2	-	-
KVTH0EDGE	Threshold Shift parameter for stress effect	V*m	KVTH0	-	-
LKVTH0EDGE	Length dependence of KVTH0EDGE	m^LLODKU0	LKVTH0	-	-
WKVTH0EDGE	Width dependence of KVTH0EDGE	m^WLODKU0	WKVTH0	-	-
PKVTH0EDGE	Area dependence of KVTH0EDGE	m^(LLODKU0+WLODKU0)	PKVTH0	-	-
STK2EDGE	K2 shift factor related to Vth change	m	STK2	-	-

Name	Description	Units	Default	Min	Max
LSTK2EDGE	Length dependence of STK2EDGE	m^2	0	-	-
WSTK2EDGE	Width dependence of STK2EDGE	m^2	0	-	-
PSTK2EDGE	Area dependence of STK2EDGE	m^3	0	-	-
STETA0EDGE	ETA0 shift related to Vth0 change	m	STETA0	-	-
LSTETA0EDGE	Length dependence of STETA0EDGE	m^2	0	-	-
WSTETA0EDGE	Width dependence of STETA0EDGE	m^2	0	-	-
PSTETA0EDGE	Area dependence of STETA0EDGE	m^3	0	-	-
IGCLAMP	Model flag	-	1	0	1
LP	Length scaling parameter for thermal noise	m	10u	0	inf
RNOIK	Exponential coefficient for enhanced correlated thermal noise	-	0	-	-
TNOIK	Empirical parameter for Leff trend of Sid at low Ids	1/m	0	-inf	inf
TNOIK2	Empirical parameter for sensitivity of RNOIK	1/m	0.1	0	inf
K0	Non-saturation effect parameter for strong inversion region	-	0	-	-
LK0	Length dependence of	m	0	-	-
WK0	Width dependence of	m	0	-	-
PK0	Area dependence of	m^2	0	-	-
K01	Temperature coefficient for K0	1/K	0	-	-
LK01	Length dependence of K0	m/K	0	-	-
WK01	Width dependence of K0	m/K	0	-	-
PK01	Area dependence of K0	m^2/K	0	-	-
M0	offset of non-saturation effect parameter for strong inversion region	-	1	-	-

Name	Description	Units	Default	Min	Max
LM0	Length dependence of	m	0	-	-
WM0	Width dependence of	m	0	-	-
PM0	Area dependence of	m^2	0	-	-
M01	Temperature coefficient for M0	1/K	0	-	-
LM01	Length dependence of M0	m/K	0	-	-
WM01	Width dependence of M0	m/K	0	-	-
PM01	Area dependence of M0	m^2/K	0	-	-
FNOIMOD	Flicker noise model selector	-	0	0	1
LH	Length of Halo transistor	m	30n	0	L
NOIA2	Flicker noise parameter A for Halo	s^(1-EF)/(eV)^1/m^3	NOIA	-	-
HNDEP	Halo Doping Concentration for IV	1/m^3	NDEP	0	inf

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model  modelname  bsimbulk version=106.2 [parm=value] ...
```

To use the version number and select the model version, the netlist must be in spectre mode.

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by MOSFET instance to refer to the model. In the fiollowing example, the modelname is my_bsimbulk. The third parameter indicates the type of model; for this model it is *BSIMBULK* and the version is 106.2. The rest of the model contains pairs of model parameters and values, separated by an equal sign.

The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example

```
simulator lang=spectre
model my_bsimbulk bsimbulk version=106.2
simulator lang=ads
my_bsimbulk: X1 n1 n2 n3 n4 n5 L=0.1u
```

Instance Parameters

Name	Description	Units	Default	Min	Max
L	Length	m	1.00E-05	0	inf
W	Total width including fingers	m	1.00E-05	0	inf
NF	Number of fingers	-	1	1	inf
NRS	Number of squares in source	-	1	0	inf
NRD	Number of squares in drain	-	1	0	inf
VFBSDOFF	Flat-band Voltage Offset Parameter	V	0	-	-
MINZ	Minimize either D or S	-	0	0	1
XGW	Distance from gate contact centre to dev edge	m	0	-	-
NGCON	Number of gate contacts	-	1	1	2
RGATEMOD	Gate resistance model selector	-	0	0	3
RBODYMOD	Distributed body R model	-	0	0	2
GEOMOD	Geometry-dependent parasitics model	-	0	0	10
RGEOMOD	Geometry-dependent source/drain resistanc	-	0	0	8
EDGEFET	0: Edge FET Model Of	-	0	0	1
SSLMOD	Sub-Surface Leakage Drain Curren	-	0	0	1
RBPB	Resistance between bNodePrime and bNode	ohm	50	0	inf
RBPD	Resistance between bNodePrime and bNode	ohm	50	0	inf

Name	Description	Units	Default	Min	Max
RBPS	Resistance between bNodePrime and sbNode	ohm	50	0	inf
RBDB	Resistance between bNode and dbNode	ohm	50	0	inf
RBSB	Resistance between bNode and sbNode	ohm	50	0	inf
SA	Distance between OD edge from Poly from one side	m	0	-	-
SB	Distance between OD edge from Poly from other side	m	0	-	-
SD	Distance between neighbouring fingers	m	0	-	-
SCA	Integral of the first distribution function for scattered well dopant	-	0	-inf	inf
SCB	Integral of second distribution function for scattered well dopant	-	0	-inf	inf
SCC	Integral of third distribution function for scattered well dopant	-	0	-inf	inf
SC	Distance to a single well edge if <=0.	m	0	-inf	inf
AS	Source to Substrate Junction Area	m^2	0	0	inf
AD	Drain to Substrate Junction Area	m^2	0	0	inf
PS	Source to Substrate Junction Perimeter	m	0	0	inf
PD	Drain to Substrate Junction Perimeter	m	0	0	inf

DC Operating Point Information

The following table lists the DC operating point parameters that can be sent to the dataset.

Name	Description	Units
QBI	Intrinsic body charge	C
QSI	Intrinsic source charge	C
QDI	Intrinsic drain charge	C
QGI	Intrinsic gate charge	C
CGGI	Intrinsic g-g MOSFET capacitance	F
CGBI	Intrinsic g-b MOSFET capacitance	F
CGSI	Intrinsic g-s MOSFET capacitance	F

Name	Description	Units
CGDI	Intrinsic g-d MOSFET capacitance	F
CSGI	Intrinsic s-g MOSFET capacitance	F
CSBI	Intrinsic s-b MOSFET capacitance	F
CSSI	Intrinsic s-s MOSFET capacitance	F
CSDI	Intrinsic s-d MOSFET capacitance	F
CDGI	Intrinsic d-g MOSFET capacitance	F
CDBI	Intrinsic d-b MOSFET capacitance	F
CDSI	Intrinsic d-s MOSFET capacitance	F
CDDI	Intrinsic d-d MOSFET capacitance	F
CBGI	Intrinsic b-g MOSFET capacitance	F
CBBI	Intrinsic b-b MOSFET capacitance	F
CBSI	Intrinsic b-s MOSFET capacitance	F
CBDI	Intrinsic b-d MOSFET capacitance	F
QB	Body charge	C
QS	Source charge	C
QD	Drain charge	C
QG	Gate charge	C
CGG	g-g MOSFET capacitance	F
CGB	g-b MOSFET capacitance	F
CGS	g-s MOSFET capacitance	F
CGD	g-d MOSFET capacitance	F
CSG	s-g MOSFET capacitance	F
CSB	s-b MOSFET capacitance	F
CSS	s-s MOSFET capacitance	F
CSD	s-d MOSFET capacitance	F

Name	Description	Units
CDG	d-g MOSFET capacitance	F
CDB	d-b MOSFET capacitance	F
CDS	d-s MOSFET capacitance	F
CDD	d-d MOSFET capacitance	F
CBG	b-g MOSFET capacitance	F
CBB	b-b MOSFET capacitance	F
CBS	b-s MOSFET capacitance	F
CBD	b-d MOSFET capacitance	F
ISUB	Substrate current	A
IGIDL	-	A
IGISL	-	A
IGS	-	A
IGD	-	A
IGCS	-	A
IGCD	-	A
IGB	-	A
CGSEXT	-	F
CGDEXT	-	F
CGBOV	Front gate charge	F
CAPBS	-	F
CAPBD	-	F
WEFF	-	m
LEFF	-	m
WEFFCV	-	m
LEFFCV	-	m

Name	Description	Units
IDS	Drain-source current	A
IDEFF	Effective drain current	A
ISEFF	Effective source current	A
IGEFF	Effective gate current	A
IBS	-	A
IBD	-	A
VDS	Drain to source voltage	V
VGS	Gate to source voltage	V
VBS	Body to source voltage	V
VDSAT	-	V
GM	-	mho
GMBS	-	mho
GDS	-	mho
T_TOTAL_K	-	K
T_TOTAL_C	-	degC
T_DELTA_SH	-	K
VTH	Threshold voltage	V

- DC operating point data is generated for this model. If a DC simulation is performed, device operating point data can be viewed for a component. The procedure for viewing device operating point data for a component is in Using Circuit Simulators.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to DataAccessComponent (Data Access Component)). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.

BSIMSOI (BSIMSOI MOSFET Model and Instance)

BSIMSOI (BSIMSOI MOSFET Model and Instance)

This sections describes the following versions of BSIMSOI model.

- BSIM3SOI Model
- BSIM3SOI NMOS, BSIM3SOI PMOS
- BSIM3SOI5 NMOS, BSIM3SOI5 PMOS
- BSIM4SOI Model

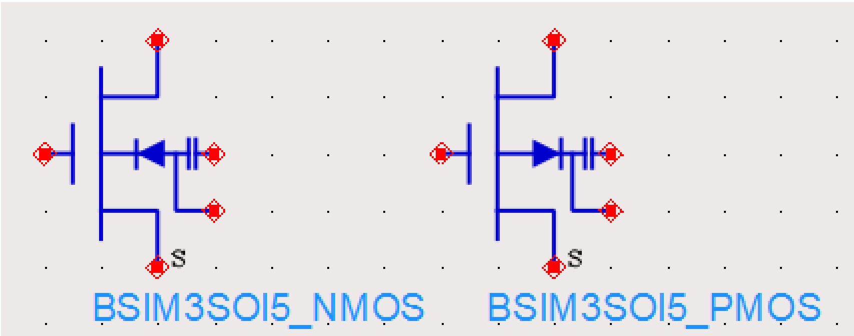
Notes

For information regarding the definition and parameter set for BSIMSOI models, refer to the BSIMSOI website.

BSIM3SOI5 NMOS, BSIM3SOI5 PMOS (BSIM3 SOI Transistor with 5th Terminal, ExtBody Contact, NMOS, PMOS)

BSIM3SOI5_NMOS, BSIM3SOI5_PMOS (BSIM3 SOI Transistor with 5th Terminal, Ext. Body Contact, NMOS, PMOS)

Symbol



Terminal Notation

Terminal Number	Description
1	Drain voltage (Vd)
2	Gate voltage (Vg)
3	Source voltage (Vs)
4	Emitter voltage (Ve)
5	If tnodeout==1, terminal 5 represents thermal node else, it represents External body bias (Vp)

Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
Model	model instance name	None	BSIM3SOIM1
Length †	channel length	m	5.0e-6

Width †	channel width	m	5.0e-6
Ad †	area of drain diffusion	m^2	0.0
As †	area of source diffusion	m^2	0.0
Pd †	perimeter of the drain junction	m	0.0
Ps †	perimeter of the drain junction	m	0.0
Nrd	number of squares of the drain diffusion	None	1.0
Nrs	number of squares of the source diffusion	None	1.0
Nrb	number of squares in body	None	1.0
Bjtoff	BJT on/off flag: yes=1, no=0	None	no
Rth0	instance thermal resistance; defaults to Rth0	(Ohm)	defaults to Rth0
Cth0	instance thermal capacitance; defaults to Cth0	(F)	defaults to Cth0
Nbc	number of body contact insulation edge	None	0.0
Nseg	number segments for width partitioning	None	1.0
Pdbcp †	perimter length for bc parasitics at drain side	m	0.0
Psbcp †	perimter length for bc parasitics at source side	m	0.0
Agbc †	gate to body overlap area for bc parasitics	m^2	0.0
Aebcp †	substrate to body overlap area for bc parasitics	m^2	0.0
Vbsusr	Vbs specified by the user; defaults to Vbs	V	defaults to Vbs
Temp	device operating temperature	°C	25
Trise	temperature rise above ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (refer to note 1)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
_M	number of devices in parallel	None	1
† Each instance parameter whose dimension contains a power of meter will be multiplied by the Scale to the same power. For example, a parameter with a dimension of *m* will be multiplied by *scale* ^{1} and a parameter with a dimension of m^2 will be multiplied by $scale^2$. Note that only parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains *cm* instead of meter is not scaled.			

- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.

- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

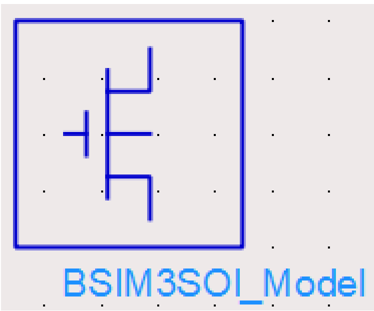
Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Ib	Bulk current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gmb	Backgate transconductance (dIds/dVbs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Vth	Threshold voltage	volts
Vdsat	Drain-source saturation voltage	volts
DqgDvgb	(dQg/dVgb)	farads
DqgDvdb	(dQg/dVdb)	farads
DqgDvsb	(dQg/dVsb)	farads
DqgDveb	(dQg/dVeb)	farads
DqbDvgb	(dQb/dVgb)	farads
DqbDvdb	(dQb/dVdb)	farads
DqbDvsb	(dQb/dVsb)	farads

Name	Description	Units
DqbDveb	(dQb/dVeb)	farads
DqdDvgb	(dQd/dVgb)	farads
DqdDvdb	(dQd/dVdb)	farads
DqdDvsb	(dQd/dVsb)	farads
DqdDveb	(dQd/dVeb)	farads
DqeDvgb	(dQe/dVgb)	farads
DqeDvdb	(dQe/dVdb)	farads
DqeDvsb	(dQe/dVsb)	farads
DqeDveb	(dQe/dVeb)	farads
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts
Vbs	Bulk-source voltage	volts
Ves	Substrate-source voltage	volts
Vps	Body-source voltage	volts

BSIM3SOI Model (BSIM3 Silicon On Insulator MOSFET Model)

BSIM3SOI_Model (BSIM3 Silicon On Insulator MOSFET Model)

Symbol



Description

In ADS, this BSIM3SOI model is equivalent to the Berkeley model named BSIMSOI, a deep submicron, silicon-on-insulator MOSFET device model for SPICE engines; it was developed by the BSIM Group under the direction of Professor Chenming Hu in the Department of Electrical Engineering and Computer Sciences at the University of California, Berkeley. BSIMSOI is closely related to the industry standard bulk MOSFET model, BSIM.

BSIMPD2.2, used for this ADS release, is the new version of the Partial Depletion SOI MOSFET model, BSIMPD SOI. The gate-body tunneling (substrate current) is added in this release to enhance the model accuracy. BSIMPD2.2 information can be found on the BSIMSOI website "http://www-device.eecs.berkeley.edu/~bsimsoi".

Parameters

Model parameters must be specified in SI units. In some cases, parameters that are simply geometric variations of a listed parameter, such as L, W, or P, are not listed.

Parameter	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Capmod	short-channel capacitance model selector	None	2
Mobmod	mobility model selector	None	1

Noimod	noise model selector	None	1
Shmod	self-heating mode selector; 0=no self-heating, 1= self-heating	None	0
Ddmod	dynamic depletion mode selector	None	0
Igmod	gate current model selector	None	0
Paramchk	model parameter checking selector	None	0
Binunit	Bin unit selector	None	1
Version	model version	None	2.0
Tox	gate oxide thickness	m	1.0e-8
Cdsc	Drain/Source and channel coupling capacitance	F/m^2	2.4e-4
Cdscb	body effect coefficient of Cdsc	$F/(V \times m^2)$	0.0
Cdscd	drain bias dependence of Cdsc	$F/(V \times m^2$	0.0
Cit	capacitance due to interface change	F/m^2	1.0
Nfactor †	subthreshold swing factor	None	0.0
Vsat †	saturation velocity at Temp	m/s	8.0e4
At †	temperature coefficient for saturation velocity	m/s	3.3e4
A0 †	bulk charge effect coefficient	None	1.0
Ags †	gate bulk coefficient of Abulk	V^{-1}	0.0
A1	first saturation factor	V^{-1}	0.0
A2 †	second non-saturation factor	None	1.0
Keta †	body-bias coefficient of the bulk charge effect	V^{-1}	-0.6
Nsub	substrate doping concentration with polarity	cm^{-3}	6.0e16
Nch	Channel doping concentration	cm^{-3}	1.7e17
Ngate	poly-gate doping concentration	cm^{-3}	0.0
Gamma1	body-effect coefficient near the interface	$V^{(1/2)}$	calculated
Gamma2	body-effect coefficient in the bulk	$V^{(1/2)}$	calculated
Vbx	Vth transition body voltage	V	calculated
Vbm	maximum body voltage	V	-3.0
Xt	doping depth	m	1.55e-7
K1 †	body-effect coefficient	$V^{(1/2)}$	0.5
Kt1	temperature coefficient for threshold voltage	V	-0.11

Kt1l	channel length sensitivity of kt1	V×m	0.0
Kt2	body-bias coefficient	None	0.022
K2 †	bulk effect coefficient 2	None	0.0
K3 †	narrow width coefficient	None	0.0
K3b †	body effect coefficient of K3	V^{-1}	0.0
W0 †	narrow width	m	2.5e6
Nlx †	lateral non-uniform doping coefficient	m	1.74e-7
Dvt0 †	first coefficient of short-channel effect on Vth	None	2.2
Dvt1 †	first coefficient of short-channel effect on Vth	None	0.53
Dvt2 †	body-bias coefficient of short-channel effect on Vth	V^{-1}	-0.032
Dvt0w †	first coefficient of narrow-width effect on Vth	None	0.0
Dvt1w †	Second Coefficient of narrow-width effect on Vth	m^{-1}	5.3e6
Dvt2w †	Body-bias Coefficient of narrow-width effect on Vth	V^{-1}	0.032
Drout †	L depend	None	0.56
Dsub †	DIBL coefficient in sub-threshold region; defaults to Drout	None	defaults to Drout
Vth0 †	zero-bias threshold voltage	V	0.7 (NMOS) -0.7 (PMOS)
Ua †	first-order mobility degradation coefficient	m/V	2.25e-9
Ua1	temperature coefficient of Ua	m/V	4.31e-9
Ub †	second-order mobility degradation coefficient	$(m/V)^2$	5.87e-19
Ub1	temperature coefficient of Ub	$(m/V)^2$	−7.61e-18
Uc †	body-bias mobility degradation coefficient	V^{-1}	-0.0465
Uc1	temperature coefficient of Uc	V^{-1}	-0.056
U0 †	low-field mobility at T=Tnom	$m^2/(V×s)$	0.067 NMOS 0.025 PMOS
Ute	Mobility temperature exponent	None	-1.5
Voff †	Offset voltage in sub-threshold region	V	-0.08
Tnom	measurement temperature	°C	25
Trise	temperature rise above ambient	°C	None

Cgso	G-S overlap capacitance per meter channel width	F/m	calculated
Cgdo	G-D overlap capacitance per meter channel width	F/m	calculated
Xpart	coefficient of channel charge share	None	0.0
Delta †	effective Vds	V	0.01
Rsh	drain and source diffusion sheet resistance	Ohm/sq	0.0
Rdsw †	parasitic resistance per unit width	Ohm × um^{Wr}	0.0
Prwg †	gate bias effect on parasitic resistance	V^{-1}	0.0
Prwb †	body effect on parasitic resistance	$V^{-1/2}$	0.0
Prt	temperature coefficient of parasitic resistance	Ohm × um	0.0
Eta0	Sub-threshold region DIBL coefficient	None	0.08
Etab	Sub-threshold region DIBL coefficient	V^{-1}	-0.07
Pclm	channel-length modulation effect coefficient	None	1.3
Pdiblc1	drain induced barrier lowering effect coefficient 1	None	0.39
Pdiblc2	drain induced barrier lowering effect coefficient 2	None	0.086
Pdiblcb	body effect on drain induced barrier lowering	V^{-1}	0.0
Pvag †	gate voltage dependence of Rout coefficient	None	0.0
Tbox	back gate oxide thickness	m	3.0e-7
Tsi	silicon-on-insulator thickness	m	1.0e-7
Xj	metallurgical junction depth; defaults to Tsi	m	defaults to Tsi
Rth0	self-heating thermal resistance	Ohm	0.0
Cth0	self-heating thermal capacitance	F	0.0
Ngidi	GIDL first parameter	V	1.2
Agidl	GIDL second parameter	Ohm^{-1}	0.0
Bgidl	GIDL third parameter	V/m	0.0
Ndiode †	diode non-ideality factor	None	1.0
Xbjt	temperature coefficient for Isbjt	None	1.0
Xdif	temperature coefficient for Isdif	None	1.0
Xrec	temperature coefficient for Isrec	None	1.0
Xtun	temperature coefficient for Istun	None	0.0
Pbswg	S/D (gate side) sidewall junction built-in potential	V	0.7

Mjswg	S/D (gate side) sidewall junction grading coefficient	None	0.5
Cjswg	S/D (gate side) sidewall junction capacitance	F/m	1.0e-10
Lint †	length reduction parameter	m	0.0
Ll	coefficient of length dependence for length offset	m	0.0
Lln	power of length dependence of length offset	None	1.0
Lw	coefficient of width dependence for length offset	m	0.0
Lwn	power of width dependence for length offset	None	1.0
Lwl	coefficient of lenth and width cross term length offset	m	0.0
Wr †	width dependence of Rds	None	1.0
Wint †	width reduction parameter	m	0.0
Dwg †	coefficient of Weff's gate dependence	m/V	0.0
Dwb †	coefficient of Weff's substrate body bias dependence	$m/V^{(1/2)}$	0.0
Wl	coefficient of length dependence for width offset	m	0.0
Wln	power of length dependence for width offset	None	1.0
Ww	coefficient of width dependence for width offset	m	0.0
Wwn	power of width dependence for width offset	None	1.0
Wwl	coefficient of length and width cross term width of offset	m	0.0
B0 †	Bulk charge effect coefficient for channel width	m	0.0
B1 †	Bulk charge effect width offset	m	0.0
Cgsl	light doped source-gate region overlap capacitance	F/m	0.0
Cgdl	Light doped drain-gate region overlap capacitance	F/m	0.0
Ckappa	coefficient for light doped source-gate region overlap capacitance	F/m	0.6
Cf	fringing field capacitance	F/m	calculated
Clc	constant term for the short channel model	m	0.1e-7
Cle	exponential term for the short channel model	None	0.0
Dwc	width offset fitting parameter from C-V; defaults to Wint	m	defaults to Wint

Dlc	length offset fitting parameter from C-V; defaults to Lint	m	defaults to Lint
Alpha0 †	first parameter of impact ionization current	m/V	0.0
Noia	noise parameter A	None	1.0e20 (NMOS) 9.9e18 (PMOS)
Noib	noise parameter B	None	5.0e4(NMOS), 2.4e3 (PMOS)
Noic	noise parameter C	None	-1,4e-12 (NMOS) 1.4e-12 (PMOS)
Em	flicker (1/f) noise parameter	V/m	4.1e-7
Ef	flicker (1/f) noise frequency exponent	None	1.0
Af	flicker (1/f) noise exponent	None	1.0
Kf	flicker (1/f) noise coefficient	None	0.0
Noif	floating body noise ideality factor	None	1.0
K1w1 †	first body effect width dependent parameter	m	0.0
K1w2 †	second body effect width dependent parameter	m	0.0
Ketas †	surface potential adjustment for bulk charge effect	V	0.0
Dwbc	width offset for body contact isolation edge	m	0.0
Beta0 †	first Vds parameter of impact isolation current	V^{-1}	0.0
Beta1 †	second Vds parameter of impact isolation current	None	0.0
Beta2 †	third Vds parameter of impact isolation current	V	0.1
Vdsatii0	nominal drain saturation voltage at threshold for impact ionization current	V	0.9
Tii †	temperature dependent parameter for impact ionization	None	0.0
Lii †	channel length dependent parameter threshold for impact ionization	None	0.0
Sii0 †	first Vgs dependent parameter for impact ionization current	V^{-1}	0.5
Sii1 †	second Vgs dependent parameter for impact ionization current	V^{-1}	0.1
Sii2 †	third Vgs dependent parameter for impact ionization current	V^{-1}	0.1

Siid †	Vgs dependent parameter for impact ionization current	V^{-1}	0.1
Fbjtii	fraction of bipolar current affecting the impact ionization	None	0.0
Esatii †	saturation electric field for impact ionization	V /m	1.0e7
Ntun †	reverse tunneling new-ideality factor	None	10.0
Nrecf0 †	recombination non-ideality factor at forward bias	None	2.0
Nrecr0 †	recombination non-ideality factor at reversed bias	None	10.0
Isbjt †	BJT injection saturation current	A/m^2	1.0e-6
Isdif †	Body to source/drain injection saturation current	A/m^2	0.0
Isrec †	recombination in depletion saturation current	A/m^2	1.0e-5
Istun †	reverse tunneling saturation current	A/m^2	0.0
Ln	electron/hole diffusion length	m	2.0e-6
Vrec0 †	voltage dependent parameter for recombination current	V	0.0
Vtun0 †	voltage dependent parameter for tunneling current	V	0.0
Nbjt †	power coefficient of channel length dependency for bipolar current	None	1.0
Lbjt0 †	Reference channel length for bipolar current	m	0.2e-6
Ldif0	channel length dependency coefficient of diffusion capacitance	None	1.0
Vabjt †	early voltage for bipolar current	V	10.0
Aely †	channel length dependency of early voltage for bipolar current	V/m	0.0
Ahli †	high level injection parameter for bipolar current	None	0.0
Rbody	intrinsic body sheet resistance	Ohm/m^2	0.0
Rbsh	extrinsic body sheet resistance	Ohm/m^2	0.0
Cgeo	Gate substrate overlap capacitance per unit channel length	F/m	0.0
Tt	diffusion capacitance transit time coefficient	sec	1.0e-12
Ndif	power coefficient of channel length dependency for diffusion capacitance	None	-1.0

Vsdfb †	Source/drain bottom diffusion capacitance flatband voltage	V	calculated
Vsdth †	Source/drain bottom diffusion capacitance threshold voltage	V	calculated
Csdmin	Source/drain bottom diffusion minimum capacitance	F	calculated
Asd	source/drain bottom diffusion smoothing parameter	None	0.3
Csdesw	source/drain sidewall fringing capacitance per unit channel length	F/m	0/0
Ntrecf	temperature coefficient for Ncref	None	0.0
Ntrecr	temperature coefficient for Ncrer	None	0.0
Dlcb	length offset fitting parameter for body charge; defaults to Lint	m	defaults to Lint
Fbody	scaling factor for body charge	None	1.0
Tcjswg	temperature coefficient of Cjswg	K^{-1}	0.0
Tpbswg	temperature coefficient of Pbswg	V/K	0.0
Acde †	exponential coefficient for finite charge thickness	m/V	1.0
Moin †	coefficient for gate-bias dependent surface potential	$V^{(1/2)}$	15.0
Delvt †	threshold voltage adjust for CV	V	0.0
Kb1 †	coefficient of Vbs0 dependency on Ves	None	1.0
Dlbg	length offset fitting parameter for backgate charge	m	0.0
Toxqm	effective oxide thickness considering quantum effect; defaults toTox	m	defaults toTox
Wth0	minimum width for thermal resistance calculation	m	0.0
Rhalo	Body halo sheet resistance	Ohm	1.0e15
Ntox	power term of gate current	None	1.0
Toxref	target oxide thickness	m	2.5e-9
Ebg	effective bandgap in gate current calculation	V	1.2
Nevb	valence-band electron non-ideality factor	V	3.0
Alphagb1	first Vox dependent parameter for gate current in inversion	None	0.35

Betagb1	second Vox dependent parameter for gate current in inversion	None	0.03
Vgb1	third Vox dependent parameter for gate current in inversion	None	300.0
Necb	condition-band electron non-ideality factor	None	1.0
Alphagb2	first Vox dependent parameter for gate current in accumulation	None	0.43
Betagb2	second Vox dependent parameter for gate current in accumulation	None	0.05
Vgb2	third Vox dependent parameter for gate current in accumulation	None	17.0
Voxh	limit of Vox in gate current calculation	V	5.0
Deltavox	Smoothing parameter in the Vox smoothing function	V	0.005
Lnch	Length dependence of nch	None	0.0
Lnsub	Length dependence of nsub	None	0.0
Lngate	Length dependence of ngate	None	0.0
Lvth0	Length dependence of vth0	None	0.0
Lk1	Length dependence of body effect coefficient	$um \times V^{(1/2)}$	0.0
Lk1w1	Length dependence of K1w1	None	0.0
Lk1w2	Length dependence of K1w2	None	0.0
Lk2	Length dependence of charge sharing coefficient	um	0.0
Lk3	Length dependence of k3	None	0.0
Lk3b	Length dependence of k3b	None	0.0
Lkb1	Length dependence of kb1	None	0.0
Lw0	Length dependence of w0	None	0.0
Lnlx	Length dependence of nlx	None	0.0
Ldvt0	Length dependence of dvt0	None	0.0
Ldvt1	Length dependence of dvt1	None	0.0
Ldvt2	Length dependence of dvt2	None	0.0
Ldvt0w	Length dependence of dvt0w	None	0.0
Ldvt1w	Length dependence of dvt1w	None	0.0
Ldvt2w	Length dependence of dvt2w	None	0.0
Lu0	Length dependence of u0	None	0.0

Lua	Length dependence of ua	None	0.0
Lub	Length dependence of ub	None	0.0
Luc	Length dependence of uc	None	0.0
Lvsat	Length dependence of vsat	None	0.0
La0	Length dependence of a0	None	0.0
Lags	Length dependence of ags	None	0.0
Lb0	Length dependence of b0	None	0.0
Lb1	Length dependence of b1	None	0.0
Lketa	Length dependence of keta	None	0.0
Lketas	Length dependence of ketas	None	0.0
La1	Length dependence of a1	None	0.0
La2	Length dependence of a2	None	0.0
Lrdsw	Length dependence of rdsw	None	0.0
Lprwb	Length dependence of prwb	None	0.0
Lprwg	Length dependence of prwg	None	0.0
Lwr	Length dependence of wr	None	0.0
Lnfactor	Length dependence of nfactor	None	0.0
Ldwg	Length dependence of dwg	None	0.0
Ldwb	Length dependence of dwb	None	0.0
Lvoff	Length dependence of voff	None	0.0
Leta0	Length dependence of barrier lowering coefficient,	um	0.0
Letab	Length dependence of sens	um/V	0.0
Ldsub	Length dependence of dsub	None	0.0
Lcit	Length dependence of cit	None	0.0
Lcdsc	Length dependence of cdsc	None	0.0
Lcdscb	Length dependence of cdscb	None	0.0
Lcdscd	Length dependence of cdscd	None	0.0
Lpclm	Length dependence of pclm	None	0.0
Lpdiblc1	Length dependence of pdiblc1	None	0.0
Lpdiblc2	Length dependence of pdiblc2	None	0.0
Lpdiblcb	Length dependence of pdiblcb	None	0.0
Ldrout	Length dependence of drout	None	0.0

Lpvag	Length dependence of pvag	None	0.0
Ldelta	Length dependence of delta	None	0.0
Lalpha0	Length dependence of alpha0	None	0.0
Lfbjtii	Length dependence of fbjtii	None	0.0
Lbeta0	Length dependence of beta0	None	0.0
Lbeta1	Length dependence of beta1	None	0.0
Lbeta2	Length dependence of beta2	None	0.0
Lvdsatii0	Length dependence of vdsatii0	None	0.0
Llii	Length dependence of lii	None	0.0
Lesatii	Length dependence of esatii	None	0.0
Lsii0	Length dependence of sii0	None	0.0
Lsii1	Length dependence of sii1	None	0.0
Lsii2	Length dependence of sii2	None	0.0
Lsiid	Length dependence of siid	None	0.0
Lagidl	Length dependence of agidl	None	0.0
Lbgidl	Length dependence of bgidl	None	0.0
Lngidl	Length dependence of ngidl	None	0.0
Lntun	Length dependence of ntun	None	0.0
Lndiode	Length dependence of ndiode	None	0.0
Lnrecf0	Length dependence of nrecf0	None	0.0
Lnrecr0	Length dependence of nrecr0	None	0.0
Lisbjt	Length dependence of isbjt	None	0.0
Lisdif	Length dependence of isdif	None	0.0
Listun	Length dependence of istun	None	0.0
Lvrec0	Length dependence of vrec0	None	0.0
Lvtun0	Length dependence of vtun0	None	0.0
Lnbjt	Length dependence of nbjt	None	0.0
Lnbjt0	Length dependence of lbjt0	None	0.0
Lvabjt	Length dependence of vabjt	None	0.0
Laely	Length dependence of aely	None	0.0
Lahli	Length dependence of ahli	None	0.0
Lvsdfb	Length dependence of vsdfb	None	0.0

Lvsdth	Length dependence of vsdth	None	0.0
Ldelvt	Length dependence of delvt	None	0.0
Lacde	Length dependence of Acde	None	0.0
Lmoin	Length dependence of Moin	um×V$^{(1/2)}$	0.0
Wnch	Width dependence of nch	None	0.0
Wnsub	Width dependence of nsub	None	0.0
Wngate	Width dependence of ngate	None	0.0
Wvth0	Width dependence of vth0	None	0.0
Wk1	Width dependence of body effect coefficient	um×V$^{(1/2)}$	0.0
Wk1w1	Width dependence of K1w1	None	0.0
Wk1w2	Width dependence of K1w2	None	0.0
Wk2	Width dependence of charge sharing coefficient	um	0.0
Wk3	Width dependence of k3	None	0.0
Wk3b	Width dependence of k3b	None	0.0
Wkb1	Width dependence of kb1	None	0.0
Ww0	Width dependence of w0	None	0.0
Wnlx	Width dependence of nlx	None	0.0
Wdvt0	Width dependence of dvt0	None	0.0
Wdvt1	Width dependence of dvt1	None	0.0
Wdvt2	Width dependence of dvt2	None	0.0
Wdvt0w	Width dependence of dvt0w	None	0.0
Wdvt1w	Width dependence of dvt1w	None	0.0
Wdvt2w	Width dependence of dvt2w	None	0.0
Wu0	Width dependence of mobility degradation coefficient	None	0.0
Wua	Width dependence of ua	None	0.0
Wub	Width dependence of ub	None	0.0
Wuc	Width dependence of uc	None	0.0
Wvsat	Width dependence of vsat	None	0.0
Wa0	Width dependence of a0	None	0.0
Wags	Width dependence of ags	None	0.0
Wb0	Width dependence of b0	None	0.0

Wb1	Width dependence of b1	None	0.0
Wketa	Width dependence of keta	None	0.0
Wketas	Width dependence of ketas	None	0.0
Wa1	Width dependence of a1	None	0.0
Wa2	Width dependence of a2	None	0.0
Wrdsw	Width dependence of rdsw	None	0.0
Wprwb	Width dependence of prwb	None	0.0
Wprwg	Width dependence of prwg	None	0.0
Wwr	Width dependence of wr	None	0.0
Wnfactor	Width dependence of nfactor	None	0.0
Wdwg	Width dependence of dwg	None	0.0
Wdwb	Width dependence of dwb	None	0.0
Wvoff	Width dependence of voff	None	0.0
Weta0	Width dependence of barrier lowering coefficient	um	0.0
Wetab	Width dependence of sens	um/V	0.0
Wdsub	Width dependence of dsub	None	0.0
Wcit	Width dependence of cit	None	0.0
Wcdsc	Width dependence of cdsc	None	0.0
Wcdscb	Width dependence of cdscb	None	0.0
Wcdscd	Width dependence of cdscd	None	0.0
Wpclm	Width dependence of pclm	None	0.0
Wpdiblc1	Width dependence of pdiblc1	None	0.0
Wpdiblc2	Width dependence of pdiblc2	None	0.0
Wpdiblcb	Width dependence of pdiblcb	None	0.0
Wdrout	Width dependence of drout	None	0.0
Wpvag	Width dependence of pvag	None	0.0
Wdelta	Width dependence of delta	None	0.0
Walpha0	Width dependence of alpha0	None	0.0
Wfbjtii	Width dependence of fbjtii	None	0.0
Wbeta0	Width dependence of beta	None	0.0
Wbeta1	Width dependence of beta1	None	0.0
Wbeta2	Width dependence of beta2	None	0.0

Wvdsatii0	Width dependence of vdsatii0	None	0.0
Wlii	Width dependence of lii	None	0.0
Wesatii	Width dependence of esatii	None	0.0
Wsii0	Width dependence of sii0	None	0.0
Wsii1	Width dependence of sii1	None	0.0
Wsii2	Width dependence of sii2	None	0.0
Wsiid	Width dependence of siid	None	0.0
Wagidl	Width dependence of agidl	None	0.0
Wbgidl	Width dependence of bgidl	None	0.0
Wngidl	Width dependence of ngidl	None	0.0
Wntun	Width dependence of ntun	None	0.0
Wndiode	Width dependence of ndiode	None	0.0
Wnrecf0	Width dependence of nrecf0	None	0.0
Wnrecr0	Width dependence of nrecr0	None	0.0
Wisbjt	Width dependence of isbjt	None	0.0
Wisdif	Width dependence of isdif	None	0.0
Wistun	Width dependence of istun	None	0.0
Wvrec0	Width dependence of vrec0	None	0.0
Wvtun0	Width dependence of vtun0	None	0.0
Wnbjt	Width dependence of nbjt	None	0.0
Wlbjt0	Width dependence of lbjt0	None	0.0
Wvabjt	Width dependence of vabjt	None	0.0
Waely	Width dependence of aely	None	0.0
Wahli	Width dependence of ahli	None	0.0
Wvsdfb	Width dependence of vsdfb	None	0.0
Wvsdth	Width dependence of vsdth	None	0.0
Wdelvt	Width dependence of delvt	None	0.0
Wacde	Width dependence of Acde	None	0.0
Wmoin	Width dependence of Moin	$um \times V^{(1/2)}$	0.0
Pnch	Cross-term dependence of nch	None	0.0
Pnsub	Cross-term dependence of nsub	None	0.0
Pngate	Cross-term dependence of ngate	None	0.0

Pvth0	Cross-term dependence of vth0	None	0.0
Pk1	Cross-term dependence of k1	None	0.0
Pk1w1	Cross-term dependence of K1w1	None	0.0
Pk1w2	Cross-term dependence of K1w2	None	0.0
Pk2	Cross-term dependence of k2	None	0.0
Pk3	Cross-term dependence of k3	None	0.0
Pk3b	Cross-term dependence of k3b	None	0.0
Pkb1	Cross-term dependence of kb1	None	0.0
Pw0	Cross-term dependence of w	None	0.0
Pnlx	Cross-term dependence of nlx	None	0.0
Pdvt0	Cross-term dependence of dvt0	None	0.0
Pdvt1	Cross-term dependence of dvt1	None	0.0
Pdvt2	Cross-term dependence of dvt2	None	0.0
Pdvt0w	Cross-term dependence of dvt0w	None	0.0
Pdvt1w	Cross-term dependence of dvt1w	None	0.0
Pdvt2w	Cross-term dependence of dvt2w	None	0.0
Pu0	Cross-term dependence of u0	None	0.0
Pua	Cross-term dependence of ua	None	0.0
Pub	Cross-term dependence of ub	None	0.0
Puc	Cross-term dependence of uc	None	0.0
Pvsat	Cross-term dependence of vsat	None	0.0
Pa0	Cross-term dependence of a0	None	0.0
Pags	Cross-term dependence of ags	None	0.0
Pb0	Cross-term dependence of b0	None	0.0
Pb1	Cross-term dependence of b1	None	0.0
Pketa	Cross-term dependence of keta	None	0.0
Pketas	Cross-term dependence of ketas	None	0.0
Pa1	Cross-term dependence of a1	None	0.0
Pa2	Cross-term dependence of a2	None	0.0
Prdsw	Cross-term dependence of rdsw	None	0.0
Pprwb	Cross-term dependence of prwb	None	0.0
Pprwg	Cross-term dependence of prwg	None	0.0

Pwr	Cross-term dependence of wr	None	0.0
Pnfactor	Cross-term dependence of nfactor	None	0.0
Pdwg	Cross-term dependence of dwg	None	0.0
Pdwb	Cross-term dependence of dwb	None	0.0
Pvoff	Cross-term dependence of voff	None	0.0
Peta0	Cross-term dependence of eta0	None	0.0
Petab	Cross-term dependence of etab	None	0.0
Pdsub	Cross-term dependence of dsub	None	0.0
Pcit	Cross-term dependence of cit	None	0.0
Pcdsc	Cross-term dependence of cdsc	None	0.0
Pcdscb	Cross-term dependence of cdscb	None	0.0
Pcdscd	Cross-term dependence of cdscd	None	0.0
Ppclm	Cross-term dependence of pclm	None	0.0
Ppdiblc1	Cross-term dependence of pdiblc1	None	0.0
Ppdiblc2	Cross-term dependence of pdiblc2	None	0.0
Ppdiblcb	Cross-term dependence of pdiblcb	None	0.0
Pdrout	Cross-term dependence of drout	None	0.0
Ppvag	Cross-term dependence of pvag	None	0.0
Pdelta	Cross-term dependence of delta	None	0.0
Palpha0	Cross-term dependence of alpha0	None	0.0
Pfbjtii	Cross-term dependence of fbjtii	None	0.0
Pbeta0	Cross-term dependence of beta0	None	0.0
Pbeta1	Cross-term dependence of beta1	None	0.0
Pbeta2	Cross-term dependence of beta2	None	0.0
Pvdsatii0	Cross-term dependence of vdsatii0	None	0.0
Plii	Cross-term dependence of lii	None	0.0
Pesatii	Cross-term dependence of esatii	None	0.0
Psii0	Cross-term dependence of sii0	None	0.0
Psii1	Cross-term dependence of sii1	None	0.0
Psii2	Cross-term dependence of sii2	None	0.0
Psiid	Cross-term dependence of siid	None	0.0
Pagidl	Cross-term dependence of agidl	None	0.0

Pbgidl	Cross-term dependence of bgidl	None	0.0
Pngidl	Cross-term dependence of ngidl	None	0.0
Pntun	Cross-term dependence of ntun	None	0.0
Pndiode	Cross-term dependence of ndiode	None	0.0
Pnrecf0	Cross-term dependence of nrecf0	None	0.0
Pnrecr0	Cross-term dependence of nrecr0	None	0.0
Pisbjt	Cross-term dependence of isbjt	None	0.0
Pisdif	Cross-term dependence of isdif	None	0.0
Pistun	Cross-term dependence of istun	None	0.0
Pvrec0	Cross-term dependence of vrec0	None	0.0
Pvtun0	Cross-term dependence of vtun0	None	0.0
Pnbjt0	Cross-term dependence of nbjt	None	0.0
Plbjt0	Cross-term dependence of lbjt0	None	0.0
Pvabjt	Cross-term dependence of vabjt	None	0.0
Paely	Cross-term dependence of aely	None	0.0
Pahli	Cross-term dependence of ahli	None	0.0
Pvsdfb	Cross-term dependence of vsdfb	None	0.0
Pvsdth	Cross-term dependence of vsdth	None	0.0
Pdelvt	Cross-term dependence of delvt	None	0.0
Pacde	Cross-term dependence of Acde	None	0.0
Gmin	P-N junction parallel conductance	None	1e-20
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvg	gate oxide breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None
† binning factor (see Note 3)			

- Several DC, AC, and capacitance parameters can be binned; these parameters follow this implementation:

$$P = P_0 + \frac{P_L}{L_{eff}} + \frac{P_w}{W_{eff}} + \frac{P_p}{L_{eff} \times W_{eff}}$$

For example, for the parameter K1, the following relationships exist: P_0 = k1, P_L = lk1, P_W = wk1, P_P=pk1. The Binunit parameter is a binning unit selector. If Binunit=1, the units of L_{eff} and W_{eff} used in the preceding binning equation have the units of microns, otherwise in meters. For example, for a device with L_{eff}=0.5mm and W_{eff}=10mm, if Binunit=1, parameter values are le5, le4, 2e4, and 3e4 for Vsat, Lvsat, Wvsat, and Pvsat, respectively, Therefore, the effective value of Vsat for this device is:

> *Vsat = 1e5 + 1e4/0.5 + 2e4/10 + 3e4/(0.5 × 10) = 1.28e5*

To get the same effective value of Vsat for Binunit=0, values of Vsat, Lvsat, Wvsat, and Pvsat would be 1e5, le–2, 2e–2, 3e–8, respectively. Thus:

> *Vsat = 1e5 + 1e-2/0.5e6 + 2e–2/10e–6 + 3e –8/(0.5e-6 × 10e–6) = 1.28e5*

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *model modelname B3SOI [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *B3SOI*. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

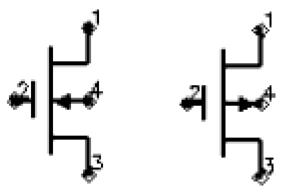
Example

```
model  Nch8 B3SOI \
  Vtho=0.7 Cj=3e-4 NMOS=y
```

BSIM3SOI NMOS, BSIM3SOI PMOS (BSIM3 SOI Transistor, Floating Body, NMOS, PMOS)

BSIM3SOI_NMOS, BSIM3SOI_PMOS (BSIM3 SOI Transistor, Floating Body, NMOS, PMOS)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
Model	model instance name	None	None
Length†	channel length	m	5.0e-6
Width†	channel width	m	5.0e-6
Ad†	area of drain diffusion	m^2	0.0
As†	area of source diffusion	m^2	0.0
Pd†	perimeter of drain junction	m	0.0
Ps†	perimeter of source junction	m	0.0
Nrd	number of squares of drain diffusion	None	1.0
Nrs	number of squares of source diffusion	None	1.0

Name	Description	Units	Default
Nrb	number of squares in body	None	1.0
Bjtoff	BJT on/off flag: yes=1, no=0	None	no
Rth0	instance thermal resistance; defaults to Rth0	Ohm	
Cth0	instance thermal capacitance; defaults to Cth0	F	
Nbc	number of body contact insulation edge	None	0.0
Nseg	number of segments for width partitioning	None	1.0
Pdbcp†	perimter length for bc parasitics at drain side	None	0.0
Psbcp†	perimter length for bc parasitics at source side	None	0.0
Agbcp†	gate to body overlap area for bc parasitics	m^2	0.0
Aebcp†	substrate to body overlap area for bc parasitics	m^2	
Vbsusr	Vbs specified by the user; defaults to Vbs	V	None
Temp	device operating temperature	°C	25
Trise	temperature rise above ambient	°C	0
Mode	simulation mode: Nonlinear, Linear, Standard (refer to note for the Mode parameter)	None	Nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

† Each instance parameter whose dimension contains a power of meter will be multiplied by the Scale to the same power. For example, a parameter with a dimension of *m* will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. Note that only

parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains *cm* instead of meter is not scaled.

DC Operating Point Information

The following table lists the DC operating point parameters that can be sent to the dataset.

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Ib	Bulk current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gmb	Backgate transconductance (dIds/dVbs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Vth	Threshold voltage	volts
Vdsat	Drain-source saturation voltage	volts
DqgDvgb	(dQg/dVgb)	farads
DqgDvdb	(dQg/dVdb)	farads
DqgDvsb	(dQg/dVsb)	farads
DqgDveb	(dQg/dVeb)	farads
DqbDvgb	(dQb/dVgb)	farads
DqbDvdb	(dQb/dVdb)	farads

Name	Description	Units
DqbDvsb	(dQb/dVsb)	farads
DqbDveb	(dQb/dVeb)	farads
DqdDvgb	(dQd/dVgb)	farads
DqdDvdb	(dQd/dVdb)	farads
DqdDvsb	(dQd/dVsb)	farads
DqdDveb	(dQd/dVeb)	farads
DqeDvgb	(dQe/dVgb)	farads
DqeDvdb	(dQe/dVdb)	farads
DqeDvsb	(dQe/dVsb)	farads
DqeDveb	(dQe/dVeb)	farads
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts
Vbs	Bulk-source voltage	volts
Ves	Substrate-source voltage	volts
Vps	Body-source voltage	volts

Notes/Equations

1. The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.

BSIM4SOI (BSIM4SOI MOSFET Model and Instance)

BSIM4SOI (BSIM4SOI MOSFET Model and Instance)

Model Parameters

The bsimsoi model uses almost the same model parameters and model parameter definitions as the BSIMSOI4.x model from the University of California-Berkeley. For more information about the model parameters and model parameter definitions, refer to BSIMSOI website.

- For **BSIMSOI 4.3.1**, refer to the Users' Manual available in the package http://bsim.berkeley.edu/BSIMSOI/BSIMSOIv431_051410.zip.
- For **BSIMSOI 4.4** refer to the Users' Manual available in the package http://bsim.berkeley.edu/BSIMSOI/bsimsoi4p4.zip.
- For **BSIMSOI 4.5** refer to the Users' Manual available in the package http://bsim.berkeley.edu/BSIMSOI/BSIMSOIv450.zip.
- For **BSIMSOI 4.6.1** refer to the User's Manual available in the package http://bsim.berkeley.edu/BSIMSOI/BSIM-SOI_4.6.1_20171114.tar.gz

Appendix B of the University of California-Berkeley documentation covers the Model Parameter List and Appendix E covers Model Parameter Binning.

The minor differences in model parameters between the ADS bsimsoi model and the BSIMSOI4.x model from University of California-Berkeley are as follows:

1. Model parameter names are in lower case.
2. Model parameter *level* is removed.
3. Bsimsoi model is specified by using its model name *bsimsoi*.
4. New model parameter *version*, model version selector. It has no unit and the default value is 4.4. Available values are 3.0, 3.1, 3.11, 3.2, 4.0, 4.3, 4.3.1, 4.4 and 4.5, 4.6, 4.6.1.
5. New model parameter *noimod*, the noise model selector for versions 3.11 and lower. It has no unit and the default is 1. Available values are 1, 2, 3, and 4.
6. In ADS, the transistor type of the bsimsoi model is specified by the model parameter *gender*. Available values are 1 (N-type) and -1 (P-type).

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to the *Design Kit Development*.

> *model modelName bsimsoi [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelName* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *bsimsoi*. Use the parameter *gender* to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables, and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

> *model Nch7 bsimsoi gender=1 version=4.4 vth0=0.7*

Instance Parameters

Name	Description	Units	Default
l	Channel length	m	5e-6
w	Channel width	m	5e-6
nf	Number of fingers	1.0	
sa	Stress effect parameter	m	0.0
sb	Stress effect parameter	m	0.0
sd	Stress effect parameter	m	0.0
ad	Drain diffusion area	m^2	0.0
as	Source diffusion area	m^2	0.0
pd	Drain diffusion perimeter length	m	0.0
ps	Source diffusion perimeter length	m	0.0
nrd	Number of squares in drain series resistance	1.0	
nrs	Number of squares in source series resistance	1.0	
off	Device simulation off	0	
bjtoff	Turn off BJT current if equal to 1	0	

Name	Description	Units	Default
rth0	Thermal resistance per unit width, if not specified, rth0 is extracted from model card, if specified, it will override the one in model card.	Ohm	0.0
cth0	Thermal capacitance per unit width, if not specified, cth0 is extracted from model card, if specified, it will override the one in model card.	Farads	1e-5
nrb	Number of squares in body series resistance	1.0	
frbody	Layout-dependent body resistance coefficient	1.0	
rbdb	Body resistance	Ohm	50.0
rbsb	Body resistance	Ohm	50.0
delvto	Zero bias threshold voltage variation	Volts	0.0
soimod	Instance model selector for PD/FD operation	0	
nbc	Number of body contact isolation edge	0.0	
nseg	Number of segments for channel width partitioning	1.0	
pdbcp	Parasitic perimeter length for body contact at drain side	m	0.0
psbcp	Parasitic perimeter length for body contact at source side	m	0.0
agbcp	Parasitic gate-to-body overlap area for body contact (n^+-p)	m^2	0.0
agbcp2	Parasitic gate-to-body overlap area for body contact (p^+-p)	m^2	0.0
agbcpd	Parasitic gate-to-body overlap area for body contact in DC	m^2	0.0
aebcp	Parasitic body-to-substrate overlap area for body contact	m^2	0.0
tnodeout	Temperature node flag indicating the usage of T node	0	
rgatemod	Gate resistance model selector	0	

Name	Description	Units	Default
rbodymod	Body resistance model selector	0	

Instance Netlist Format

> *modelName:instanceName D G S E [P] [B] [T] [parm=value]*

where:
D is the drain node
G is the gate node
S is the source node
E is the substrate node
P is the optional external body contact node
B is the optional internal body node
T is the optional temperature node.
Refer to Note 2 for more information on optional nodes.

Example:

> *Nch7:M1 2 1 0 0 w=1u l=0.1u*

Notes

1. BSIMSOI4.4 was developed by the Device Research Group of the Department of Electrical Engineering and Computer Science, University of California, Berkeley and copyrighted by the University of California.
   More information about this model is available at the BSIMSOI website.
2. There are three optional nodes, P, B, and T. P and B nodes are used for body contact devices. Consider the case when tnodeout is 0, if you specify four nodes, this element is a 4-terminal device, i.e., floating body. If you specify five nodes, the fifth node represents the external body contact node (P). There is a body resistance between the internal body node and the P node. In these two cases, an internal body node is created but it is not accessible in the circuit deck. If you specify six nodes, the fifth node represents the P node and the sixth node represents the internal body node (B). This configuration is useful for distributed body resistance simulation. If tnodeout is set to 1, the last node is interpreted as the temperature node. In this case, if you specify five nodes, it is a floating body case. If you specify six nodes, it is a body-contacted case. Finally, if you specify seven nodes, it is a body-contacted case with an accessible internal body node. The temperature node is useful for thermal coupling simulation.
3. Following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes

Name	Description	Units
Ig	Gate current	amperes
Is	Source current	amperes
Ie	Substrate current	amperes
Ip	External body current	amperes
Ib	Internal body current	amperes
Power	Total dissipated power	watts
Vds	External drain-source voltage	volts
Vgs	External gate-source voltage	volts
Ves	External substrate-source voltage	volts
Vps	External body contact to source voltage	volts
Vbs	External source to internal body voltage	volts
Ids	Internal drain-source current	amperes
Ibd	Internal body-drain current	amperes
Ibs	Internal body-source current	amperes
Isub	Internal impact ionization current	amperes
Igidl	Internal GIDL current	amperes
Igisl	Internal GISL current	amperes
Igs	Internal gate-source tunneling current	amperes
Igd	Internal gate-drain tunneling current	amperes

Name	Description	Units
Igb	Internal gate-body tunneling current	amperes
Igcs	Internal gate-channel tunneling current at source side	amperes
Igcd	Internal gate-channel tunneling current at drain side	amperes
Vdsat	Drain-source saturation voltage	volts
Vth	Threshold voltage	volts
Qg	Internal gate charge	coulombs
Qb	Internal body charge	coulombs
Qd	Internal drain charge	coulombs
Qs	Internal source charge	coulombs
Gmbs	Body transconductance	siemens
Gm	Forward transconductance	siemens
Gmids	Gm/Ids	1/volts
Gds	Output conductance	siemens
Cgg	dQg/dVgb	farads
Cgd	dQg/dVdb	farads
Cgs	dQg/dVsb	farads
Cbg	dQb/dVgb	farads
Cbd	dQb/dVdb	farads
Cbs	dQb/dVsb	farads

Name	Description	Units
Cdg	dQd/dVgb	farads
Cdd	dQd/dVdb	farads
Cds	dQd/dVsb	farads

BSIMCMG Model

BSIMCMG Model

BSIMCMG was developed by the Device Research Group of the Department of Electrical Engineering and Computer Science, University of California, Berkeley and copyrighted by the University of California. More information about this model, visit http://bsim.berkeley.edu/models/bsimcmg/.

This section describes the following versions of the BSIMCMG model.

- BSIMCMG 106 Model
- BSIMCMG 107 Model
- BSIMCMG 108 Model
- BSIMCMG 110 Model

BSIMCMG 106 Model

BSIMCMG 106 Model

The following topic lists the BSIMCMG 106.1.0 model and instance parameters. For detailed information, refer to BSIMCMG manual.

Model Parameters

Name (Alias)	Description
XL	L offset for channel length due to mask/etch effect
BULKMOD	Substrate model selector. 0 = multi-gate on SOI substrate, 1 = multi-gate on bulk substrate.
COREMOD	simplified surface potential selector ; 0=turnoff, 1=turn on (lightly-doped or undoped)
GEOMOD	structure selector; 0 = double gate, 1 = triple gate, 2 = quadruple gate, 3 = cylindrical gate
RDSMOD	bias-dependent source/drain resistance model selector 0 = internal, 1 = external
ASYMMOD	Asymmetry Model ; 0=turned off - forward mode parameters used, 1= turned on
IGCMOD	model selector for Igc, Igs and Igd; 1=turn on, 0=turn off
IGBMOD	model selector for Igb; 1=turn on, 0=turn off
GIDLMOD	GIDL/GISL current switcher; 1=turn on, 0=turn off
IIMOD	impact ionization model switch; 0 = OFF, 1= BSIM4 based, 2 = BSIMSOI based
NQSMOD	NQS gate resistor and gi node switcher;1=turn on, 0=turn off
SHMOD	Self-heating and T node switcher; 1=turn on,0=turn off

Name (Alias)	Description
RGATEMOD	Gate electrode resistor and ge node switcher ;1=turn on, 0=turn off
RGEOMOD	bias independent parasitic resistance model selector
CGEOMOD	parasitic capacitance model selector
CAPMOD	accumulation region capacitance model selector; 0=no accumulation capacitance, 1=accumulation capacitance included
LINT	Length reduction parameter (dopant diffusion effect)
LL	Length reduction parameter (dopant diffusion effect)
LLN	Length reduction parameter (dopant diffusion effect)
DLC	Length reduction parameter for CV (dopant diffusion effect)
DLCACC	Delta L for C-V model in accumulation region
DLBIN	Length reduction parameter for binning
LLC	Length reduction parameter for CV (dopant diffusion effect)
EOT	SiO2 equivalent gate dielectric thickness (including inversion layer thickness)
TOXP	Physical oxide thickness
EOTBOX	SiO2 equivalent buried oxide thickness (including substrate depletion)
HFIN	fin height
FECH	end-channel factor, for different orientation/shape (Mobility difference between the side channel and the top channel is handled by this parameter)
DELTAW	reduction of effective width due to shape of fin
FECHCV	CV end-channel factor, for different orientation/shape

Name (Alias)	Description
DELTAWCV	CV reduction of effective width due to shape of fin
NBODY	channel (body) doping concentration
NSD	S/D doping concentration
PHIG	work function of gate
EPSROX	relative dielectric constant of the gate insulator
EPSRSUB	relative dielectric constant of the channel material
EASUB	electron affinity of the substrate material
NI0SUB	intrinsic carrier concentration of channel at 300.15K
BG0SUB	band gap of the channel material at 300.15K
NC0SUB	conduction band density of states at 300.15K
NGATE	parameter for Poly Gate doping. Set NGATE = 0 for metal gates
Imin	Parameter for Vgs Clamping for inversion region calc. in accumulation
CIT	parameter for interface trap
CDSC	coupling capacitance between S/D and channel
CDSCD	drain-bias sensitivity of CDSC
CDSCDR	Reverse-mode drain-bias sensitivity of CDSC
DVT0	SCE coefficient
DVT1	SCE exponent coefficient
PHIN	nonuniform vertical doping effect on surface potential

Name (Alias)	Description
ETA0	DIBL coefficient
ETA0R	Reverse-mode DIBL coefficient
DSUB	DIBL exponent coefficient
K1RSCE	prefactor for reverse short channel effect
LPE0	equivalent length of pocket region at zero bias
DVTSHIFT	Additional Vth shift handle
K0	Lateral non-uniform doping voltage parameter, V
K01	Temperature dependence of lateral non-uniform doping voltage parameter, V/K
K0SI	Correction factor for strong inversion, used in Mnud, after binning should be from (0:inf)
K0SI1	Temperature dependence of K0SI, 1/K
K1SI	Correction factor for strong inversion, used in Mob
K1SI1	Temperature dependence of K1SI, 1/K
PHIBE	Body effect voltage parameter, V, after binning should be from [0.2:1.2]
K1	Body effect coefficient for sub-threshold region
K11	Temperature dependence of K1
K1SAT	Correction factor for K1 in saturation (high Vds)
K1SAT1	Temperature dependence of K1SAT1
QMFACTOR	Prefactor + switch for QM Vth correction

Name (Alias)	Description
QMTCENIV	Prefactor + switch for QM Width correction for IV
QMTCENCV	Prefactor + switch for QM Width and Toxeff correction for CV
QMTCENCVA	Prefactor + switch for QM Width and Toxeff correction for CV (accumulation region)
AQMTCEN	Parameter for Geometric dependence of Tcen on R/TFIN/HFIN
BQMTCEN	Parameter for Geometric dependence of Tcen on R/TFIN/HFIN
ETAQM	Bulk charge coefficient for Tcen
QM0	Knee-Point for Tcen in inversion (Charge normalized to Cox)
PQM	Slope of normalized Tcen in inversion
QM0ACC	Knee-Point for Tcen in accumulation (Charge normalized to Cox)
PQMACC	Slope of normalized Tcen in accumulation
VSAT	
AVSAT	
BVSAT	
VSAT1	Velocity Saturation parameter for I_on degradation - forward mode
VSAT1R	Velocity Saturation parameter for I_on degradation - reverse mode
AVSAT1	
BVSAT1	
DELTAVSAT	
PSAT	Velocity saturation exponent, after binnig should be from [2.0:inf)

Name (Alias)	Description
APSAT	
BPSAT	
KSATIV	
VSATCV	Velocity Saturation parameter for CV
AVSATCV	
BVSATCV	
DELTAVSATCV	
PSATCV	Velocity saturation exponent for C-V
APSATCV	
BPSATCV	
MEXP	
AMEXP	
BMEXP	
PTWG	Gmsat degradation parameter - forward mode
PTWGR	Gmsat degradation parameter - reverse mode
APTWG	
BPTWG	
AT	
TMEXP	

Name (Alias)	Description
PTWGT	
U0	
ETAMOB	
UP	
LPA	
UA	
AUA	
BUA	
UC	Body effect for mobility degradation parameter - BULKMOD=1
EU	
AEU	
BEU	
UD	
AUD	
BUD	
UCS	
UTE	
UTL	
EMOBT	

Name (Alias)	Description
UA1	
UC1	
UD1	
UCSTE	
RDSWMIN	
RDSW	
ARDSW	
BRDSW	
RSWMIN	
RSW	
ARSW	
BRSW	
RDWMIN	
RDW	
ARDW	
BRDW	
RSDR	Source side drift resistance parameter - forward mode
RSDRR	Source side drift resistance parameter - reverse mode
RDDR	Drain side drift resistance parameter - forward mode

Name (Alias)	Description
RDDRR	Drain side drift resistance parameter - reverse mode
PRSDR	Source side quasi-saturation parameter
PRDDR	Drain side quasi-saturation parameter
PRWGS	Gate bias dependence of source extension resistance, Units:V^-1
PRWGD	Gate bias dependence of drain extension resistance, Units:V^-1
WR	
PRT	
TRSDR	
TRDDR	
PDIBL1	DIBL Output Conductance parameter - forward mode
PDIBL1R	DIBL Output Conductance parameter - reverse mode
PDIBL2	DIBL Output Conductance parameter
DROUT	
PVAG	
PCLM	CLM parameter for Short Channel CV
APCLM	
BPCLM	
PCLMG	
PCLMCV	

Name (Alias)	Description
A1	Non-saturation effect parameter for strong inversion region
A11	Temperature dependence of A1
A2	Non-saturation effect parameter for moderate inversion region
A21	Temperature dependence of A2
RGEXT	Effective gate electrode external resistance
RGFIN	Effective gate electrode per finger per fin resistance
RSHS	Source-side sheet resistance
RSHD	Drain-side sheet resistance
HEPI	Height of the raised source/drain on top of the fin
TSILI	Thickness of the silicide on top of the raised source/drain
RHOC	
RHORSD	
RHOEXT	
CRATIO	
DELTAPRSD	
SDTERM	
LDG	
EPSRSP	Relative dielectric constant of the spacer
TGATE	Gate height on top of the hard mask

Name (Alias)	Description
TMASK	Height of hard mask on top of the fin
ASILIEND	
ARSDEND	
PRSDEND	
NSDE	Source/drain active doping concentration at Leff edge
RGEOA	Fitting parameter for RGEOMOD=1
RGEOB	Fitting parameter for RGEOMOD=1
RGEOC	Fitting parameter for RGEOMOD=1
RGEOD	Fitting parameter for RGEOMOD=1
RGEOE	Fitting parameter for RGEOMOD=1
CGEOA	Fitting parameter for CGEOMOD=2
CGEOB	Fitting parameter for CGEOMOD=2
CGEOC	Fitting parameter for CGEOMOD=2
CGEOD	Fitting parameter for CGEOMOD=2
CGEOE	Fitting parameter for CGEOMOD=2
AIGBINV	parameter for Igb in inversion
AIGBINV1	parameter for Igb in inversion
BIGBINV	parameter for Igb in inversion
CIGBINV	parameter for Igb in inversion

Name (Alias)	Description
EIGBINV	parameter for Igb in inversion
NIGBINV	parameter for Igb in inversion
AIGBACC	parameter for Igb in accumulation
AIGBACC1	parameter for Igb in accumulation
BIGBACC	parameter for Igb in accumulation
CIGBACC	parameter for Igb in accumulation
NIGBACC	parameter for Igb in accumulation
AIGC	parameter for Igc in inversion
AIGC1	parameter for Igc in inversion
BIGC	parameter for Igc in inversion
CIGC	parameter for Igc in inversion
PIGCD	parameter for Igc partition
DLCIGS	Delta L for Igs model
AIGS	parameter for Igs in inversion
AIGS1	parameter for Igs in inversion
BIGS	parameter for Igs in inversion
CIGS	parameter for Igs in inversion
DLCIGD	Delta L for Igd model
AIGD	parameter for Igd in inversion

Name (Alias)	Description
AIGD1	parameter for Igd in inversion
BIGD	parameter for Igd in inversion
CIGD	parameter for Igd in inversion
TOXREF	Target tox value [m]
TOXG	oxide thickness for gate current model in meters
NTOX	Exponent for Tox ratio
POXEDGE	Factor for the gate edge Tox
AGISL	pre-exponential coeff. for GISL in mho
BGISL	exponential coeff. for GISL in V/m
CGISL	parameter for body-effect of GISL in V^3
EGISL	band bending parameter for GISL in V
PGISL	parameter for body-bias effect on GISL
AGIDL	pre-exponential coeff. for GIDL in mho
BGIDL	exponential coeff. for GIDL in V/m
CGIDL	parameter for body-effect of GIDL in V^3
EGIDL	band bending parameter for GIDL in V
PGIDL	parameter for body-bias effect on GIDL
ALPHA0	first parameter of Iii, m/V
ALPHA01	Temperature dependence of ALPHA0, m/V/degrees

Name (Alias)	Description
ALPHA1	L scaling parameter of Iii, 1/V
ALPHA11	Temperature dependence ALPHA1, 1/V/degree
BETA0	Vds dependent parameter of Iii, 1/V
ALPHAII0	first parameter of Iii for IIMOD=2, m/V
ALPHAII01	Temperature dependence of ALPHAII0, m/V/degrees
ALPHAII1	L scaling parameter of Iii for IIMOD=2, 1/V
ALPHAII11	Temperature dependence of ALPHAII1, 1/V/degrees
BETAII0	Vds dependent parameter of Iii, 1/V
BETAII1	Vds dependent parameter of Iii
BETAII2	Vds dependent parameter of Iii, V
ESATII	Saturation channel E-Field for Iii, V/m
LII	Channel length dependent parameter of Iii, V-m
SII0	Vgs dependent parameter of Iii, 1/V
SII1	1st Vgs dependent parameter of Iii, 1/V
SII2	2nd Vgs dependent parameter of Iii
SIID	3rd Vds dependent parameter of Iii, 1/V
EOTACC	equivalent oxide thickness for accumulation region in meters
DELVFBACC	Change in Flatband Voltage
CFS	Outer Fringe Cap (source side)

Name (Alias)	Description
CFD	Outer Fringe Cap (drain side)
COVS	Constant g/s overlap capacitance
COVD	Constant g/d overlap capacitance
CGSO	Non LDD region source-gate overlap capacitance per unit channel width
CGDO	Non LDD region drain-gate overlap capacitance per unit channel width
CGSL	
CGDL	
CKAPPAS	
CKAPPAD	
CGBO	Gate to substrate overlap cap per unit channel length per finger per NGCON
CGBN	Gate to substrate overlap cap per unit channel length per fin per finger
CGBL	Bias dependent component of Gate to substrate overlap cap
CKAPPAB	per unit channel length per fin per finger
CSDESW	Coefficient for source/drain to substrate sidewall cap
CJS	Unit area source-side junction capacitance at zero bias
CJD	Unit area drain-side junction capacitance at zero bias
CJSWS	Unit length source-side sidewall junction capacitance at zero bias
CJSWD	Unit length drain-side sidewall junction capacitance at zero bias
CJSWGS	Unit length source-side gate sidewall junction capacitance at zero bias

Name (Alias)	Description
CJSWGD	Unit length drain-side gate sidewall junction capacitance at zero bias
PBS	Source-side bulk junction built-in potential
PBD	Drain-side bulk junction built-in potential
PBSWS	Built-in potential for Source-side sidewall junction capacitance
PBSWD	Built-in potential for drain-side sidewall junction capacitance
PBSWGS	Built-in potential for Source-side gate sidewall junction capacitance
PBSWGD	Built-in potential for drain-side gate sidewall junction capacitance
MJS	Source bottom junction capacitance grading coefficient
MJD	Drain bottom junction capacitance grading coefficient
MJSWS	Source sidewall junction capacitance grading coefficient
MJSWD	Drain sidewall junction capacitance grading coefficient
MJSWGS	Source-side gate sidewall junction capacitance grading coefficient
MJSWGD	Drain-side gate sidewall junction capacitance grading coefficient
SJS	Constant for source-side two-step second junction
SJD	Constant for drain-side two-step second junction
SJSWS	Constant for source-side sidewall two-step second junction
SJSWD	Constant for drain-side sidewall two-step second junction
SJSWGS	Constant for source-side gate sidewall two-step second junction
SJSWGD	Constant for drain-side gate sidewall two-step second junction

Name (Alias)	Description
MJS2	Source bottom two-step second junction capacitance grading coefficient
MJD2	Drain bottom two-step second junction capacitance grading coefficient
MJSWS2	Source sidewall two-step second junction capacitance grading coefficient
MJSWD2	Drain sidewall two-step second junction capacitance grading coefficient
MJSWGS2	Source-side gate sidewall two-step second junction capacitance grading coefficient
MJSWGD2	Drain-side gate sidewall two-step second junction capacitance grading coefficient
JSS	Bottom source junction reverse saturation current density
JSD	Bottom drain junction reverse saturation current density
JSWS	Unit length reverse saturation current for sidewall source junction
JSWD	Unit length reverse saturation current for sidewall drain junction
JSWGS	Unit length reverse saturation current for gate-edge sidewall source junction
JSWGD	Unit length reverse saturation current for gate-edge sidewall drain junction
NJS	Source junction emission coefficient
NJD	Drain junction emission coefficient
IJTHSFWD	Forward source diode breakdown limiting current
IJTHDFWD	Forward drain diode breakdown limiting current
IJTHSREV	Reverse source diode breakdown limiting current
IJTHDREV	Reverse drain diode breakdown limiting current

Name (Alias)	Description
BVS	Source diode breakdown voltage
BVD	Drain diode breakdown voltage
XJBVS	Fitting parameter for source diode breakdown current
XJBVD	Fitting parameter for drain diode breakdown current
JTSS	Bottom source junction trap-assisted saturation current density
JTSD	Bottom drain junction trap-assisted saturation current density
JTSSWS	Unit length trap-assisted saturation current for sidewall source junction
JTSSWD	Unit length trap-assisted saturation current for sidewall drain junction
JTSSWGS	Unit length trap-assisted saturation current for gate-edge sidewall source junction
JTSSWGD	Unit length trap-assisted saturation current for gate-edge sidewall drain junction
JTWEFF	Trap assisted tunneling current width dependence
NJTS	Non-ideality factor for JTSS
NJTSD	Non-ideality factor for JTSD
NJTSSW	Non-ideality factor for JTSSWS
NJTSSWD	Non-ideality factor for JTSSWD
NJTSSWG	Non-ideality factor for JTSSWGS
NJTSSWGD	Non-ideality factor for JTSSWGD
VTSS	Bottom source junction trap-assisted current voltage dependent parameter

Name (Alias)	Description
VTSD	Bottom drain junction trap-assisted current voltage dependent parameter
VTSSWS	Unit length trap-assisted current voltage dependent parameter for sidewall source junction
VTSSWD	Unit length trap-assisted current voltage dependent parameter for sidewall drain junction
VTSSWGS	Unit length trap-assisted current voltage dependent parameter for gate-edge sidewall source junction
VTSSWGD	Unit length trap-assisted current voltage dependent parameter for gate-edge sidewall drain junction
LINTIGEN	Lint for Thermal Generation Current
NTGEN	Thermal Generation Current Parameter
AIGEN	Thermal Generation Current Parameter
BIGEN	Thermal Generation Current Parameter
XRCRG1	
XRCRG2	
NSEG	Number of segments for NQSMOD=3 (3,5 & 10 supported)
EF	Flicker Noise frequency exponent
EM	
NOIA	
NOIB	
NOIC	
NTNOI	

Name (Alias)	Description
TBGASUB	Bandgap Temperature Coefficient (eV/degrees)
TBGBSUB	Bandgap Temperature Coefficient (degrees)
KT1	Vth Temperature Coefficient (V)
KT1L	Vth Temperature L Coefficient (m-V)
TSS	SSwing Temperature Coefficient (/ degrees)
IIT	Impact Ionization Temperature Dependence, IIMOD=1
TII	Impact Ionization Temperature Dependence, IIMOD=2
TGIDL	GIDL/GISL Temperature Dependence
IGT	Gate Current Temperature Dependence
TCJ	Temperature coefficient for CJS/CJD
TCJSW	Temperature coefficient for CJSWS/CJSWD
TCJSWG	Temperature coefficient for CJSWGS/CJSWGD
TPB	Temperature coefficient for PBS/PBD
TPBSW	Temperature coefficient for PBSWS/PBSWD
TPBSWG	Temperature coefficient for PBSWGS/PBSWGD
XTIS	Source junction current temperature exponent
XTID	Drain junction current temperature exponent
XTSS	Power dependence of JTSS on temperature
XTSD	Power dependence of JTSD on temperature

Name (Alias)	Description
XTSSWS	Power dependence of JTSSWS on temperature
XTSSWD	Power dependence of JTSSWD on temperature
XTSSWGS	Power dependence of JTSSWGS on temperature
XTSSWGD	Power dependence of JTSSWGD on temperature
TNJTS	Temperature coefficient for NJTS
TNJTSD	Temperature coefficient for NJTSD
TNJTSSW	Temperature coefficient for NJTSSW
TNJTSSWD	Temperature coefficient for NJTSSWD
TNJTSSWG	Temperature coefficient for NJTSSWG
TNJTSSWGD	Temperature coefficient for NJTSSWGD
RTH0	Thermal resistance
CTH0	Thermal capacitance
WTH0	Width dependence coefficient for Rth and Cth
LNBODY	
NNBODY	
PNBODY	
LPHIG	
NPHIG	
PPHIG	

Name (Alias)	Description
LNGATE	
NNGATE	
PNGATE	
LCIT	
NCIT	
PCIT	
LCDSC	
NCDSC	
PCDSC	
LCDSCD	
NCDSCD	
PCDSCD	
LCDSCDR	
NCDSCDR	
PCDSCDR	
LDVT0	
NDVT0	
PDVT0	
LDVT1	

Name (Alias)	Description
NDVT1	
PDVT1	
LPHIN	
NPHIN	
PPHIN	
LETA0	
NETA0	
PETA0	
LETA0R	
NETA0R	
PETA0R	
LDSUB	
NDSUB	
PDSUB	
LK1RSCE	
NK1RSCE	
PK1RSCE	
LLPE0	
NLPE0	

Name (Alias)	Description
PLPE0	
LDVTSHIFT	
NDVTSHIFT	
PDVTSHIFT	
LPHIBE	
NPHIBE	
PPHIBE	
LK0	
NK0	
PK0	
LK01	
NK01	
PK01	
LK0SI	
NK0SI	
PK0SI	
LK0SI1	
NK0SI1	
PK0SI1	

Name (Alias)	Description
LK1SI	
NK1SI	
PK1SI	
LK1SI1	
NK1SI1	
PK1SI1	
LK1	
NK1	
PK1	
LK11	
NK11	
PK11	
LK1SAT	
NK1SAT	
PK1SAT	
LK1SAT1	
NK1SAT1	
PK1SAT1	
LDVTB	

Name (Alias)	Description
NDVTB	
PDVTB	
LLPEB	
NLPEB	
PLPEB	
LQMFACTOR	
NQMFACTOR	
PQMFACTOR	
LQMTCENIV	
NQMTCENIV	
PQMTCENIV	
LQMTCENCV	
NQMTCENCV	
PQMTCENCV	
LQMTCENCVA	
NQMTCENCVA	
PQMTCENCVA	
LVSAT	
NVSAT	

Name (Alias)	Description
PVSAT	
LVSAT1	
NVSAT1	
PVSAT1	
LVSAT1R	
NVSAT1R	
PVSAT1R	
LPSAT	
NPSAT	
PPSAT	
LDELTAVSAT	
NDELTAVSAT	
PDELTAVSAT	
LKSATIV	
NKSATIV	
PKSATIV	
LVSATCV	
NVSATCV	
PVSATCV	

Name (Alias)	Description
LPSATCV	
NPSATCV	
PPSATCV	
LDELTAVSATCV	
NDELTAVSATCV	
PDELTAVSATCV	
LMEXP	
NMEXP	
PMEXP	
LPTWG	
NPTWG	
PPTWG	
LPTWGR	
NPTWGR	
PPTWGR	
LU0	
NU0	
PU0	
LETAMOB	

Name (Alias)	Description
NETAMOB	
PETAMOB	
LUP	
NUP	
PUP	
LUA	
NUA	
PUA	
LUC	
NUC	
PUC	
LEU	
NEU	
PEU	
LUD	
NUD	
PUD	
LUCS	
NUCS	

Name (Alias)	Description
PUCS	
LPCLM	
NPCLM	
PPCLM	
LPCLMG	
NPCLMG	
PPCLMG	
LPCLMCV	
NPCLMCV	
PPCLMCV	
LA1	
NA1	
PA1	
LA11	
NA11	
PA11	
LA2	
NA2	
PA2	

Name (Alias)	Description
LA21	
NA21	
PA21	
LRDSW	
NRDSW	
PRDSW	
LRSW	
NRSW	
PRSW	
LRDW	
NRDW	
PRDW	
LPRWGS	
NPRWGS	
PPRWGS	
LPRWGD	
NPRWGD	
PPRWGD	
LWR	

Name (Alias)	Description
NWR	
PWR	
LPDIBL1	
NPDIBL1	
PPDIBL1	
LPDIBL1R	
NPDIBL1R	
PPDIBL1R	
LPDIBL2	
NPDIBL2	
PPDIBL2	
LDROUT	
NDROUT	
PDROUT	
LPVAG	
NPVAG	
PPVAG	
LAIGBINV	
NAIGBINV	

Name (Alias)	Description
PAIGBINV	
LAIGBINV1	
NAIGBINV1	
PAIGBINV1	
LBIGBINV	
NBIGBINV	
PBIGBINV	
LCIGBINV	
NCIGBINV	
PCIGBINV	
LEIGBINV	
NEIGBINV	
PEIGBINV	
LNIGBINV	
NNIGBINV	
PNIGBINV	
LAIGBACC	
NAIGBACC	
PAIGBACC	

Name (Alias)	Description
LAIGBACC1	
NAIGBACC1	
PAIGBACC1	
LBIGBACC	
NBIGBACC	
PBIGBACC	
LCIGBACC	
NCIGBACC	
PCIGBACC	
LNIGBACC	
NNIGBACC	
PNIGBACC	
LAIGC	
NAIGC	
PAIGC	
LAIGC1	
NAIGC1	
PAIGC1	
LBIGC	

Name (Alias)	Description
NBIGC	
PBIGC	
LCIGC	
NCIGC	
PCIGC	
LPIGCD	
NPIGCD	
PPIGCD	
LAIGS	
NAIGS	
PAIGS	
LAIGS1	
NAIGS1	
PAIGS1	
LBIGS	
NBIGS	
PBIGS	
LCIGS	
NCIGS	

Name (Alias)	Description
PCIGS	
LAIGD	
NAIGD	
PAIGD	
LAIGD1	
NAIGD1	
PAIGD1	
LBIGD	
NBIGD	
PBIGD	
LCIGD	
NCIGD	
PCIGD	
LNTOX	
NNTOX	
PNTOX	
LPOXEDGE	
NPOXEDGE	
PPOXEDGE	

Name (Alias)	Description
LAGISL	
NAGISL	
PAGISL	
LBGISL	
NBGISL	
PBGISL	
LCGISL	
NCGISL	
PCGISL	
LEGISL	
NEGISL	
PEGISL	
LPGISL	
NPGISL	
PPGISL	
LAGIDL	
NAGIDL	
PAGIDL	
LBGIDL	

Name (Alias)	Description
NBGIDL	
PBGIDL	
LCGIDL	
NCGIDL	
PCGIDL	
LEGIDL	
NEGIDL	
PEGIDL	
LPGIDL	
NPGIDL	
PPGIDL	
LALPHA0	
NALPHA0	
PALPHA0	
LALPHA1	
NALPHA1	
PALPHA1	
LALPHAII0	
NALPHAII0	

Name (Alias)	Description
PALPHAII0	
LALPHAII1	
NALPHAII1	
PALPHAII1	
LBETA0	
NBETA0	
PBETA0	
LBETAII0	
NBETAII0	
PBETAII0	
LBETAII1	
NBETAII1	
PBETAII1	
LBETAII2	
NBETAII2	
PBETAII2	
LESATII	
NESATII	
PESATII	

Name (Alias)	Description
LLII	
NLII	
PLII	
LSII0	
NSII0	
PSII0	
LSII1	
NSII1	
PSII1	
LSII2	
NSII2	
PSII2	
LSIID	
NSIID	
PSIID	
LCFS	
NCFS	
PCFS	
LCFD	

Name (Alias)	Description
NCFD	
PCFD	
LCOVS	
NCOVS	
PCOVS	
LCOVD	
NCOVD	
PCOVD	
LCGSL	
NCGSL	
PCGSL	
LCGDL	
NCGDL	
PCGDL	
LCKAPPAS	
NCKAPPAS	
PCKAPPAS	
LCKAPPAD	
NCKAPPAD	

Name (Alias)	Description
PCKAPPAD	
LCGBL	
NCGBL	
PCGBL	
LCKAPPAB	
NCKAPPAB	
PCKAPPAB	
LNTGEN	
NNTGEN	
PNTGEN	
LAIGEN	
NAIGEN	
PAIGEN	
LBIGEN	
NBIGEN	
PBIGEN	
LXRCRG1	
NXRCRG1	
PXRCRG1	

Name (Alias)	Description
LXRCRG2	
NXRCRG2	
PXRCRG2	
LINTNOI	
NINTNOI	
PINTNOI	
LUTE	
NUTE	
PUTE	
LUTL	
NUTL	
PUTL	
LEMOBT	
NEMOBT	
PEMOBT	
LUA1	
NUA1	
PUA1	
LUC1	

Name (Alias)	Description
NUC1	
PUC1	
LUD1	
NUD1	
PUD1	
LUCSTE	
NUCSTE	
PUCSTE	
LPTWGT	
NPTWGT	
PPTWGT	
LAT	
NAT	
PAT	
LSTTHETASAT	
NSTTHETASAT	
PSTTHETASAT	
LPRT	
NPRT	

Name (Alias)	Description
PPRT	
LKT1	
NKT1	
PKT1	
LTSS	
NTSS	
PTSS	
LIIT	
NIIT	
PIIT	
LTII	
NTII	
PTII	
LTGIDL	
NTGIDL	
PTGIDL	
LIGT	
NIGT	
PIGT	

Name (Alias)	Description
Version	

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

> *model modelName bsimcmg [parm=value]**

Instance Parameters

Name (Alias)	Description
L	Designed Gate Length
D	Diameter of cylinder (for GEOMOD = 3)
TFIN	Body (fin) thickness
FPITCH	Fin Pitch
NF	Number of fingers
NFIN	Number of fins per finger
NGCON	Number of gate contacts
ASEO	Source to substrate overlap area through oxide (all fingers)
ADEO	Drain to substrate overlap area through oxide (all fingers)
PSEO	Perimeter of source to substrate overlap region through oxide (all fingers)
PDEO	Perimeter of drain to substrate overlap region through oxide (all fingers)
ASEJ	Source junction area (all fingers; for bulk MuGFETs, BULKMOD = 1)

Name (Alias)	Description
ADEJ	Drain junction area (all fingers; for bulk MuGFETs, BULKMOD = 1)
PSEJ	Source junction perimeter (all fingers; for bulk MuGFETs, BULKMOD = 1)
PDEJ	Drain junction perimeter (all fingers; for bulk MuGFETs, BULKMOD = 1)
CGSP	Constant gate to source fringe capacitance (for CGEOMOD = 1)
CGDP	Constant gate to drain fringe capacitance (for CGEOMOD = 1)
CDSP	Constant drain to source fringe capacitance
NRS	Number of source dffusion squares (for RGEOMOD = 0)
NRD	Number of drain dffusion squares (for RGEOMOD = 0)
LRSD	Length of the source/drain
LSP	Thickness of the gate sidewall spacer
XL	
DELVTRAND	
U0MULT	
IDS0MULT	

Instance Netlist Format

> *modelName [:Name] d g s b*

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example

> *Nch7:M1 2 1 0 0 W=10u L=0.9u*

BSIMCMG 107 Model

BSIMCMG 107 Model

The following topic lists the BSIMCMG 107 model and instance parameters.

Model Parameters

Name (Alias)	Description
XL	L offset for channel length due to mask/etch effect
BULKMOD	Substrate model selector. 0=multi-gate on SOI substrate, 1=multi-gate on bulk substrate.
COREMOD	simplified surface potential selector ; 0=turnoff, 1=turn on (lightly-doped or undoped)
GEOMOD	structure selector; 0 = double gate, 1 = triple gate, 2 = quadruple gate, 3 = cylindrical gate
RDSMOD	bias-dependent source/drain resistance model selector 0 = internal, 1 = external
ASYMMOD	Asymmetry Model ; 0=turned off - forward mode parameters used, 1= turned on
IGCMOD	model selector for Igc, Igs and Igd; 1=turn on, 0=turn off
IGBMOD	model selector for Igb; 1=turn on, 0=turn off
GIDLMOD	GIDL/GISL current switcher; 1=turn on, 0=turn off
IIMOD	impact ionization model switch; 0 = OFF, 1= BSIM4 based, 2 = BSIMSOI based
NQSMOD	NQS gate resistor and gi node switcher;1=turn on, 0=turn off
SHMOD	Self-heating and T node switcher; 1=turn on,0=turn off
RGATEMOD	Gate electrode resistor and ge node switcher ;1=turn on, 0=turn off

Name (Alias)	Description
RGEOMOD	bias independent parasitic resistance model selector
CGEOMOD	parasitic capacitance model selector
CAPMOD	accumulation region capacitance model selector; 0=no accumulation capacitance, 1=accumulation capacitance included
LINT	Length reduction parameter (dopant diffusion effect)
LL	Length reduction parameter (dopant diffusion effect)
LLN	Length reduction parameter (dopant diffusion effect)
DLC	Length reduction parameter for CV (dopant diffusion effect)
DLCACC	Delta L for C-V model in accumulation region
DLBIN	Length reduction parameter for binning
LLC	Length reduction parameter for CV (dopant diffusion effect)
EOT	SiO2 equivalent gate dielectric thickness (including inversion layer thickness)
TOXP	Physical oxide thickness
EOTBOX	SiO2 equivalent buried oxide thickness (including substrate depletion)
HFIN	fin height
FECH	end-channel factor, for different orientation/shape (Mobility difference between the side channel and the top channel is handled by this parameter)
DELTAW	reduction of effective width due to shape of fin
FECHCV	CV end-channel factor, for different orientation/shape
DELTAWCV	CV reduction of effective width due to shape of fin

Name (Alias)	Description
NBODY	channel (body) doping concentration
NSD	S/D doping concentration
PHIG	work function of gate
EPSROX	relative dielectric constant of the gate insulator
EPSRSUB	relative dielectric constant of the channel material
EASUB	electron affinity of the substrate material
NI0SUB	intrinsic carrier concentration of channel at 300.15K
BG0SUB	band gap of the channel material at 300.15K
NC0SUB	conduction band density of states at 300.15K
NGATE	parameter for Poly Gate doping. Set NGATE = 0 for metal gates
Imin	Parameter for Vgs Clamping for inversion region calc. in accumulation
CIT	parameter for interface trap
CDSC	coupling capacitance between S/D and channel
CDSCD	drain-bias sensitivity of CDSC
CDSCDR	Reverse-mode drain-bias sensitivity of CDSC
DVT0	SCE coefficient
DVT1	SCE exponent coefficient
PHIN	nonuniform vertical doping effect on surface potential
ETA0	DIBL coefficient

Name (Alias)	Description
ETA0R	Reverse-mode DIBL coefficient
DSUB	DIBL exponent coefficient
K1RSCE	prefactor for reverse short channel effect
LPE0	equivalent length of pocket region at zero bias
DVTSHIFT	Additional Vth shift handle
K0	Lateral non-uniform doping voltage parameter, V
K01	Temperature dependence of lateral non-uniform doping voltage parameter, V/K
K0SI	Correction factor for strong inversion, used in Mnud, after binning should be from (0:inf)
K0SI1	Temperature dependence of K0SI, 1/K
K1SI	Correction factor for strong inversion, used in Mob
K1SI1	Temperature dependence of K1SI, 1/K
PHIBE	Body effect voltage parameter, V, after binning should be from [0.2:1.2]
K1	Body effect coefficient for sub-threshold region
K11	Temperature dependence of K1
K1SAT	Correction factor for K1 in saturation (high Vds)
K1SAT1	Temperature dependence of K1SAT1
QMFACTOR	Prefactor + switch for QM Vth correction
QMTCENIV	Prefactor + switch for QM Width correction for IV

Name (Alias)	Description
QMTCENCV	Prefactor + switch for QM Width and Toxeff correction for CV
QMTCENCVA	Prefactor + switch for QM Width and Toxeff correction for CV (accumulation region)
AQMTCEN	Parameter for Geometric dependence of Tcen on R/TFIN/HFIN
BQMTCEN	Parameter for Geometric dependence of Tcen on R/TFIN/HFIN
ETAQM	Bulk charge coefficient for Tcen
QM0	Knee-Point for Tcen in inversion (Charge normalized to Cox)
PQM	Slope of normalized Tcen in inversion
QM0ACC	Knee-Point for Tcen in accumulation (Charge normalized to Cox)
PQMACC	Slope of normalized Tcen in accumulation
VSAT	
AVSAT	
BVSAT	
VSAT1	Velocity Saturation parameter for I_on degradation - forward mode
VSAT1R	Velocity Saturation parameter for I_on degradation - reverse mode
AVSAT1	
BVSAT1	
DELTAVSAT	
PSAT	Velocity saturation exponent, after binnig should be from [2.0:inf)
APSAT	

Name (Alias)	Description
BPSAT	
KSATIV	
VSATCV	Velocity Saturation parameter for CV
AVSATCV	
BVSATCV	
DELTAVSATCV	
PSATCV	Velocity saturation exponent for C-V
APSATCV	
BPSATCV	
MEXP	
AMEXP	
BMEXP	
PTWG	Gmsat degradation parameter - forward mode
PTWGR	Gmsat degradation parameter - reverse mode
APTWG	
BPTWG	
AT	
TMEXP	
PTWGT	

Name (Alias)	Description
U0	
ETAMOB	
UP	
LPA	
UA	
AUA	
BUA	
UC	Body effect for mobility degradation parameter - BULKMOD=1
EU	
AEU	
BEU	
UD	
AUD	
BUD	
UCS	
UTE	
UTL	
EMOBT	
UA1	

Name (Alias)	Description
UC1	
UD1	
UCSTE	
RDSWMIN	
RDSW	
ARDSW	
BRDSW	
RSWMIN	
RSW	
ARSW	
BRSW	
RDWMIN	
RDW	
ARDW	
BRDW	
RSDR	Source side drift resistance parameter - forward mode
RSDRR	Source side drift resistance parameter - reverse mode
RDDR	Drain side drift resistance parameter - forward mode
RDDRR	Drain side drift resistance parameter - reverse mode

Name (Alias)	Description
PRSDR	Source side quasi-saturation parameter
PRDDR	Drain side quasi-saturation parameter
PRWGS	Gate bias dependence of source extension resistance, Units:V^-1
PRWGD	Gate bias dependence of drain extension resistance, Units:V^-1
WR	
PRT	
TRSDR	
TRDDR	
PDIBL1	DIBL Output Conductance parameter - forward mode
PDIBL1R	DIBL Output Conductance parameter - reverse mode
PDIBL2	DIBL Output Conductance parameter
DROUT	
PVAG	
PCLM	CLM parameter for Short Channel CV
APCLM	
BPCLM	
PCLMG	
PCLMCV	
A1	Non-saturation effect parameter for strong inversion region

Name (Alias)	Description
A11	Temperature dependence of A1
A2	Non-saturation effect parameter for moderate inversion region
A21	Temperature dependence of A2
RGEXT	Effective gate electrode external resistance
RGFIN	Effective gate electrode per finger per fin resistance
RSHS	Source-side sheet resistance
RSHD	Drain-side sheet resistance
HEPI	Height of the raised source/drain on top of the fin
TSILI	Thickness of the silicide on top of the raised source/drain
RHOC	
RHORSD	
RHOEXT	
CRATIO	
DELTAPRSD	
SDTERM	
LDG	
EPSRSP	Relative dielectric constant of the spacer
TGATE	Gate height on top of the hard mask
TMASK	Height of hard mask on top of the fin

Name (Alias)	Description
ASILIEND	
ARSDEND	
PRSDEND	
NSDE	Source/drain active doping concentration at Leff edge
RGEOA	Fitting parameter for RGEOMOD=1
RGEOB	Fitting parameter for RGEOMOD=1
RGEOC	Fitting parameter for RGEOMOD=1
RGEOD	Fitting parameter for RGEOMOD=1
RGEOE	Fitting parameter for RGEOMOD=1
CGEOA	Fitting parameter for CGEOMOD=2
CGEOB	Fitting parameter for CGEOMOD=2
CGEOC	Fitting parameter for CGEOMOD=2
CGEOD	Fitting parameter for CGEOMOD=2
CGEOE	Fitting parameter for CGEOMOD=2
AIGBINV	parameter for Igb in inversion
AIGBINV1	parameter for Igb in inversion
BIGBINV	parameter for Igb in inversion
CIGBINV	parameter for Igb in inversion
EIGBINV	parameter for Igb in inversion

Name (Alias)	Description
NIGBINV	parameter for Igb in inversion
AIGBACC	parameter for Igb in accumulation
AIGBACC1	parameter for Igb in accumulation
BIGBACC	parameter for Igb in accumulation
CIGBACC	parameter for Igb in accumulation
NIGBACC	parameter for Igb in accumulation
AIGC	parameter for Igc in inversion
AIGC1	parameter for Igc in inversion
BIGC	parameter for Igc in inversion
CIGC	parameter for Igc in inversion
PIGCD	parameter for Igc partition
DLCIGS	Delta L for Igs model
AIGS	parameter for Igs in inversion
AIGS1	parameter for Igs in inversion
BIGS	parameter for Igs in inversion
CIGS	parameter for Igs in inversion
DLCIGD	Delta L for Igd model
AIGD	parameter for Igd in inversion
AIGD1	parameter for Igd in inversion

Name (Alias)	Description
BIGD	parameter for Igd in inversion
CIGD	parameter for Igd in inversion
TOXREF	Target tox value [m]
TOXG	oxide thickness for gate current model in meters
NTOX	Exponent for Tox ratio
POXEDGE	Factor for the gate edge Tox
AGISL	pre-exponential coeff. for GISL in mho
BGISL	exponential coeff. for GISL in V/m
CGISL	parameter for body-effect of GISL in V^3
EGISL	band bending parameter for GISL in V
PGISL	parameter for body-bias effect on GISL
AGIDL	pre-exponential coeff. for GIDL in mho
BGIDL	exponential coeff. for GIDL in V/m
CGIDL	parameter for body-effect of GIDL in V^3
EGIDL	band bending parameter for GIDL in V
PGIDL	parameter for body-bias effect on GIDL
ALPHA0	first parameter of Iii, m/V
ALPHA01	Temperature dependence of ALPHA0, m/V/degrees
ALPHA1	L scaling parameter of Iii, 1/V

Name (Alias)	Description
ALPHA11	Temperature dependence ALPHA1, 1/V/degree
BETA0	Vds dependent parameter of Iii, 1/V
ALPHAII0	first parameter of Iii for IIMOD=2, m/V
ALPHAII01	Temperature dependence of ALPHAII0, m/V/degrees
ALPHAII1	L scaling parameter of Iii for IIMOD=2, 1/V
ALPHAII11	Temperature dependence of ALPHAII1, 1/V/degrees
BETAII0	Vds dependent parameter of Iii, 1/V
BETAII1	Vds dependent parameter of Iii
BETAII2	Vds dependent parameter of Iii, V
ESATII	Saturation channel E-Field for Iii, V/m
LII	Channel length dependent parameter of Iii, V-m
SII0	Vgs dependent parameter of Iii, 1/V
SII1	1st Vgs dependent parameter of Iii, 1/V
SII2	2nd Vgs dependent parameter of Iii
SIID	3rd Vds dependent parameter of Iii, 1/V
EOTACC	equivalent oxide thickness for accumulation region in meters
DELVFBACC	Change in Flatband Voltage
CFS	Outer Fringe Cap (source side)
CFD	Outer Fringe Cap (drain side)

Name (Alias)	Description
COVS	Constant g/s overlap capacitance
COVD	Constant g/d overlap capacitance
CGSO	Non LDD region source-gate overlap capacitance per unit channel width
CGDO	Non LDD region drain-gate overlap capacitance per unit channel width
CGSL	
CGDL	
CKAPPAS	
CKAPPAD	
CGBO	Gate to substrate overlap cap per unit channel length per finger per NGCON
CGBN	Gate to substrate overlap cap per unit channel length per fin per finger
CGBL	Bias dependent component of Gate to substrate overlap cap
CKAPPAB	per unit channel length per fin per finger
CSDESW	Coefficient for source/drain to substrate sidewall cap
CJS	Unit area source-side junction capacitance at zero bias
CJD	Unit area drain-side junction capacitance at zero bias
CJSWS	Unit length source-side sidewall junction capacitance at zero bias
CJSWD	Unit length drain-side sidewall junction capacitance at zero bias
CJSWGS	Unit length source-side gate sidewall junction capacitance at zero bias
CJSWGD	Unit length drain-side gate sidewall junction capacitance at zero bias

Name (Alias)	Description
PBS	Source-side bulk junction built-in potential
PBD	Drain-side bulk junction built-in potential
PBSWS	Built-in potential for Source-side sidewall junction capacitance
PBSWD	Built-in potential for drain-side sidewall junction capacitance
PBSWGS	Built-in potential for Source-side gate sidewall junction capacitance
PBSWGD	Built-in potential for drain-side gate sidewall junction capacitance
MJS	Source bottom junction capacitance grading coefficient
MJD	Drain bottom junction capacitance grading coefficient
MJSWS	Source sidewall junction capacitance grading coefficient
MJSWD	Drain sidewall junction capacitance grading coefficient
MJSWGS	Source-side gate sidewall junction capacitance grading coefficient
MJSWGD	Drain-side gate sidewall junction capacitance grading coefficient
SJS	Constant for source-side two-step second junction
SJD	Constant for drain-side two-step second junction
SJSWS	Constant for source-side sidewall two-step second junction
SJSWD	Constant for drain-side sidewall two-step second junction
SJSWGS	Constant for source-side gate sidewall two-step second junction
SJSWGD	Constant for drain-side gate sidewall two-step second junction
MJS2	Source bottom two-step second junction capacitance grading coefficient

Name (Alias)	Description
MJD2	Drain bottom two-step second junction capacitance grading coefficient
MJSWS2	Source sidewall two-step second junction capacitance grading coefficient
MJSWD2	Drain sidewall two-step second junction capacitance grading coefficient
MJSWGS2	Source-side gate sidewall two-step second junction capacitance grading coefficient
MJSWGD2	Drain-side gate sidewall two-step second junction capacitance grading coefficient
JSS	Bottom source junction reverse saturation current density
JSD	Bottom drain junction reverse saturation current density
JSWS	Unit length reverse saturation current for sidewall source junction
JSWD	Unit length reverse saturation current for sidewall drain junction
JSWGS	Unit length reverse saturation current for gate-edge sidewall source junction
JSWGD	Unit length reverse saturation current for gate-edge sidewall drain junction
NJS	Source junction emission coefficient
NJD	Drain junction emission coefficient
IJTHSFWD	Forward source diode breakdown limiting current
IJTHDFWD	Forward drain diode breakdown limiting current
IJTHSREV	Reverse source diode breakdown limiting current
IJTHDREV	Reverse drain diode breakdown limiting current
BVS	Source diode breakdown voltage

Name (Alias)	Description
BVD	Drain diode breakdown voltage
XJBVS	Fitting parameter for source diode breakdown current
XJBVD	Fitting parameter for drain diode breakdown current
JTSS	Bottom source junction trap-assisted saturation current density
JTSD	Bottom drain junction trap-assisted saturation current density
JTSSWS	Unit length trap-assisted saturation current for sidewall source junction
JTSSWD	Unit length trap-assisted saturation current for sidewall drain junction
JTSSWGS	Unit length trap-assisted saturation current for gate-edge sidewall source junction
JTSSWGD	Unit length trap-assisted saturation current for gate-edge sidewall drain junction
JTWEFF	Trap assisted tunneling current width dependence
NJTS	Non-ideality factor for JTSS
NJTSD	Non-ideality factor for JTSD
NJTSSW	Non-ideality factor for JTSSWS
NJTSSWD	Non-ideality factor for JTSSWD
NJTSSWG	Non-ideality factor for JTSSWGS
NJTSSWGD	Non-ideality factor for JTSSWGD
VTSS	Bottom source junction trap-assisted current voltage dependent parameter
VTSD	Bottom drain junction trap-assisted current voltage dependent parameter

Name (Alias)	Description
VTSSWS	Unit length trap-assisted current voltage dependent parameter for sidewall source junction
VTSSWD	Unit length trap-assisted current voltage dependent parameter for sidewall drain junction
VTSSWGS	Unit length trap-assisted current voltage dependent parameter for gate-edge sidewall source junction
VTSSWGD	Unit length trap-assisted current voltage dependent parameter for gate-edge sidewall drain junction
LINTIGEN	Lint for Thermal Generation Current
NTGEN	Thermal Generation Current Parameter
AIGEN	Thermal Generation Current Parameter
BIGEN	Thermal Generation Current Parameter
XRCRG1	
XRCRG2	
NSEG	Number of segments for NQSMOD=3 (3,5 & 10 supported)
EF	Flicker Noise frequency exponent
EM	
NOIA	
NOIB	
NOIC	
NTNOI	
TBGASUB	Bandgap Temperature Coefficient (eV/degrees)

Name (Alias)	Description
TBGBSUB	Bandgap Temperature Coefficient (degrees)
KT1	Vth Temperature Coefficient (V)
KT1L	Vth Temperature L Coefficient (m-V)
TSS	SSwing Temperature Coefficient (/ degrees)
IIT	Impact Ionization Temperature Dependence, IIMOD=1
TII	Impact Ionization Temperature Dependence, IIMOD=2
TGIDL	GIDL/GISL Temperature Dependence
IGT	Gate Current Temperature Dependence
TCJ	Temperature coefficient for CJS/CJD
TCJSW	Temperature coefficient for CJSWS/CJSWD
TCJSWG	Temperature coefficient for CJSWGS/CJSWGD
TPB	Temperature coefficient for PBS/PBD
TPBSW	Temperature coefficient for PBSWS/PBSWD
TPBSWG	Temperature coefficient for PBSWGS/PBSWGD
XTIS	Source junction current temperature exponent
XTID	Drain junction current temperature exponent
XTSS	Power dependence of JTSS on temperature
XTSD	Power dependence of JTSD on temperature
XTSSWS	Power dependence of JTSSWS on temperature

Name (Alias)	Description
XTSSWD	Power dependence of JTSSWD on temperature
XTSSWGS	Power dependence of JTSSWGS on temperature
XTSSWGD	Power dependence of JTSSWGD on temperature
TNJTS	Temperature coefficient for NJTS
TNJTSD	Temperature coefficient for NJTSD
TNJTSSW	Temperature coefficient for NJTSSW
TNJTSSWD	Temperature coefficient for NJTSSWD
TNJTSSWG	Temperature coefficient for NJTSSWG
TNJTSSWGD	Temperature coefficient for NJTSSWGD
RTH0	Thermal resistance
CTH0	Thermal capacitance
WTH0	Width dependence coefficient for Rth and Cth
LNBODY	
NNBODY	
PNBODY	
LPHIG	
NPHIG	
PPHIG	
LNGATE	

Name (Alias)	Description
NNGATE	
PNGATE	
LCIT	
NCIT	
PCIT	
LCDSC	
NCDSC	
PCDSC	
LCDSCD	
NCDSCD	
PCDSCD	
LCDSCDR	
NCDSCDR	
PCDSCDR	
LDVT0	
NDVT0	
PDVT0	
LDVT1	
NDVT1	

Name (Alias)	Description
PDVT1	
LPHIN	
NPHIN	
PPHIN	
LETA0	
NETA0	
PETA0	
LETA0R	
NETA0R	
PETA0R	
LDSUB	
NDSUB	
PDSUB	
LK1RSCE	
NK1RSCE	
PK1RSCE	
LLPE0	
NLPE0	
PLPE0	

Name (Alias)	Description
LDVTSHIFT	
NDVTSHIFT	
PDVTSHIFT	
LPHIBE	
NPHIBE	
PPHIBE	
LK0	
NK0	
PK0	
LK01	
NK01	
PK01	
LK0SI	
NK0SI	
PK0SI	
LK0SI1	
NK0SI1	
PK0SI1	
LK1SI	

Name (Alias)	Description
NK1SI	
PK1SI	
LK1SI1	
NK1SI1	
PK1SI1	
LK1	
NK1	
PK1	
LK11	
NK11	
PK11	
LK1SAT	
NK1SAT	
PK1SAT	
LK1SAT1	
NK1SAT1	
PK1SAT1	
LDVTB	
NDVTB	

Name (Alias)	Description
PDVTB	
LLPEB	
NLPEB	
PLPEB	
LQMFACTOR	
NQMFACTOR	
PQMFACTOR	
LQMTCENIV	
NQMTCENIV	
PQMTCENIV	
LQMTCENCV	
NQMTCENCV	
PQMTCENCV	
LQMTCENCVA	
NQMTCENCVA	
PQMTCENCVA	
LVSAT	
NVSAT	
PVSAT	

Name (Alias)	Description
LVSAT1	
NVSAT1	
PVSAT1	
LVSAT1R	
NVSAT1R	
PVSAT1R	
LPSAT	
NPSAT	
PPSAT	
LDELTAVSAT	
NDELTAVSAT	
PDELTAVSAT	
LKSATIV	
NKSATIV	
PKSATIV	
LVSATCV	
NVSATCV	
PVSATCV	
LPSATCV	

Name (Alias)	Description
NPSATCV	
PPSATCV	
LDELTAVSATCV	
NDELTAVSATCV	
PDELTAVSATCV	
LMEXP	
NMEXP	
PMEXP	
LPTWG	
NPTWG	
PPTWG	
LPTWGR	
NPTWGR	
PPTWGR	
LU0	
NU0	
PU0	
LETAMOB	
NETAMOB	

Name (Alias)	Description
PETAMOB	
LUP	
NUP	
PUP	
LUA	
NUA	
PUA	
LUC	
NUC	
PUC	
LEU	
NEU	
PEU	
LUD	
NUD	
PUD	
LUCS	
NUCS	
PUCS	

Name (Alias)	Description
LPCLM	
NPCLM	
PPCLM	
LPCLMG	
NPCLMG	
PPCLMG	
LPCLMCV	
NPCLMCV	
PPCLMCV	
LA1	
NA1	
PA1	
LA11	
NA11	
PA11	
LA2	
NA2	
PA2	
LA21	

Name (Alias)	Description
NA21	
PA21	
LRDSW	
NRDSW	
PRDSW	
LRSW	
NRSW	
PRSW	
LRDW	
NRDW	
PRDW	
LPRWGS	
NPRWGS	
PPRWGS	
LPRWGD	
NPRWGD	
PPRWGD	
LWR	
NWR	

Name (Alias)	Description
PWR	
LPDIBL1	
NPDIBL1	
PPDIBL1	
LPDIBL1R	
NPDIBL1R	
PPDIBL1R	
LPDIBL2	
NPDIBL2	
PPDIBL2	
LDROUT	
NDROUT	
PDROUT	
LPVAG	
NPVAG	
PPVAG	
LAIGBINV	
NAIGBINV	
PAIGBINV	

Name (Alias)	Description
LAIGBINV1	
NAIGBINV1	
PAIGBINV1	
LBIGBINV	
NBIGBINV	
PBIGBINV	
LCIGBINV	
NCIGBINV	
PCIGBINV	
LEIGBINV	
NEIGBINV	
PEIGBINV	
LNIGBINV	
NNIGBINV	
PNIGBINV	
LAIGBACC	
NAIGBACC	
PAIGBACC	
LAIGBACC1	

Name (Alias)	Description
NAIGBACC1	
PAIGBACC1	
LBIGBACC	
NBIGBACC	
PBIGBACC	
LCIGBACC	
NCIGBACC	
PCIGBACC	
LNIGBACC	
NNIGBACC	
PNIGBACC	
LAIGC	
NAIGC	
PAIGC	
LAIGC1	
NAIGC1	
PAIGC1	
LBIGC	
NBIGC	

Name (Alias)	Description
PBIGC	
LCIGC	
NCIGC	
PCIGC	
LPIGCD	
NPIGCD	
PPIGCD	
LAIGS	
NAIGS	
PAIGS	
LAIGS1	
NAIGS1	
PAIGS1	
LBIGS	
NBIGS	
PBIGS	
LCIGS	
NCIGS	
PCIGS	

Name (Alias)	Description
LAIGD	
NAIGD	
PAIGD	
LAIGD1	
NAIGD1	
PAIGD1	
LBIGD	
NBIGD	
PBIGD	
LCIGD	
NCIGD	
PCIGD	
LNTOX	
NNTOX	
PNTOX	
LPOXEDGE	
NPOXEDGE	
PPOXEDGE	
LAGISL	

Name (Alias)	Description
NAGISL	
PAGISL	
LBGISL	
NBGISL	
PBGISL	
LCGISL	
NCGISL	
PCGISL	
LEGISL	
NEGISL	
PEGISL	
LPGISL	
NPGISL	
PPGISL	
LAGIDL	
NAGIDL	
PAGIDL	
LBGIDL	
NBGIDL	

Name (Alias)	Description
PBGIDL	
LCGIDL	
NCGIDL	
PCGIDL	
LEGIDL	
NEGIDL	
PEGIDL	
LPGIDL	
NPGIDL	
PPGIDL	
LALPHA0	
NALPHA0	
PALPHA0	
LALPHA1	
NALPHA1	
PALPHA1	
LALPHAII0	
NALPHAII0	
PALPHAII0	

Name (Alias)	Description
LALPHAII1	
NALPHAII1	
PALPHAII1	
LBETA0	
NBETA0	
PBETA0	
LBETAII0	
NBETAII0	
PBETAII0	
LBETAII1	
NBETAII1	
PBETAII1	
LBETAII2	
NBETAII2	
PBETAII2	
LESATII	
NESATII	
PESATII	
LLII	

Name (Alias)	Description
NLII	
PLII	
LSII0	
NSII0	
PSII0	
LSII1	
NSII1	
PSII1	
LSII2	
NSII2	
PSII2	
LSIID	
NSIID	
PSIID	
LCFS	
NCFS	
PCFS	
LCFD	
NCFD	

Name (Alias)	Description
PCFD	
LCOVS	
NCOVS	
PCOVS	
LCOVD	
NCOVD	
PCOVD	
LCGSL	
NCGSL	
PCGSL	
LCGDL	
NCGDL	
PCGDL	
LCKAPPAS	
NCKAPPAS	
PCKAPPAS	
LCKAPPAD	
NCKAPPAD	
PCKAPPAD	

Name (Alias)	Description
LCGBL	
NCGBL	
PCGBL	
LCKAPPAB	
NCKAPPAB	
PCKAPPAB	
LNTGEN	
NNTGEN	
PNTGEN	
LAIGEN	
NAIGEN	
PAIGEN	
LBIGEN	
NBIGEN	
PBIGEN	
LXRCRG1	
NXRCRG1	
PXRCRG1	
LXRCRG2	

Name (Alias)	Description
NXRCRG2	
PXRCRG2	
LINTNOI	
LUTE	
NUTE	
PUTE	
LUTL	
NUTL	
PUTL	
LEMOBT	
NEMOBT	
PEMOBT	
LUA1	
NUA1	
PUA1	
LUC1	
NUC1	
PUC1	
LUD1	

Name (Alias)	Description
NUD1	
PUD1	
LUCSTE	
NUCSTE	
PUCSTE	
LPTWGT	
NPTWGT	
PPTWGT	
LAT	
NAT	
PAT	
LSTTHETASAT	
NSTTHETASAT	
PSTTHETASAT	
LPRT	
NPRT	
PPRT	
LKT1	
NKT1	

Name (Alias)	Description
PKT1	
LTSS	
NTSS	
PTSS	
LIIT	
NIIT	
PIIT	
LTII	
NTII	
PTII	
LTGIDL	
NTGIDL	
PTGIDL	
LIGT	
NIGT	
PIGT	
Version	

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

> *model modelName bsimcmg [parm=value]**

Instance Parameters

Name (Alias)	Description
L	Designed Gate Length
D	Diameter of cylinder (for GEOMOD = 3)
TFIN	Body (fin) thickness
FPITCH	Fin Pitch
NF	Number of fingers
NFIN	Number of fins per finger
NGCON	Number of gate contacts
ASEO	Source to substrate overlap area through oxide (all fingers)
ADEO	Drain to substrate overlap area through oxide (all fingers)
PSEO	Perimeter of source to substrate overlap region through oxide (all fingers)
PDEO	Perimeter of drain to substrate overlap region through oxide (all fingers)
ASEJ	Source junction area (all fingers; for bulk MuGFETs, BULKMOD = 1)
ADEJ	Drain junction area (all fingers; for bulk MuGFETs, BULKMOD = 1)
PSEJ	Source junction perimeter (all fingers; for bulk MuGFETs, BULKMOD = 1)
PDEJ	Drain junction perimeter (all fingers; for bulk MuGFETs, BULKMOD = 1)

Name (Alias)	Description
CGSP	Constant gate to source fringe capacitance (for CGEOMOD = 1)
CGDP	Constant gate to drain fringe capacitance (for CGEOMOD = 1)
CDSP	Constant drain to source fringe capacitance
NRS	Number of source dffusion squares (for RGEOMOD = 0)
NRD	Number of drain dffusion squares (for RGEOMOD = 0)
LRSD	Length of the source/drain
LSP	Thickness of the gate sidewall spacer
XL	
DELVTRAND	
U0MULT	
IDS0MULT	

Instance Netlist Format

> *modelName [:Name] d g s b*

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example

> *Nch7:M1 2 1 0 0 W=10u L=0.9u*

For detailed information, refer to BSIMCMG manual.

BSIMCMG 108 Model

BSIMCMG 108 Model

The following topic lists the BSIMCMG 108 model and instance parameters.

Model Parameters

Name (Alias)	Description
XL	L offset for channel length due to mask/etch effect
BULKMOD	Substrate model selector. 0 = multi-gate on SOI substrate, 1 = multi-gate on bulk substrate.
COREMOD	simplified surface potential selector ; 0=turnoff, 1=turn on (lightly-doped or undoped)
GEOMOD	structure selector; 0 = double gate, 1 = triple gate, 2 = quadruple gate, 3 = cylindrical gate
RDSMOD	bias-dependent source/drain resistance model selector 0 = internal bias dependent, ext bias indep, 1 = external, 2= internal bias indep
ASYMMOD	Asymmetry Model ; 0=turned off - forward mode parameters used, 1= turned on
IGCMOD	model selector for Igc, Igs and Igd; 1=turn on, 0=turn off
IGBMOD	model selector for Igb; 1=turn on, 0=turn off
GIDLMOD	GIDL/GISL current switcher; 1=turn on, 0=turn off
IIMOD	impact ionization model switch; 0 = OFF, 1= BSIM4 based, 2 = BSIMSOI based
NQSMOD	NQS gate resistor and gi node switcher;1=turn on, 0=turn off
SHMOD	Self-heating and T node switcher; 1=turn on,0=turn off
RGATEMOD	Gate electrode resistor and ge node switcher ;1=turn on, 0=turn off

Name (Alias)	Description
RGEOMOD	bias independent parasitic resistance model selector
CGEOMOD	parasitic capacitance model selector
CAPMOD	accumulation region capacitance model selector; 0=no accumulation capacitance, 1=accumulation capacitance included
TEMPMOD	select various temperature models for certain parameters; 0=type A, 1=type B
TNOIMOD	noise model selector: 0=charge based, 1=holistic thermal noise based on BSIM4 noise model, 2=correlated thermal noise (BSIM4)
TYPE	Alias for DEVTYPE (takes precedence over DEVTYPE)
LINT	Length reduction parameter (dopant diffusion effect)
LL	Length reduction parameter (dopant diffusion effect)
LLN	Length reduction parameter (dopant diffusion effect)
DLC	Length reduction parameter for CV (dopant diffusion effect)
DLCACC	Delta L for C-V model in accumulation region
DLBIN	Length reduction parameter for binning
LLC	Length reduction parameter for CV (dopant diffusion effect)
EOT	SiO2 equivalent gate dielectric thickness (including inversion layer thickness)
TOXP	Physical oxide thickness
EOTBOX	SiO2 equivalent buried oxide thickness (including substrate depletion)
HFIN	fin height
FECH	end-channel factor, for different orientation/shape (Mobility difference between the side channel and the top channel is handled by this parameter)

Name (Alias)	Description
DELTAW	reduction of effective width due to shape of fin
FECHCV	CV end-channel factor, for different orientation/shape
DELTAWCV	CV reduction of effective width due to shape of fin
NBODY	channel (body) doping concentration
NSD	S/D doping concentration
PHIG	work function of gate
EPSROX	relative dielectric constant of the gate insulator
EPSRSUB	relative dielectric constant of the channel material
EASUB	electron affinity of the substrate material
NI0SUB	intrinsic carrier concentration of channel at 300.15K
BG0SUB	band gap of the channel material at 300.15K
NC0SUB	conduction band density of states at 300.15K
NGATE	parameter for Poly Gate doping. Set NGATE = 0 for metal gates
Imin	Parameter for Vgs Clamping for inversion region calc. in accumulation
CIT	parameter for interface trap
CDSC	coupling capacitance between S/D and channel
CDSCD	drain-bias sensitivity of CDSC
CDSCDR	Reverse-mode drain-bias sensitivity of CDSC
DVT0	SCE coefficient

Name (Alias)	Description
DVT1	SCE exponent coefficient
PHIN	nonuniform vertical doping effect on surface potential
ETA0	DIBL coefficient
ETA0R	Reverse-mode DIBL coefficient
DSUB	DIBL exponent coefficient
K1RSCE	prefactor for reverse short channel effect
LPE0	equivalent length of pocket region at zero bias
DVTSHIFT	Additional Vth shift handle
K0	Lateral non-uniform doping voltage parameter, V
K01	Temperature dependence of lateral non-uniform doping voltage parameter, V/K
K0SI	Correction factor for strong inversion, used in Mnud, after binning should be from (0:inf)
K0SI1	Temperature dependence of K0SI, 1/K
K1SI	Correction factor for strong inversion, used in Mob
K1SI1	Temperature dependence of K1SI, 1/K
PHIBE	Body effect voltage parameter, V, after binning should be from [0.2:1.2]
K1	Body effect coefficient for sub-threshold region
K11	Temperature dependence of K1
K1SAT	Correction factor for K1 in saturation (high Vds)

Name (Alias)	Description
K1SAT1	Temperature dependence of K1SAT1
QMFACTOR	Prefactor + switch for QM Vth correction
QMTCENIV	Prefactor + switch for QM Width correction for IV
QMTCENCV	Prefactor + switch for QM Width and Toxeff correction for CV
QMTCENCVA	Prefactor + switch for QM Width and Toxeff correction for CV (accumulation region)
AQMTCEN	Parameter for Geometric dependence of Tcen on R/TFIN/HFIN
BQMTCEN	Parameter for Geometric dependence of Tcen on R/TFIN/HFIN
ETAQM	Bulk charge coefficient for Tcen
QM0	Knee-Point for Tcen in inversion (Charge normalized to Cox)
PQM	Slope of normalized Tcen in inversion
QM0ACC	Knee-Point for Tcen in accumulation (Charge normalized to Cox)
PQMACC	Slope of normalized Tcen in accumulation
VSAT	
AVSAT	
BVSAT	
VSAT1	Velocity Saturation parameter for I_on degradation - forward mode
VSAT1R	Velocity Saturation parameter for I_on degradation - reverse mode
AVSAT1	
BVSAT1	

Name (Alias)	Description
DELTAVSAT	
PSAT	Velocity saturation exponent, after binnig should be from [2.0:inf)
APSAT	
BPSAT	
KSATIV	
VSATCV	Velocity Saturation parameter for CV
AVSATCV	
BVSATCV	
DELTAVSATCV	
PSATCV	Velocity saturation exponent for C-V
APSATCV	
BPSATCV	
MEXP	
AMEXP	
BMEXP	
PTWG	Gmsat degradation parameter - forward mode
PTWGR	Gmsat degradation parameter - reverse mode
APTWG	
BPTWG	

Name (Alias)	Description
AT	
ATCV	Saturation Velocity Temperature Coefficient for C-V
TMEXP	
PTWGT	
U0	
ETAMOB	
UP	
LPA	
UA	
AUA	
BUA	
UC	Body effect for mobility degradation parameter - BULKMOD=1
EU	
AEU	
BEU	
UD	
AUD	
BUD	
UCS	

Name (Alias)	Description
UTE	
UTL	
EMOBT	
UA1	
UC1	
UD1	
UCSTE	
RDSWMIN	
RDSW	
ARDSW	
BRDSW	
RSWMIN	
RSW	
ARSW	
BRSW	
RDWMIN	
RDW	
ARDW	
BRDW	

Name (Alias)	Description
THETASCE	Vth roll-off length dependence. If defined by user, will overwrite Theta_SCE in the code
THETADIBL	DIBL length dependence. If defined by user, will overwrite Theta_DIBL in the code
THETASS	Subthreshold swing length dependence. If defined by user, will overwrite Theta_SW in the code
NVTM	Subthreshold swing factor multiplied by Vtm. If defined by user, will overwrite nVtm in the code
RSDR	Source side drift resistance parameter - forward mode
RSDRR	Source side drift resistance parameter - reverse mode
RDDR	Drain side drift resistance parameter - forward mode
RDDRR	Drain side drift resistance parameter - reverse mode
PRSDR	Source side quasi-saturation parameter
PRDDR	Drain side quasi-saturation parameter
PRWGS	Gate bias dependence of source extension resistance, Units:V^-1
PRWGD	Gate bias dependence of drain extension resistance, Units:V^-1
WR	
PRT	
TRSDR	
TRDDR	
PDIBL1	DIBL Output Conductance parameter - forward mode
PDIBL1R	DIBL Output Conductance parameter - reverse mode

Name (Alias)	Description
PDIBL2	DIBL Output Conductance parameter
DROUT	
PVAG	
PCLM	CLM parameter for Short Channel CV
APCLM	
BPCLM	
PCLMG	
PCLMCV	
A1	Non-saturation effect parameter for strong inversion region
A11	Temperature dependence of A1
A2	Non-saturation effect parameter for moderate inversion region
A21	Temperature dependence of A2
RGEXT	Effective gate electrode external resistance
RGFIN	Effective gate electrode per finger per fin resistance
RSHS	Source-side sheet resistance
RSHD	Drain-side sheet resistance
HEPI	Height of the raised source/drain on top of the fin
TSILI	Thickness of the silicide on top of the raised source/drain
RHOC	

Name (Alias)	Description
RHORSD	
RHOEXT	
CRATIO	
DELTAPRSD	
SDTERM	
LDG	
EPSRSP	Relative dielectric constant of the spacer
TGATE	Gate height on top of the hard mask
TMASK	Height of hard mask on top of the fin
ASILIEND	
ARSDEND	
PRSDEND	
NSDE	Source/drain active doping concentration at Leff edge
RGEOA	Fitting parameter for RGEOMOD=1
RGEOB	Fitting parameter for RGEOMOD=1
RGEOC	Fitting parameter for RGEOMOD=1
RGEOD	Fitting parameter for RGEOMOD=1
RGEOE	Fitting parameter for RGEOMOD=1
CGEOA	Fitting parameter for CGEOMOD=2

Name (Alias)	Description
CGEOB	Fitting parameter for CGEOMOD=2
CGEOC	Fitting parameter for CGEOMOD=2
CGEOD	Fitting parameter for CGEOMOD=2
CGEOE	Fitting parameter for CGEOMOD=2
AIGBINV	parameter for Igb in inversion
AIGBINV1	parameter for Igb in inversion
BIGBINV	parameter for Igb in inversion
CIGBINV	parameter for Igb in inversion
EIGBINV	parameter for Igb in inversion
NIGBINV	parameter for Igb in inversion
AIGBACC	parameter for Igb in accumulation
AIGBACC1	parameter for Igb in accumulation
BIGBACC	parameter for Igb in accumulation
CIGBACC	parameter for Igb in accumulation
NIGBACC	parameter for Igb in accumulation
AIGC	parameter for Igc in inversion
AIGC1	parameter for Igc in inversion
BIGC	parameter for Igc in inversion
CIGC	parameter for Igc in inversion

Name (Alias)	Description
PIGCD	parameter for Igc partition
DLCIGS	Delta L for Igs model
AIGS	parameter for Igs in inversion
AIGS1	parameter for Igs in inversion
BIGS	parameter for Igs in inversion
CIGS	parameter for Igs in inversion
DLCIGD	Delta L for Igd model
AIGD	parameter for Igd in inversion
AIGD1	parameter for Igd in inversion
BIGD	parameter for Igd in inversion
CIGD	parameter for Igd in inversion
TOXREF	Target tox value [m]
TOXG	oxide thickness for gate current model in meters
NTOX	Exponent for Tox ratio
POXEDGE	Factor for the gate edge Tox
AGISL	pre-exponential coeff. for GISL in mho
BGISL	exponential coeff. for GISL in V/m
CGISL	parameter for body-effect of GISL in V^3
EGISL	band bending parameter for GISL in V

Name (Alias)	Description
PGISL	parameter for body-bias effect on GISL
AGIDL	pre-exponential coeff. for GIDL in mho
BGIDL	exponential coeff. for GIDL in V/m
CGIDL	parameter for body-effect of GIDL in V^3
EGIDL	band bending parameter for GIDL in V
PGIDL	parameter for body-bias effect on GIDL
ALPHA0	first parameter of Iii, m/V
ALPHA01	Temperature dependence of ALPHA0, m/V/degrees
ALPHA1	L scaling parameter of Iii, 1/V
ALPHA11	Temperature dependence ALPHA1, 1/V/degree
BETA0	Vds dependent parameter of Iii, 1/V
ALPHAII0	first parameter of Iii for IIMOD=2, m/V
ALPHAII01	Temperature dependence of ALPHAII0, m/V/degrees
ALPHAII1	L scaling parameter of Iii for IIMOD=2, 1/V
ALPHAII11	Temperature dependence of ALPHAII1, 1/V/degrees
BETAII0	Vds dependent parameter of Iii, 1/V
BETAII1	Vds dependent parameter of Iii
BETAII2	Vds dependent parameter of Iii, V
ESATII	Saturation channel E-Field for Iii, V/m

Name (Alias)	Description
LII	Channel length dependent parameter of Iii, V-m
SII0	Vgs dependent parameter of Iii, 1/V
SII1	1st Vgs dependent parameter of Iii, 1/V
SII2	2nd Vgs dependent parameter of Iii
SIID	3rd Vds dependent parameter of Iii, 1/V
EOTACC	equivalent oxide thickness for accumulation region in meters
DELVFBACC	Change in Flatband Voltage
CFS	Outer Fringe Cap (source side)
CFD	Outer Fringe Cap (drain side)
COVS	Constant g/s overlap capacitance
COVD	Constant g/d overlap capacitance
CGSO	Non LDD region source-gate overlap capacitance per unit channel width
CGDO	Non LDD region drain-gate overlap capacitance per unit channel width
CGSL	
CGDL	
CKAPPAS	
CKAPPAD	
CGBO	Gate to substrate overlap cap per unit channel length per finger per NGCON
CGBN	Gate to substrate overlap cap per unit channel length per fin per finger

Name (Alias)	Description
CGBL	Bias dependent component of Gate to substrate overlap cap
CKAPPAB	per unit channel length per fin per finger
CSDESW	Coefficient for source/drain to substrate sidewall cap
CJS	Unit area source-side junction capacitance at zero bias
CJD	Unit area drain-side junction capacitance at zero bias
CJSWS	Unit length source-side sidewall junction capacitance at zero bias
CJSWD	Unit length drain-side sidewall junction capacitance at zero bias
CJSWGS	Unit length source-side gate sidewall junction capacitance at zero bias
CJSWGD	Unit length drain-side gate sidewall junction capacitance at zero bias
PBS	Source-side bulk junction built-in potential
PBD	Drain-side bulk junction built-in potential
PBSWS	Built-in potential for Source-side sidewall junction capacitance
PBSWD	Built-in potential for drain-side sidewall junction capacitance
PBSWGS	Built-in potential for Source-side gate sidewall junction capacitance
PBSWGD	Built-in potential for drain-side gate sidewall junction capacitance
MJS	Source bottom junction capacitance grading coefficient
MJD	Drain bottom junction capacitance grading coefficient
MJSWS	Source sidewall junction capacitance grading coefficient
MJSWD	Drain sidewall junction capacitance grading coefficient

Name (Alias)	Description
MJSWGS	Source-side gate sidewall junction capacitance grading coefficient
MJSWGD	Drain-side gate sidewall junction capacitance grading coefficient
SJS	Constant for source-side two-step second junction
SJD	Constant for drain-side two-step second junction
SJSWS	Constant for source-side sidewall two-step second junction
SJSWD	Constant for drain-side sidewall two-step second junction
SJSWGS	Constant for source-side gate sidewall two-step second junction
SJSWGD	Constant for drain-side gate sidewall two-step second junction
MJS2	Source bottom two-step second junction capacitance grading coefficient
MJD2	Drain bottom two-step second junction capacitance grading coefficient
MJSWS2	Source sidewall two-step second junction capacitance grading coefficient
MJSWD2	Drain sidewall two-step second junction capacitance grading coefficient
MJSWGS2	Source-side gate sidewall two-step second junction capacitance grading coefficient
MJSWGD2	Drain-side gate sidewall two-step second junction capacitance grading coefficient
JSS	Bottom source junction reverse saturation current density
JSD	Bottom drain junction reverse saturation current density
JSWS	Unit length reverse saturation current for sidewall source junction
JSWD	Unit length reverse saturation current for sidewall drain junction

Name (Alias)	Description
JSWGS	Unit length reverse saturation current for gate-edge sidewall source junction
JSWGD	Unit length reverse saturation current for gate-edge sidewall drain junction
NJS	Source junction emission coefficient
NJD	Drain junction emission coefficient
IJTHSFWD	Forward source diode breakdown limiting current
IJTHDFWD	Forward drain diode breakdown limiting current
IJTHSREV	Reverse source diode breakdown limiting current
IJTHDREV	Reverse drain diode breakdown limiting current
BVS	Source diode breakdown voltage
BVD	Drain diode breakdown voltage
XJBVS	Fitting parameter for source diode breakdown current
XJBVD	Fitting parameter for drain diode breakdown current
JTSS	Bottom source junction trap-assisted saturation current density
JTSD	Bottom drain junction trap-assisted saturation current density
JTSSWS	Unit length trap-assisted saturation current for sidewall source junction
JTSSWD	Unit length trap-assisted saturation current for sidewall drain junction
JTSSWGS	Unit length trap-assisted saturation current for gate-edge sidewall source junction
JTSSWGD	Unit length trap-assisted saturation current for gate-edge sidewall drain junction

Name (Alias)	Description
JTWEFF	Trap assisted tunneling current width dependence
NJTS	Non-ideality factor for JTSS
NJTSD	Non-ideality factor for JTSD
NJTSSW	Non-ideality factor for JTSSWS
NJTSSWD	Non-ideality factor for JTSSWD
NJTSSWG	Non-ideality factor for JTSSWGS
NJTSSWGD	Non-ideality factor for JTSSWGD
VTSS	Bottom source junction trap-assisted current voltage dependent parameter
VTSD	Bottom drain junction trap-assisted current voltage dependent parameter
VTSSWS	Unit length trap-assisted current voltage dependent parameter for sidewall source junction
VTSSWD	Unit length trap-assisted current voltage dependent parameter for sidewall drain junction
VTSSWGS	Unit length trap-assisted current voltage dependent parameter for gate-edge sidewall source junction
VTSSWGD	Unit length trap-assisted current voltage dependent parameter for gate-edge sidewall drain junction
LINTIGEN	Lint for Thermal Generation Current
NTGEN	Thermal Generation Current Parameter
AIGEN	Thermal Generation Current Parameter
BIGEN	Thermal Generation Current Parameter
XRCRG1	

Name (Alias)	Description
XRCRG2	
NSEG	Number of segments for NQSMOD=3 (3,5 & 10 supported)
EF	Flicker Noise frequency exponent
EM	
NOIA	
NOIB	
NOIC	
NTNOI	
TBGASUB	Bandgap Temperature Coefficient (eV/degrees)
TBGBSUB	Bandgap Temperature Coefficient (degrees)
KT1	Vth Temperature Coefficient (V)
KT1L	Vth Temperature L Coefficient (m-V)
TSS	SSwing Temperature Coefficient (/ degrees)
IIT	Impact Ionization Temperature Dependence, IIMOD=1
TII	Impact Ionization Temperature Dependence, IIMOD=2
TGIDL	GIDL/GISL Temperature Dependence
IGT	Gate Current Temperature Dependence
TCJ	Temperature coefficient for CJS/CJD
TCJSW	Temperature coefficient for CJSWS/CJSWD

Name (Alias)	Description
TCJSWG	Temperature coefficient for CJSWGS/CJSWGD
TPB	Temperature coefficient for PBS/PBD
TPBSW	Temperature coefficient for PBSWS/PBSWD
TPBSWG	Temperature coefficient for PBSWGS/PBSWGD
XTIS	Source junction current temperature exponent
XTID	Drain junction current temperature exponent
XTSS	Power dependence of JTSS on temperature
XTSD	Power dependence of JTSD on temperature
XTSSWS	Power dependence of JTSSWS on temperature
XTSSWD	Power dependence of JTSSWD on temperature
XTSSWGS	Power dependence of JTSSWGS on temperature
XTSSWGD	Power dependence of JTSSWGD on temperature
TNJTS	Temperature coefficient for NJTS
TNJTSD	Temperature coefficient for NJTSD
TNJTSSW	Temperature coefficient for NJTSSW
TNJTSSWD	Temperature coefficient for NJTSSWD
TNJTSSWG	Temperature coefficient for NJTSSWG
TNJTSSWGD	Temperature coefficient for NJTSSWGD
RTH0	Thermal resistance

Name (Alias)	Description
CTH0	Thermal capacitance
WTH0	Width dependence coefficient for Rth and Cth
LNBODY	
NNBODY	
PNBODY	
LPHIG	
NPHIG	
PPHIG	
LNGATE	
NNGATE	
PNGATE	
LCIT	
NCIT	
PCIT	
LCDSC	
NCDSC	
PCDSC	
LCDSCD	
NCDSCD	

Name (Alias)	Description
PCDSCD	
LCDSCDR	
NCDSCDR	
PCDSCDR	
LDVT0	
NDVT0	
PDVT0	
LDVT1	
NDVT1	
PDVT1	
LPHIN	
NPHIN	
PPHIN	
LETA0	
NETA0	
PETA0	
LETA0R	
NETA0R	
PETA0R	

Name (Alias)	Description
LDSUB	
NDSUB	
PDSUB	
LK1RSCE	
NK1RSCE	
PK1RSCE	
LLPE0	
NLPE0	
PLPE0	
LDVTSHIFT	
NDVTSHIFT	
PDVTSHIFT	
LPHIBE	
NPHIBE	
PPHIBE	
LK0	
NK0	
PK0	
LK01	

Name (Alias)	Description
NK01	
PK01	
LK0SI	
NK0SI	
PK0SI	
LK0SI1	
NK0SI1	
PK0SI1	
LK1SI	
NK1SI	
PK1SI	
LK1SI1	
NK1SI1	
PK1SI1	
LK1	
NK1	
PK1	
LK11	
NK11	

Name (Alias)	Description
PK11	
LK1SAT	
NK1SAT	
PK1SAT	
LK1SAT1	
NK1SAT1	
PK1SAT1	
LDVTB	
NDVTB	
PDVTB	
LLPEB	
NLPEB	
PLPEB	
LQMFACTOR	
NQMFACTOR	
PQMFACTOR	
LQMTCENIV	
NQMTCENIV	
PQMTCENIV	

Name (Alias)	Description
LQMTCENCV	
NQMTCENCV	
PQMTCENCV	
LQMTCENCVA	
NQMTCENCVA	
PQMTCENCVA	
LVSAT	
NVSAT	
PVSAT	
LVSAT1	
NVSAT1	
PVSAT1	
LVSAT1R	
NVSAT1R	
PVSAT1R	
LPSAT	
NPSAT	
PPSAT	
LDELTAVSAT	

Name (Alias)	Description
NDELTAVSAT	
PDELTAVSAT	
LKSATIV	
NKSATIV	
PKSATIV	
LVSATCV	
NVSATCV	
PVSATCV	
LPSATCV	
NPSATCV	
PPSATCV	
LDELTAVSATCV	
NDELTAVSATCV	
PDELTAVSATCV	
LMEXP	
NMEXP	
PMEXP	
LPTWG	
NPTWG	

Name (Alias)	Description
PPTWG	
LPTWGR	
NPTWGR	
PPTWGR	
LU0	
NU0	
PU0	
LETAMOB	
NETAMOB	
PETAMOB	
LUP	
NUP	
PUP	
LUA	
NUA	
PUA	
LUC	
NUC	
PUC	

Name (Alias)	Description
LEU	
NEU	
PEU	
LUD	
NUD	
PUD	
LUCS	
NUCS	
PUCS	
LPCLM	
NPCLM	
PPCLM	
LPCLMG	
NPCLMG	
PPCLMG	
LPCLMCV	
NPCLMCV	
PPCLMCV	
LA1	

Name (Alias)	Description
NA1	
PA1	
LA11	
NA11	
PA11	
LA2	
NA2	
PA2	
LA21	
NA21	
PA21	
LRDSW	
NRDSW	
PRDSW	
LRSW	
NRSW	
PRSW	
LRDW	
NRDW	

Name (Alias)	Description
PRDW	
LPRWGS	
NPRWGS	
PPRWGS	
LPRWGD	
NPRWGD	
PPRWGD	
LWR	
NWR	
PWR	
LPDIBL1	
NPDIBL1	
PPDIBL1	
LPDIBL1R	
NPDIBL1R	
PPDIBL1R	
LPDIBL2	
NPDIBL2	
PPDIBL2	

Name (Alias)	Description
LDROUT	
NDROUT	
PDROUT	
LPVAG	
NPVAG	
PPVAG	
LAIGBINV	
NAIGBINV	
PAIGBINV	
LAIGBINV1	
NAIGBINV1	
PAIGBINV1	
LBIGBINV	
NBIGBINV	
PBIGBINV	
LCIGBINV	
NCIGBINV	
PCIGBINV	
LEIGBINV	

Name (Alias)	Description
NEIGBINV	
PEIGBINV	
LNIGBINV	
NNIGBINV	
PNIGBINV	
LAIGBACC	
NAIGBACC	
PAIGBACC	
LAIGBACC1	
NAIGBACC1	
PAIGBACC1	
LBIGBACC	
NBIGBACC	
PBIGBACC	
LCIGBACC	
NCIGBACC	
PCIGBACC	
LNIGBACC	
NNIGBACC	

Name (Alias)	Description
PNIGBACC	
LAIGC	
NAIGC	
PAIGC	
LAIGC1	
NAIGC1	
PAIGC1	
LBIGC	
NBIGC	
PBIGC	
LCIGC	
NCIGC	
PCIGC	
LPIGCD	
NPIGCD	
PPIGCD	
LAIGS	
NAIGS	
PAIGS	

Name (Alias)	Description
LAIGS1	
NAIGS1	
PAIGS1	
LBIGS	
NBIGS	
PBIGS	
LCIGS	
NCIGS	
PCIGS	
LAIGD	
NAIGD	
PAIGD	
LAIGD1	
NAIGD1	
PAIGD1	
LBIGD	
NBIGD	
PBIGD	
LCIGD	

Name (Alias)	Description
NCIGD	
PCIGD	
LNTOX	
NNTOX	
PNTOX	
LPOXEDGE	
NPOXEDGE	
PPOXEDGE	
LAGISL	
NAGISL	
PAGISL	
LBGISL	
NBGISL	
PBGISL	
LCGISL	
NCGISL	
PCGISL	
LEGISL	
NEGISL	

Name (Alias)	Description
PEGISL	
LPGISL	
NPGISL	
PPGISL	
LAGIDL	
NAGIDL	
PAGIDL	
LBGIDL	
NBGIDL	
PBGIDL	
LCGIDL	
NCGIDL	
PCGIDL	
LEGIDL	
NEGIDL	
PEGIDL	
LPGIDL	
NPGIDL	
PPGIDL	

Name (Alias)	Description
LALPHA0	
NALPHA0	
PALPHA0	
LALPHA1	
NALPHA1	
PALPHA1	
LALPHAII0	
NALPHAII0	
PALPHAII0	
LALPHAII1	
NALPHAII1	
PALPHAII1	
LBETA0	
NBETA0	
PBETA0	
LBETAII0	
NBETAII0	
PBETAII0	
LBETAII1	

Name (Alias)	Description
NBETAII1	
PBETAII1	
LBETAII2	
NBETAII2	
PBETAII2	
LESATII	
NESATII	
PESATII	
LLII	
NLII	
PLII	
LSII0	
NSII0	
PSII0	
LSII1	
NSII1	
PSII1	
LSII2	
NSII2	

Name (Alias)	Description
PSII2	
LSIID	
NSIID	
PSIID	
LCFS	
NCFS	
PCFS	
LCFD	
NCFD	
PCFD	
LCOVS	
NCOVS	
PCOVS	
LCOVD	
NCOVD	
PCOVD	
LCGSL	
NCGSL	
PCGSL	

Name (Alias)	Description
LCGDL	
NCGDL	
PCGDL	
LCKAPPAS	
NCKAPPAS	
PCKAPPAS	
LCKAPPAD	
NCKAPPAD	
PCKAPPAD	
LCGBL	
NCGBL	
PCGBL	
LCKAPPAB	
NCKAPPAB	
PCKAPPAB	
LNTGEN	
NNTGEN	
PNTGEN	
LAIGEN	

Name (Alias)	Description
NAIGEN	
PAIGEN	
LBIGEN	
NBIGEN	
PBIGEN	
LXRCRG1	
NXRCRG1	
PXRCRG1	
LXRCRG2	
NXRCRG2	
PXRCRG2	
LINTNOI	
LUTE	
NUTE	
PUTE	
LUTL	
NUTL	
PUTL	
LEMOBT	

Name (Alias)	Description
NEMOBT	
PEMOBT	
LUA1	
NUA1	
PUA1	
LUC1	
NUC1	
PUC1	
LUD1	
NUD1	
PUD1	
LUCSTE	
NUCSTE	
PUCSTE	
LPTWGT	
NPTWGT	
PPTWGT	
LAT	
NAT	

Name (Alias)	Description
PAT	
LSTTHETASAT	
NSTTHETASAT	
PSTTHETASAT	
LPRT	
NPRT	
PPRT	
LKT1	
NKT1	
PKT1	
LTSS	
NTSS	
PTSS	
LIIT	
NIIT	
PIIT	
LTII	
NTII	
PTII	

Name (Alias)	Description
LTGIDL	
NTGIDL	
PTGIDL	
LIGT	
NIGT	
PIGT	
Version	

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

> *model modelName bsimcmg [parm=value]**

Instance Parameters

Name (Alias)	Description
L	Designed Gate Length
D	Diameter of cylinder (for GEOMOD = 3)
TFIN	Body (fin) thickness
FPITCH	Fin Pitch
NF	Number of fingers
NFIN	Number of fins per finger

Name (Alias)	Description
NGCON	Number of gate contacts
ASEO	Source to substrate overlap area through oxide (all fingers)
ADEO	Drain to substrate overlap area through oxide (all fingers)
PSEO	Perimeter of source to substrate overlap region through oxide (all fingers)
PDEO	Perimeter of drain to substrate overlap region through oxide (all fingers)
ASEJ	Source junction area (all fingers; for bulk MuGFETs, BULKMOD = 1)
ADEJ	Drain junction area (all fingers; for bulk MuGFETs, BULKMOD = 1)
PSEJ	Source junction perimeter (all fingers; for bulk MuGFETs, BULKMOD = 1)
PDEJ	Drain junction perimeter (all fingers; for bulk MuGFETs, BULKMOD = 1)
CGSP	Constant gate to source fringe capacitance (for CGEOMOD = 1)
CGDP	Constant gate to drain fringe capacitance (for CGEOMOD = 1)
CDSP	Constant drain to source fringe capacitance
NRS	Number of source dffusion squares (for RGEOMOD = 0)
NRD	Number of drain dffusion squares (for RGEOMOD = 0)
LRSD	Length of the source/drain
LSP	Thickness of the gate sidewall spacer
XL	
DELVTRAND	
U0MULT	

Name (Alias)	Description
IDS0MULT	

Instance Netlist Format

> *modelName [:Name] d g s b*

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example

> *Nch7:M1 2 1 0 0 W=10u L=0.9u*

For detailed information, refer to BSIMCMG manual.

BSIMCMG 110 Model

BSIMCMG 110 Model

The following topic lists the BSIMCMG 110 model and instance parameters.

NOTE This component is not available in the library browser, component palette, or component history. You must use a netlist fragment and include it using the NetlistInclude component. For more information on creating model netlist see, Netlist Format section.

Model Parameters

Parameter	Description	Default	Range	Unit
TYPE	NMOS = 1, PMOS = 0	NMOS	PMOS or NMOS	-
BULKMOD	Substrate model selector. 0: SOI substrate, 1: bulk substrate.	0	0 or 1	-
GEOMOD	Structure selector. 0: double gate, 1: triple gate, 2: quadruple gate, 3: cylindrical gate.	1	0, 1, 2, or 3	-
GEO1SW	For CGEOMOD = 1 only, GEO1SW = 1 enables the parameters COVS, COVD, CGSP, and CGDP to be in F per fin, per gate-finger, per unit channel width.	0	0 or 1	-
RDSMOD	Bias-dependent source/drain extension resistance model selector. 0: internal bias-dependent, 1: both external, 2: both internal.	0	0 or 1	-
ASYMMOD	Asymmetric I-V model selector. 0: turned off, 1: turned on.	0	0 or 1	-
IGCMOD	Model selector for I_{gc}, I_{gs}, and I_{gd}. 0: turned off, 1: turned on.	0	0 or 1	-
IGBMOD	Model selector for I_{gb}. 0: turned off, 1: turned on.	0	0 or 1	-
GIDLMOD	GIDL/GISL current switcher. 0: turned off, 1: BSIM4 based, 2: BSIM-SOI based.	0	0 or 1	-
NQSMOD	NQS gate resistor and gi gi node switcher. 0: turned off, 1: turned on.	0	0 or 1	-
SHMOD	Self-heating and t t node switcher. 0: turned off, 1: turned on.	0	0 or 1	-

Parameter	Description	Default	Range	Unit
RGATEMOD	Gate electrode resistor and ge ge node switcher. 0: turned off, 1: turned on.	0	0 or 1	-
RGEOMOD	Bias-independent parasitic resistance model selector.	0	0 or 1	-
CGEOMOD	Parasitic capacitance model selector.	0	0, 1, or 2	-
CAPMOD	Accumulation region capacitance model selector. 0: no accumulation capacitance, 1: accumulation capacitance included.	0	0 or 1	-
TEMPMOD	Temperature dependence model selector.	0	0 or 1	-
TNOIMOD	Thermal noise model selector, 0: charge-based, 1: correlated noise model.	0	0 or 1	-
SH_WARN	Warning on Self-heating network being disabled, 0: turned off, 1: turned on.	0	0 or 1	-
IGCLAMP	I_{gs}, I_{gd} clamp selector. 0: turned off, 1: turned on.	1	0 or 1	-
XL	L offset for channel length due to mask/ etch effect.	0	-	m
LINT	Length reduction parameter for dopant diffusion effect.	0	-	m
LL	Length reduction parameter for dopant diffusion effect.	0	-	$m^{(LLN + 1)}$
LLN	Length reduction parameter for dopant diffusion effect.	1	-	-
DLC	Length reduction parameter for C-V for dopant diffusion effect.	0	-	m
DLCACC	Length reduction parameter for C-V in accumulation region (BULKMOD = 1; CAPMOD = 1).	0	-	m
LLC	Length reduction parameter for C-V for dopant diffusion effect.	0	-	$m^{(LLN + 1)}$
DLBIN	Length reduction parameter for binning.	0	-	m

Parameter	Description	Default	Range	Unit
EOT	SiO_2 equivalent gate dielectric thickness including inversion layer thickness.	1 nm	> 0.1 nm	m
TOXP	Physical oxide thickness.	1.2 nm	> 0.1 nm	m
EOTBOX	SiO_2 equivalent buried oxide thickness including substrate depletion.	140 nm	> 1 nm	m
HFIN	Fin height.	30 nm	> 1 nm	m
FECH	End-channel factor for different orientaion/shape (mobility difference between the side channel and the top channel is handled by this parameter).	1	> 0	-
DELTAW	Reduction of effective width due to shape of fin.	0	-	m
FECHCV	C-V end-channel factor for different orientaion/shape.	1	> 0	-
DELTAWCV	C-V reduction of effective width due to shape of fin.	0	-	m
NBODY	Channel doping concentration.	1.00E+22	-	m^{-3}
NBODYN1	NFIN dependence of NBODY.	0	> -0.08	-
NBODYN2	NFIN dependence of NBODY.	1.00E+05	> 1.0e-5	-
NSD	Source/drain doping concentration.	2.00E+26	2.0e25 ~ 1.0e27	m^{-3}
PHIG	Gate workfunction	4.61E+00	> 0	eV
PHIGL	Length dependence of gate workfunction.	0	-	eV/m
PHIGLT	Coupled NFIN and length dependence of gate workfunction.	0	-	1/m
PHIGN1	NFIN dependence of PHIG.	0	> -0.08	-
PHIGN2	NFIN dependence of PHIG.	1.00E+05	> 1.0e-5	-
EPSROX	Relative dielectric constant of the gate insulator.	3.90	> 1	-
EPSRSUB	Relative dielectric constant of the channel material.	11.9	> 1	-

Parameter	Description	Default	Range	Unit
EASUB	Electron affinity of the substrate material.	4.05	> 0	eV
NI0SUB	Intrinsic carrier concentration of channel at 300.15 K.	1.10E+16	-	m^{-3}
BG0SUB	Band gap of the channel material at 300.15 K.	1.12	-	eV
NC0SUB	Conduction band density of states at 300.15 K.	2.86E+25	-	m^{-3}
NGATE	Parameter for poly gate doping. Set NGATE = 0 for metal gates.	0	-	m^{-3}
Imin	Parameter for voltage clamping for inversion region calculation in accumulation.	1.00E-15	-	A/m^2
CIT	Parameter for interface trap.	0.00E+00	-	F/m^2
CDSC	Coupling capacitance between S/D and channel.	0.007	> 0	F/m^2
CDSCN1	NFIN dependence of CDSC.	0	> -0.08	-
CDSCN2	NFIN dependence of CDSC.	1.00E+05	> 1.0e-5	-
CDSCD	Drain-bias sensitivity of CDSC CDSC	0.007	> 0	F/m^2
CDSCDN1	NFIN dependence of CDSCD.	0	> -0.08	-
CDSCDN2	NFIN dependence of CDSCD.	1.00E+05	> 1.0e-5	-
CDSCDR	Reverse-mode drain-bias sensitivity.	CDSCD	> 0	F/m^2
CDSCDRN1	NFIN dependence of CDSCDR.	CDSCDN1	> -0.08	-
CDSCDRN2	NFIN dependence of CDSCDR.	CDSCDN2	> 1.0e-5	-
DVT0	SCE coefficient.	0	> 0	-
DVT1	SCE exponent coefficient.	0.6	> 0	-
DVT1SS	Subthreshold swing exponent coefficient.	DVT1	> 0	-
PHIN	Nonuniform vertical doping effect on surface potential.	0.05	-	V

Parameter	Description	Default	Range	Unit
ETA0	DIBL coefficient.	0.6	> 0	-
ETA0LT	Coupled NFIN and length dependence of ETA0.	0	-	1/m
ETA0N1	NFIN dependence of ETA0.	0	> -0.08	-
ETA0N2	NFIN dependence of ETA0.	0	> 1.0e-5	-
DSUB	DIBL exponent coefficient.	1.06	> 0	-
DVTP0	Coefficient for drain-induced V_{th} shift (DITS).	0	-	-
DVTP1	DITS exponent coefficient.	0	-	-
K1RSCE	Prefactor for reverse short channel effect.	0	-	$V^{1/2}$
LPE0	Equivalent length of pocket region at zero bias.	5.00E-09	$> -L_{eff}$	m
K0	Lateral NUD parameter.	0	-	V
K0SI	Correction factor for strong inversion/ g_m.	1	> 0	-
K1SI	Correction factor for strong inversion, used in M_{ob}	K0SI	> 0	-
DVTSHIFT	Additional V_{th} shift handle.	0	-	V
PHIBE	Body-effect voltage parameter.	0.7	0.2 ~ 1.2	V
K1	Body effect coefficient for subthreshold region.	0	> 0	$V^{1/2}$
K1SAT	Body effect coefficient for saturation region.	0	> 0	$V^{-1/2}$
QMFACTOR	Prefactor for QM V_{th} shift correction.	0	-	-
QMTCENIV	Prefactor/switch for QM effective width correction for I-V.	0	-	-
QMTCENCV	Prefactor/switch for QM effective width and oxide thickness correction for C-V.	0	-	-
QMTCENCVA	Prefactor/switch for QM effective width and oxide thickness correction for accumulation region C-V.	0	-	-

Parameter	Description	Default	Range	Unit
ETAQM	Body charge coefficient for QM charge centroid.	0.54	-	-
QM0	Normalization parameter for QM charge centroid at inversion.	0.001	> 0	V
PQM	Fitting parameter for QM charge centroid at inversion.	0.66	-	-
QM0ACC	Normalization parameter for QM charge centroid at accumulation.	0.001	> 0	V
PQMACC	Fitting parameter for QM charge centroid at accumulation.	0.66	-	-
VSAT	Saturation velocity for the saturation region.	85000	-	m/s
VSATN1	NFIN dependence of VSAT.	0	> -0.08	-
VSATN2	NFIN dependence of VSAT.	1.00E+05	> 1.0e-5	-
VSAT1	Saturation velocity for the linear region in forward mode.	VSAT	-	m/s
VSAT1N1	NFIN dependence of VSAT1.	0	> -0.08	-
VSAT1N2	NFIN dependence of VSAT1.	1.00E+05	> 1.0e-5	-
VSAT1R	Saturation velocity for the linear region in reverse mode.	VSAT1	-	m/s
VSAT1RN1	NFIN dependence of VSAT1R.	VSAT1N1	> -0.08	-
VSAT1RN2	NFIN dependence of VSAT1R.	VSAT1N2	> 1.0e-5	-
DELTAVSAT	Velocity saturation parameter in the linear region.	1	> 0.01	-
PSAT	Exponent for field for velocity saturation.	2	> 2.0	-
KSATIV	Parameter for long channel V_{dsat}.	1	-	-
VSATCV	Saturation velocity for the capacitance model.	VSAT	-	m/s
DELTAVSATCV	Velocity saturation parameter in the linear region for the capacitance model.	DELTAVSAT	> 0.01	-

Parameter	Description	Default	Range	Unit
PSATCV	Exponent for field for velocity saturation for the capacitance model.	PSAT	> 2.0	-
MEXP	Smoothing function factor for V_{dsat}.	4	> 2.0	-
MEXPR	Reverse-mode smoothing function factor for V_{dsat}.	MEXP	> 2.0	-
PTWG	Correction factor for velocity saturation in forward mode.	0	-	V^{-2}
PTWGR	Correction factor for velocity saturation in reverse mode.	PTWG	-	V^{-2}
A1	Non-saturation effect parameter in strong inversion region.	0	-	V^{-2}
A2	Non-saturation effect parameter in moderate inversion region.	0	-	V^{-1}
U0	Low field mobility.	0.03	-	$m^2/V-s$
U0LT	Coupled NFIN NFIN and Length dependence of U0 U0.	0	-	1/m
U0N1	NFIN dependence of U0.	0	> -0.08	-
U0N2	NFIN dependence of U0.	1.00E+05	> 1.0e-5	-
CHARGEWF	Average channel charge weighting (sampling) factor. 1: source-side, 0: middle, -1: drain-side.	0	-1 ~ 1	-
ETAMOB	Effective field parameter.	2	-	-
UP	Mobility L coefficient.	0	-	μm^{LPA}
LPA	Mobility L power coefficient.	1	-	-
UA	Phonon/surface roughness scattering parameter.	0.3	> 0	cm/MV^{EU}
UC	Body effect coefficient of mobility for BULKMOD = 1.	0	-	$(1.0e-6 \times cm/MV^2)^{EU}$
EU	Phonon/surface roughness scattering parameter.	2.5	> 0	cm/MV
UD	Columbic scattering parameter.	0	> 0	cm/MV

Parameter	Description	Default	Range	Unit
UCS	Columbic scattering parameter.	1	> 0	-
PCLM	Channel length modulation (CLM) parameter.	0.013	> 0	-
PCLMG	Gate bias-dependent parameter for channel length modulation (CLM).	0	-	-
RDSWMIN	For RDSMOD = 0, S/D extension resistance per unit width at high V_{gs}.	0	> 0	$\Omega-\mu_m{}^{WR}$
RDSW	For RDSMOD = 0, zero bias S/D extension resistance per unit width.	100	> 0	$\Omega-\mu_m{}^{WR}$
RSWMIN	For RDSMOD = 1, source extension resistance per unit width at high V_{gs}.	0	> 0	$\Omega-\mu_m{}^{WR}$
RSW	For RDSMOD = 1, zero bias source extension resistance per unit width.	50	> 0	$\Omega-\mu_m{}^{WR}$
RDWMIN	For RDSMOD = 1, drain extension resistance per unit width at high V_{gs}.	0	> 0	$\Omega-\mu_m{}^{WR}$
RDW	For RDSMOD = 1, zero bias drain extension resistance per unit width.	50	> 0	$\Omega-\mu_m{}^{WR}$
RSDR	For RDSMOD = 1, source side drift resistance parameter in forward mode.	0	> 0	V^{-PRSDR}
RSDRR	For RDSMOD = 1, source side drift resistance parameter in reverse mode.	RSDR	> 0	V^{-PRSDR}
RDDR	For RDSMOD = 1, drain side drift resistance parameter in forward mode.	RSDR	> 0	V^{-PRSDR}
RSDRR	For RDSMOD = 1, drain side drift resistance parameter in reverse mode.	RDDR	> 0	V^{-PRSDR}
PRWGS	Source side quasi-saturation parameter.	0	> 0	1/V
PRWGD	Drain side quasi-saturation parameter	PRWGS	> 0	1/V
PRSDR	For RDSMOD = 1, drain side drift resistance parameter in forward mode.	1	> 0	-
PRDDR	For RDSMOD = 1, drain side drift resistance parameter in reverse mode.	PRSDR	> 0	-
WR	W dependence parameter of S/D extension resistance.	1	-	-

Parameter	Description	Default	Range	Unit
RGEXT	Effective gate electrode external resistance.	0	> 0	Ω
RGFIN	Effective gate electrode resistance per fin per finger.	0.001	> 0.001	Ω
RSHS	Source-side sheet resistance	0	> 0	Ω
RSHD	Drain-side sheet resistance.	RSHS	> 0	Ω
PDIBL1	Parameter for DIBL effect on Rout in forward mode.	1.3	> 0	-
PDIBL1R	Parameter for DIBL effect on Rout in reverse mode.	PDIBL1	> 0	-
PDIBL2	Parameter for DIBL effect on R_{out}.	0.0002	> 0	-
DROUT	L dependence of DIBL effect on R_{out}.	1.06	> 0	-
PVAG	V_{gs} dependence on early voltage.	1	-	-
TOXREF	Nominal gate oxide thickness for gate tunneling current.	1.2 nm	> 0	m
TOXG	Oxide thickness for gate current model.	TOXP	> 0	m
NTOX	Exponent for gate oxide ratio.	1	-	-
AIGBINV	Parameter for I_{gb} in inversion.	0.0111	-	$(F\text{-}s^2/g)^{0.5}$ x m^{-1}
BIGBINV	Parameter for I_{gb} in inversion.	0.000949	-	$(F-s^2/g)^{0.5} \times (m-V)^{-1}$
CIGBINV	Parameter for I_{gb} in inversion.	0.006	-	V^{-1}
EIGBINV	Parameter for I_{gb} in inversion.	1.1	-	V
NIGBINV	Parameter for I_{gb} in inversion.	3	> 0	-
AIGBACC	Parameter for I_{gb} in accumulation.	0.0136	-	$(F\text{-}s^2/g)^{0.5}$ x m^{-1}
BIGBACC	Parameter for I_{gb} in accumulation.	0.00171	-	$(F-s^2/g)^{0.5} \times (m-V)^{-1}$
CIGBACC	Parameter for I_{gb} in accumulation.	7.50E-02	-	V^{-1}

Parameter	Description	Default	Range	Unit
NIGBACC	Parameter for I_{gb} in accumulation.	1	> 0	-
AIGC	Parameter for I_{gc} in inversion.	1.36E-02	-	$(F\text{-}s^2/g)^{0.5}$ x m^{-1}
BIGC	Parameter for I_{gc} in inversion.	1.71E-03	-	$(F{-}s^2/g)^{0.5} \times (m{-}V)^{-1}$
CIGC	Parameter for I_{gc} in inversion.	7.50E-02	-	V^{-1}
PIGCD	V_{ds} dependence of I_{gcs} and I_{gcd}.	1	> 0	-
DLCIGS	Delta L for I_{gs} model.	0	-	m
AIGS	Parameter for I_{gs} in inversion.	1.36E-02	-	$(F\text{-}s^2/g)^{0.5}$ x m^{-1}
BIGS	Parameter for I_{gs} in inversion.	1.71E-03	-	$(F{-}s^2/g)^{0.5} \times (m{-}V)^{-1}$
CIGS	Parameter for I_{gs} in inversion.	7.50E-02	-	V^{-1}
DLCIGD	Delta L for I_{gd} model.	DLCIGS	-	m
AIGD	Parameter for I_{gd} in inversion.	AIGS	-	$(F\text{-}s^2/g)^{0.5}$ x m^{-1}
BIGD	Parameter for I_{gd} in inversion.	BIGS	-	$(F{-}s^2/g)^{0.5} \times (m{-}V)^{-1}$
CIGD	Parameter for I_{gd} in inversion.	CIGS	-	V^{-1}
VFBSD	Flatband voltage for S/D region	0	-	V
VFBSDCV	Flat band voltage for S/D region for C-V calculations.	VFBSD	-	V
POXEDGE	Factor for the gate edge T_{ox}.	1	> 0	-
AGIDL	Pre-exponetial coefficient for GIDL.	6.06E-12	-	Ω^{-1}
BGIDL	Exponential coefficient for GIDL.	3.00E+08	-	V/m
CGIDL	Parameter for body bias effect of GIDL.	0.2	-	V^3
EGIDL	Band bending parameter for GIDL.	1.2	-	V
PGIDL	Exponent of electric field for GIDL.	1	-	-

Parameter	Description	Default	Range	Unit
AGISL	Pre-exponetial coefficient for GISL.	AIGDL	-	Ω^{-1}
BGISL	Exponential coefficient for GISL.	BGIDL	-	V/m
CGISL	Parameter for body bias effect of GISL.	0.2	-	V^3
EGISL	Band bending parameter for GISL.	EGIDL		V
PGISL	Exponent of electric field for GISL.	1	-	-
ALPHA0	First parameter of I_{ii} for IIMOD = 1.	0	-	V^{-1}
ALPHA1	L scaling parameter of I_{ii} for IIMOD = 1.	0	-	V^{-1}
ALPHAII0	First parameter of I_{ii} for IIMOD = 2.	0	-	V^{-1}
ALPHAII1	First parameter of I_{ii} for IIMOD = 2.	0	-	V^{-1}
BETA0	V_{ds} -dependent paramter of I_{ii} for IIMOD = 1.	0	-	V^{-1}
BETAII0	V_{ds} -dependent paramter of I_{ii} for IIMOD = 1.	0	-	V^{-1}
BETAII1	V_{ds} -dependent paramter of I_{ii} for IIMOD = 2.	0	-	V^{-1}
BETAII2	V_{ds} -dependent paramter of I_{ii} for IIMOD = 2.	0	-	-
ESATII	Saturation channel E-field for I_{ii} for IIMOD IIMOD = 2.	1.00E+07	-	V/m
LII	Channel length dependent parameter of I_{ii} for IIMOD = 2.	5.00E-10	-	V - m
SII0	V_{gs} -dependent paramter of I_{ii} for IIMOD = 2.	0.5	-	V^{-1}
SII1	V_{gs} -dependent paramter of I_{ii} for IIMOD = 2.	0.1	-	-
SII2	V_{gs} -dependent paramter of I_{ii} for IIMOD = 2.	0	-	V
SIID	V_{gs} -dependent paramter of I_{ii} for IIMOD = 2.	0	-	V

Parameter	Description	Default	Range	Unit
EOTACC	SiO^2 equivalent gate dielectric thickness for accumulation region.	EOT	> 0.1 nm	m
DELVFBACC	Additional V_{fb} shift required for accumulation region.	0	-	V
PCLMCV	Channel length modulation (CLM) parameter for the capacitance model.	0.013	> 0	-
CFS	Source-side outer fringe capacitance for CGEOMOD = 0.	2.50E-11	> 0	F/m
CFD	Drain-side outer fringe capacitance for CGEOMOD = 0.	CFS	> 0	F/m
CGSO	Non-LDD region source-gate overlap capacitance per unit channel width for CGEOMOD = 0 or 2.	Calculated	> 0	F/m
CGDO	Non-LDD region drain-gate overlap capacitance per unit channel width for CGEOMOD = 0 or 2.	Calculated	> 0	F/m
CGSL	Overlap capacitance between gate and lightly-doped source region for CGEOMOD = 0 or 2.	CGSL	> 0	F/m
CGDL	Overlap capacitance between gate and lightly-doped drain region for CGEOMOD = 0 or 2.	-	-	F/m
CKAPPAS	Coefficient of bias-dependent overlap capacitance for the source side for CGEOMOD = 0 or 2.	0.6	> 0.02	V
CKAPPAD	Coefficient of bias-dependent overlap capacitance for the drain side for CGEOMOD = 0 or 2.	CKAPPAS	> 0.02	V
CGBO	Gate-substrate overlap capacitance per unit channel length per finger per gate contact.	0	> 0	F/m
CGBN	Gate-substrate overlap capacitance per unit channel length per finger per fin.	0	> 0	F/m
CSDESW	Source/drain sidewall fringing capacitance per unit length.	0	> 0	F/m
CJS	Unit area source-side junction capacitance at zero bias.	0.0005	> 0	F/m^2

Parameter	Description	Default	Range	Unit
CJD	Unit area drain-side junction capacitance at zero bias.	CJS	> 0	F/m^2
CJSWS	Unit length sidewall junction capacitance at zero bias on the source side.	5.00E-10	> 0	F/m
CJSWD	Unit length sidewall junction capacitance at zero bias on the drain side.	CJSWS	> 0	F/m
CJSWGS	Unit length gate sidewall junction capacitance at zero bias on the source side.	0	> 0	F/m
CJSWGD	Unit length gate sidewall junction capacitance at zero bias on the drain side.	CJSWGS	> 0	F/m
PBS	Bottom junction built-in potential on the source side.	1	> 0.01	V
PBD	Bottom junction built-in potential on the drain side.	PBS	> 0.01	V
PBSWS	Isolation-edge sidewall junction built-in potential on the source side.	1	> 0.01	V
PBSWD	Isolation-edge sidewall junction built-in potential on the drain side.	PBSWS	> 0.01	V
PBSWGS	Gate-edge sidewall junction built-in potential on the source side.	PBSWS	> 0.01	V
PBSWGD	Gate-edge sidewall junction built-in potential on the drain side.	PBSWGS	> 0.01	V
MJS	Source bottom junction capacitance grading coefficient.	0.5	-	-
MJD	Drain bottom junction capacitance grading coefficient.	MJS	-	-
MJSWS	Isolation-edge sidewall junction capacitance grading coefficient on the source side.	0.33	-	-
MJSWD	Isolation-edge sidewall junction capacitance grading coefficient on the drain side.	MJSWS	-	-

Parameter	Description	Default	Range	Unit
MJSWGS	Gate-edge sidewall junction capacitance grading coefficient on the source side.	MJSWS	-	-
MJSWGD	Gate-edge sidewall junction capacitance grading coefficient on the drain side.	MJSWGS	-	-
SJS	Constant for source-side two-step second junction capacitance.	0	> 0	-
SJD	Constant for drain-side two-step second junction capacitance.	SJS	> 0	-
SJSWS	Constant for sidewall two-step second junction capacitance on the source side.	0	> 0	-
SJSWD	Constant for sidewall two-step second junction capacitance on the drain side.	SJSWS	> 0	-
SJSWGS	Constant for gate sidewall two-step second junction capacitance on the source side.	0	> 0	
SJSWGD	Constant for gate sidewall two-step second junction capacitance on the drain side.	SJSWGS	> 0	-
MJS2	Source bottom two-step second junction capacitance grading coefficient.	0.125	-	-
MJD2	Drain bottom two-step second junction capacitance grading coefficient.	MJS2	-	-
MJSWS2	Isolation-edge sidewall two-step second junction capacitance grading coefficient on the source side.	0.083	-	-
MJSWD2	Isolation-edge sidewall two-step second junction capacitance grading coefficient on the drain side.	MJSWS2	-	-
MJSWGS2	Gate-edge sidewall two-step second junction capacitance grading coefficient on the source side.	MJSWS2		
MJSWGD2	Gate-edge sidewall two-step second junction capacitance grading coefficient on the drain side.	MJSWGS2		
JSS	Bottom source junction reverse saturation current density.	1.00E-04	> 0	A/m^2

Parameter	Description	Default	Range	Unit
JSD	Bottom drain junction reverse saturation current density.	JSS	> 0	A/m^2
JSWS	Unit length reverse saturation current for isolation-edge source sidewall junction.	0	> 0	A/m
JSWD	Unit length reverse saturation current for isolation-edge drain sidewall junction.	JSWS	> 0	A/m
JSWGS	Unit length reverse saturation current for gate-edge source sidewall junction.	0	> 0	A/m
JSWGD	Unit length reverse saturation current for gate-edge drain sidewall junction.	JSWGS	> 0	A/m
JTSS	Bottom source junction trap-assisted saturation current density.	0	> 0	A/m^2
JTSD	Bottom drain junction trap-assisted saturation current density.	JTSS	> 0	A/m^2
JTSSWS	Unit length trap-assisted saturation current for isolation-edge source sidewall junction.	0	> 0	A/m
JTSSWD	Unit length trap-assisted saturation current for isolation-edge drain sidewall junction.	JTSSWS	> 0	A/m
JTSSWGS	Unit length trap-assisted saturation current for gate-edge source sidewall junction.	0	> 0	A/m
JTSSWGD	Unit length trap-assisted saturation current for gate-edge drain sidewall junction.	JTSSWGS	> 0	A/m
JTWEFF	Trap-assisted tunneling current width dependence.	0	> 0	m
NJS	Source junction emission coefficient.	1	> 0	
NJD	Drain junction emission coefficient.	NJS	> 0	
NJTS	Non-ideality factor for JTSS.	20	> 0	
NJTSD	Non-ideality factor for JTSD	NJTS	> 0	
NJTSSW	Non-ideality factor for JTSSWS.	20	> 0	

Parameter	Description	Default	Range	Unit
NJTSSWD	Non-ideality factor for JTSSWD.	NJTSSW	> 0	
NJTSSWG	Non-ideality factor for JTSSWGS.	20	> 0	
NJTSSWGD	Non-ideality factor for JTSSWGD.	NJTSSWG	> 0	
VTSS	Bottom source junction trap-assisted current voltage dependent parameter.	10	> 0	V
VTSD	Bottom drain junction trap-assisted current voltage dependent parameter.	VTSS	> 0	V
VTSSWS	Unit length trap-assisted current voltage dependent parameter for sidewall source junction.	10	> 0	V
VTSSWD	Unit length trap-assisted current voltage dependent parameter for sidewall drain junction.	VTSSWS	> 0	V
VTSSWGS	Unit length trap-assisted current voltage dependent parameter for gate-edge sidewall source junction.	10	> 0	V
VTSSWGD	Unit length trap-assisted current voltage dependent parameter for gate-edge sidewall drain junction.	VTSSWGS	> 0	V
IJTHSFWD	Forward source diode breakdown limiting current.	0.1	$>10 \cdot I_{sbs}$	A
IJTHDFWD	Forward drain diode breakdown limiting current.	IJTHSFWD	$>10 \cdot I_{sbd}$	A
IJTHSREV	Reverse source diode breakdown limiting current.	0.1	$>10 \cdot I_{sbs}$	A
IJTHDREV	Reverse drain diode breakdown limiting current.	IJTHSREV	$>10 \cdot I_{sbd}$	A
BVS	Source diode breakdown voltage.	10	-	V
BVD	Drain diode breakdown voltage.	BVS	-	V
XJBVS	Fitting parameter for source diode breakdown current.	1	-	-
XJBVD	Fitting parameter for source diode breakdown current.	XJBVS	-	-
LINTIGEN	L_{int} offset for recombination/generation current.	0	$< L_{eff} / 2$	m

Parameter	Description	Default	Range	Unit
NTGEN	Parameter for recombination/ generation current.	1	> 0	-
AIGEN	Parameter for recombination/ generation current.	0	-	$(m\text{-}V)^{-3}$
BIGEN	Parameter for recombination/ generation current.	0	-	$(m\text{-}V)^{-3}$
XRCRG1	Parameter for non-quasi-static gate resistance for NQSMOD = 1 or 2.	12	0 or > 0.001	-
XRCRG2	Parameter for non-quasi-static gate resistance for NQSMOD = 1 or 2.	1	-	-
NSEG	Number of channel segments for NQSMOD = 3.	5	4 ~ 10	-
EF	Flicker noise frequency exponent.	1	0 ~ 2	-
LINTNOI	Lint offset for icker noise calculation.	0	$< L_{eff}/2$	m
EM	Flicker noise parameter.	4.10E+07	-	V/m
NOIA	Flicker noise parameter.	6.25E+39	-	$eV^{-1} \cdot s^{1-EF} \cdot m^{-3}$
NOIB	Flicker noise parameter.	3.13E+24	-	$eV^{-1} \cdot s^{1-EF} \cdot m^{-3}$
NOIC	Flicker noise parameter.	8.75E+07	-	$eV^{-1} \cdot s^{1-EF} \cdot m^{-3}$
NTNOI	Thermal noise parameter.	1	> 0	-
RNOIA	Thermal noise parameter.	0.577	-	-
RNOIB	Thermal noise parameter.	0.37	-	-
TNOIA	Thermal noise parameter.	1.5	> 0	m^{-1}
TNOIB	Thermal noise parameter.	3.5	> 0	m^{-1}
NVTM	If provided, NVTM will override nkT/q calculated in the model.	nkT/q	-	V
THETASCE	If provided, THETASCE will override Θ_{SCE} calculated in the model.	Θ_{SCE}	-	-
THETASW	If provided, THETASCE will override Θ_{Sw} calculated in the model.	Θ_{Sw}	-	-

Parameter	Description	Default	Range	Unit
THETADIBL	If provided, THETASCE will override Θ_{DIBL} calculated in the model.	Θ_{DIBL}	-	-
TFIN_BASE	Base fin thickness for trapezoidal triple gate.	15 nm	> 1 nm	m
TFIN_TOP	Top fin thickness for trapezoidal triple gate.	15 nm	-	m
ACH_UFCM	Area of the channel for the unified model.	1	-	m^2
CINS_UFCM	Insulator capacitance for the unified model.	1	-	F
W_UFCM	Effective channel width for the unified model.	1	-	m
ALPHA_UFCM	Mobile charge scaling term taking QM effects into account.	1/1.8	-	-

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName bsimcmg [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *bsimcmg*. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables, and equations, refer to ADS Simulator Input Syntax.

```
model Nch7 bsimcmg \
TYPE=1
```

Instance Parameters

Parameter	Description	Default	Range	Unit
L	Designed gate length.	30 nm	> 1 nm	m
D	Diameter of cylinder for GEOMOD = 3.	40 nm	> 1 nm	m
TFIN	Fin thickness.	15 nm	> 1 nm	m
FPITCH	Fin pitch.	80 nm	> TFIN TFIN	m
NF	Number of fingers.	1	> 1	-
NFIN	Number of fins per finger.	1	> 0	-
NFINNOM	Nominal number of fins per finger.	1	> 0	-
NGCON	Number of gate contacts.	1	1 or 2	-
ASEO	Source-to-substrate overlap area through oxide for all fingers.	0	> 0	m^2
ADEO	Drain-to-substrate overlap area through oxide for all fingers.	0	> 0	m^2
PSEO	Perimeter of source-to-substrate overlap region through oxide for all fingers.	0	> 0	m
PDEO	Perimeter of drain-to-substrate overlap region through oxide for all fingers.	0	> 0	m
ASEJ	Source junction area for all fingers; for bulk MuGFETs, BULKMOD = 1.	0	> 0	m^2
ADEJ	Drain junction area for all fingers; for bulk MuGFETs, BULKMOD = 1.	0	> 0	m^2
PSEJ	Source junction perimeter for all fingers; for bulk MuGFETs, BULKMOD = 1.	0	> 0	m
PDEJ	Drain junction perimeter for all fingers; for bulk MuGFETs, BULKMOD = 1.	0	> 0	m
COVS	Constant gate-to-source overlap capacitance for CGEOMOD = 1.	0	> 0	F/m
COVD	Constant gate-to-drain overlap capacitance for CGEOMOD = 1.	COVS	> 0	F/m
CGSP	Constant gate-to-source fringe capacitance for CGEOMOD = 1.	0	> 0	F/m

Parameter	Description	Default	Range	Unit
CGDP	Constant gate-to-drain fringe capacitance for CGEOMOD = 1	0	> 0	F/m
CDSP	Constant drain-to-source fringe capacitance.	0	> 0	F
NRS	Number of source diffusion squares for RGEOMOD = 0.	0	> 0	-
NRD	Number of drain diffusion squares for RGEOMOD = 0.	0	> 0	-
LRSD	Length of the source/drain.	L	> 0	m

Instance Netlist Format

> *modelName [:Name] d g s b*

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example

> *Nch7:M1 2 1 0 0 W=10u L=0.9u*

BSIMIMG 102 Model

BSIMIMG 102 Model

The following topic lists the BSIMIMG 102 model and instance parameters. Following are the supported models:

- BSIMIMG 102.6
- BSIMIMG 102.7
- BSIMIMG 102.8
- BSIMIMG 102.9.1
- BSIMIMG 102.9.2

Model Parameters

Name	Default	Units	Description
L	3.00E-08	[1e-9 : inf)	Designed Gate Length
W	1.00E-06	[1e-9 : inf)	Designed Gate Width
NF	1	[1 : inf)	Number of fingers
AS	0	[0:inf)	Source area
AD	0	[0:inf)	Drain area
PS	0	[0:inf)	Source perimeter
PD	0	[0:inf)	Drain perimeter
NRS	0	[0:inf)	Number of source diffusion squares
NRD	0	[0:inf)	Number of drain diffusion squares
XL	0		L offset for channel length due to mask/etch effect
DTEMP	0		Variability in Device Temperature

Name	Default	Units	Description	
DELVTRAND	0		Variability in Vth	
U0MULT	1	(0:inf)	Variability in carrier mobility	
TYPE	1	[-1: 1] exclude 0	NMOS=1	PMOS=-1
WELLTYPE	-TYPE	[-1: 1] exclude 0	Well (substrate) type	
CHARGEMOD	0	[0 : 1]	0: Computationally efficient charge density model	1: Accurate inversion charge density model
RDSMOD	0	[0 : 2]	0: Internal s/d resistance model	1: External s/d resistance model
GIDLMOD	0	[0 : 1]	0: Turn off GIDL/GISL current	1: Turn on GIDL/GISL current
IGCMOD	0	[0 : 1]	0: Turn off Igc	Igs and Igd
IGBMOD	0	[0 : 1]	0: Turn off Igb	
SHMOD	0	[0 : 1]	0: No self-heating	
RGATEMOD	0	[0 : 1]	Gate resistance model selector	
NFMOD	0	[0 : 1]	0: W taken as total width like BSIM4	1: W taken as single finger width
XW	0		W offset for channel width due to mask/etch effect	
LINT	0		delta L for IV	
LL	0			
LW	0			
LWL	0			

Name	Default	Units	Description
LLN	1		
LWN	1		
WINT	0		delta W for IV
WL	0		
WW	0		
WWL	0		
WLN	1		
WWN	1		
DLC	0		delta L for CV
LLC	0		
LWC	0		
LWLC	0		
DWC	0		delta W for CV
WLC	0		
WWC	0		
WWLC	0		
EOT1	1.00E-09	[0.1e-9 : inf)	Equivalent front gate dielectric thickness relative to SiO2
EOT2	1.00E-08	[0.1e-9 : inf)	Equivalent back gate dielectric thickness relative to SiO2

Name	Default	Units	Description	
EOT1P	EOT1	[0.1e-9 : inf)	Equivalent physical front gate dielectric thickness relative to SiO2	
DTOX1	0		Difference between effective dielectric thickness and physical thickness	
TSI	8.00E-09	[1e-9 : inf)	Body thickness	
NBODY	1.00E+22	[1e18 : 5e24]	channel (body) doping	
NSD	2.00E+26	[2e25 : 1e27]	Source/drain active doping concentration	
NBG	5.00E+23		Well/substrate (or also called back-gate) doping	zero for metal
EASUB	4.05	[0:inf)	Electron affinity of well/substrate	
NI0SUB	1.10E+16	(0:inf)	Intrinsic carrier constant at 300.15K	
BG0SUB	1.12		Band gap of well/substrate at 300.15K	
NC0SUB	2.86E+25	(0:inf)	Conduction band density of states	
PHIG1	4.61		Front Gate Workfunction	
PHIG2	((WELLTYPE== -1)?(EASUB+BG0SUB):EASUB)		Back gate workfunction	will be modified according to NBG later in the code
EPSRSUB	11.9		Relative dielectric constant of the channel material	
EPSROX1	3.9		Relative dielectric constant of the front gate dielectric	
ASCL	0		Parameter for back-gate dependent scale length	
BSCL	0		Parameter for back-gate dependent scale length	

Name	Default	Units	Description
CIT	0		parameter for interface trap
CDSC	0.14		coupling capacitance between S/D and channel
CDSCD	0.14		drain-bias sensitivity of CDSC
CBGCBG0	0		backgate-bias sensitivity of SS for long channel
CBGCBG0P	0		backgate-bias sensitivity of SS for long channel
CBGCBG	0		backgate-bias sensitivity of CDSC
CBGCBGP	0		Nonlinear backgate-bias sensitivity of SS
CBGCBGD	0		backgate-bias sensitivity of CDSCD
DVT0	19.2		SCE coefficient
DVT1	0.45		SCE exponent coefficient
PHIN	0.045		Nonuniform vertical doping effect on surface potential
ETA0	2		DIBL coefficient 1
DSUB	0.375		DIBL coefficient 2 (exponent coefficient)
ETAB	0		DIBL coefficient - Back Gate dependence
K1RSCE	-0.32		Vt Roll-off at moderate Lg
LPE0	8.20E-09		Equivalent length of pocket region at zero bias
DSC0	0		Parameter for short channel effect at moderate L and high drain bias

Name	Default	Units	Description	
DSC1	1.00E-09		Parameter for short channel effect at moderate L and high drain bias	
K0	0		Lateral NUD voltage parameter	
K01	0		Temperature dependence of lateral NUD voltage parameter	
K0SI	1		Correction factor for strong inversion	used in Mnud
K0SI1	0		Temperature dependence of K0SI	
QMTCENCV	0		Prefactor + switch for QM Width and Toxeff correction for CV	
ETAQM	0.54		Bulk charge coefficient for Tcen	
QM0	1.00E-03		Knee-Point for Tcen in inversion (Charge normalized to Cox)	
PQM	0.66		Slope of normalized Tcen in inversion	
TOXP	EOT1	[0.1e-9 : inf)	physical oxide thickness	
VSAT	85000		Saturation Velocity	
AVSAT	0			
BVSAT	1.00E-07	exclude 0.0		
VSAT1	VSAT		Velocity Saturation parameter	
AVSAT1	AVSAT			
BVSAT1	BVSAT	exclude 0.0		
VSATCV	VSAT		Velocity Saturation parameter for CV	

Name	Default	Units	Description
AVSATCV	AVSAT		
BVSATCV	BVSAT	exclude 0.0	
DELTAVSAT	1		Velocity saturation parameter
KSATIV	1		Parameter for strong inversion regime for long channel Vdsat
KSUBIV	1		Parameter for weak inversion regime for long channel Vdsat
MEXP	4		Smoothing function factor for Vdsat
AMEXP	0		
BMEXP	1		
PTWG	0		Correction factor for velocity saturation
APTWG	0		
BPTWG	1.00E-07	exclude 0.0	
AT	-1.56E-03		Saturation Velocity Temperature Coefficient
ATL	0		Length scaling for AT
TMEXP	0		
PTWGT	0.004		
PTWGB	0		
PTWGB2	0		
APTWGB	0		

Name	Default	Units	Description
BPTWGB	1.00E-07	exclude 0.0	
APTWGB 2	0		
BPTWGB 2	1.00E-07	exclude 0.0	
VSATB	0		
ATB	0		Back bias sensitivity parameter for saturation velocity temperature coefficient
ATBL	0		Length scaling for ATB
AVSATB	0		
BVSATB	1.00E-07	exclude 0.0	
DVSATCL AMP	0.01	[0.01 : inf)	Minimum clamp on Dvsat
U0	0.03	exclude 0.0	Low Field Mobility
ETAMOB	2		
UP	0		
LPA	1		
UA	0.3		
AUA	0		
BUA	1.00E-07	exclude 0.0	
EU	2.5		

Name	Default	Units	Description	
AEU	0			
BEU	1.00E-07	exclude 0.0		
UC	0			
AUC	0			
BUC	1.00E-07	exclude 0.0		
UD	0			
AUD	0			
BUD	5.00E-08	exclude 0.0		
UDB	0			
AUDB	0			
BUDB	5.00E-08	exclude 0.0		
DMOBCLAMP	0.01	[0.01 : inf)	Minimum clamp on Dmob	
UCS	1			
UTE	0			
UTL	-1.50E-03			
UA1	1.03E-03			
UC1	0			

Name	Default	Units	Description	
UD1	0			
UCSTE	-4.78E-03			
CHARGE WF	0	[-1 : 1]	Average Channel Charge Weighting Factor	+1:source-side
RDSWMIN	0		RDSMOD = 0 S/D extension resistance per unit width at high Vgs	
RDSW	100		RDSMOD = 0 zero bias S/D extension resistance per unit width	
ARDSW	0			
BRDSW	1.00E-07	exclude 0.0		
RSWMIN	0		RDSMOD = 1 source extension resistance per unit width at high Vgs	
RSW	50		RDSMOD = 1 zero bias source extension resistance per unit width	
ARSW	0		pre-exponential coefficient for RSW	
BRSW	1.00E-07	exclude 0.0	exponential coefficient for RSW	
RDWMIN	RSWMIN		RDSMOD = 1 drain extension resistance per unit width at high Vgs	
RDW	50		RDSMOD = 1 zero bias drain extension resistance per unit width	
ARDW	0			
BRDW	1.00E-07	exclude 0.0		
PRWG	0		Gate bias dependence of source/drain extension resistance	
PRWB	0			

Name	Default	Units	Description
WR	1		W dependence parameter of S/D extension resistance
PRT	0.001		Series Resistance Temperature coefficient
PDIBL1	1.3		DIBL Output Conductance parameter
PDIBL2	2.00E-04		DIBL Output Conductance parameter
DROUT	1.06		L dependence of DIBL effect on Rout
PVAG	1		Vgs dependence on early voltage
PCLM	0.013		Channel Length Modulation (CLM) parameter
APCLM	0		
BPCLM	1.00E-07	exclude 0.0	
PCLMG	0		Gate bias dependent parameter for channel Length Modulation (CLM)
PCLMCV	0.013		Channel Length Modulation (CLM) parameter for C-V
RSHS	0		Source-side sheet resistance
RSHD	RSHS		Drain-side sheet resistance
AIGBINV	1.11E-02		parameter for Igb in inversion
BIGBINV	9.49E-04		parameter for Igb in inversion
CIGBINV	6.00E-03		parameter for Igb in inversion
EIGBINV	1.1		parameter for Igb in inversion
NIGBINV	3		parameter for Igb in inversion

Name	Default	Units	Description	
AIGBACC	1.36E-02		parameter for Igb in accumulation	
BIGBACC	1.71E-03		parameter for Igb in accumulation	
CIGBACC	7.50E-02		parameter for Igb in accumulation	
NIGBACC	1		parameter for Igb in accumulation	
AIGC	1.36E-02		parameter for Igc in inversion	
BIGC	1.71E-03		parameter for Igc in inversion	
CIGC	0.075		parameter for Igc in inversion	
PIGCD	1		parameter for Igc partition	
AIGS	1.36E-02		parameter for Igs	Igd
BIGS	1.71E-03		parameter for Igs	Igd
CIGS	0.075		parameter for Igs	Igd
DLCIGS	0		Delta L for Igs model	
DLCIGD	DLCIGS		Delta L for Igd model	
AIGD	AIGS		parameter for Igd in inversion	
BIGD	BIGS		parameter for Igd in inversion	
CIGD	CIGS		parameter for Igs	Igd
TOXREF	1.20E-09	(0:inf)	Target tox value	
NTOX	1		Exponent for Tox ratio	
POXEDGE	1		Factor for the gate edge Tox	

Name	Default	Units	Description
AGISL	6.06E-12		pre-exponential coeff. for GISL
BGISL	3.00E+08		exponential coeff. for GISL
EGISL	0.2		band bending parameter for GISL
PGISL	1		parameter for body-bias effect on GISL
AGIDL	AGISL		pre-exponential coeff. for GIDL
BGIDL	BGISL		exponential coeff. for GIDL
EGIDL	EGISL		band bending parameter for GIDL
PGIDL	PGISL		parameter for body-bias effect on GIDL
ALPHA0	0		first parameter of Iii
ALPHA1	0		L scaling parameter of Iii
BETA0	0		Vds dependent parameter of Iii
LOVS	0		Overlap length for fg/s fg/d overlap
LOVD	LOVS		Overlap length for fg/s fg/d overlap
CFS	0		Outer Fringe Cap
CFD	CFS		Outer Fringe Cap
CGSL	0	[0:inf)	Overlap capacitance between gate and lightly-doped source region
CGDL	CGSL	[0:inf)	Overlap capacitance between gate and lightly-doped drain region
CKAPPAS	0.6	[0.02 : inf)	Coefficient of bias-dependent overlap capacitance for the source side

Name	Default	Units	Description	
CKAPPAD	CKAPPAS	[0.02 : inf)	Coefficient of bias-dependent overlap capacitance for the drain side	
CSDBGSW	0		Source/drain sidewall fringing capacitance per unit length	
KBG0PW	1		Length dependence of substrate factor	
KBG1PW	0		Length dependence of substrate factor	
KBG2PW	-1		Length dependence of substrate factor	
DBGPW	0.12		Length dependence of substrate factor	
BPFACTORPW	0		Back-plane (BP) effect	1 means no BP
VKNEE1PW	0		Back gate voltage at which the substrate depletion below the BOX starts	
VKNEE2PW	1	[0.0 : inf)	Maximum potential drop below the BOX	
KBG0NW	KBG0PW		Length dependence of body factor	
KBG1NW	KBG1PW		Length dependence of body factor	
KBG2NW	KBG2PW		Length dependence of body factor	
DBGNW	DBGPW		Length dependence of body factor	
BPFACTORNW	BPFACTORPW		Back-plane (BP) effect	1 means no BP
VKNEE1NW	VKNEE1PW		Back gate voltage at which the substrate depletion below the BOX starts	
VKNEE2NW	VKNEE2PW	[0.0 : inf)	Maximum potential drop below the BOX	

Name	Default	Units	Description
EF	1	(0.0 : 2.0]	Flicker noise frequency exponent
EM	4.10E+07		Flicker noise parameter
NOIA	6.25E+39		Flicker noise parameter
NOIB	3.13E+24		Flicker noise parameter
NOIC	8.75E+07		Flicker noise parameter
NTNOI	1	[0:inf)	Thermal noise parameter
LINTNOI	0		Lint offset for flicker noise calculation
TNOM	27	[-273.15 : inf)	Temperature at which the model is extracted
TBGASUB	7.02E-04		Bandgap Temperature Coefficient
TBGBSUB	1108		Bandgap Temperature Coefficient
KT1	0		Vth Temperature Coefficient
KT1L	0		Vth Temperature L Coefficient
KT2	0		Vth Temperature Vbg Coefficient
KT2L	0		Vbg Temperature L Coefficient
IIT	-0.5		Impact Ionization Temperature Dependence
TGIDL	-0.003		GIDL Temperature Dependence
TGISL	-0.003		GISL Temperature Dependence
IGT	2.5		Gate Current Temperature Dependence

Name	Default	Units	Description
TETA0	0		Temperature Dependence for DIBL effects
RTH0	0.01		Thermal resistance
CTH0	1.00E-05		Thermal capacitance
WTH0	0		Width dependence coefficient for Rth and Cth
XGW	0		Dist from gate contact center to dev edge
XGL	0	(-inf : L+XL)	Variation in Ldrawn
NGCON	1	[1 : 2]	Number of gate contacts
RSHG	0.1	[0:inf)	Gate sheet resistance
LRDSW	0		
WRDSW	0		
PRDSW	0		
LRDW	0		
WRDW	0		
PRDW	0		
LRSW	0		
WRSW	0		
PRSW	0		
LPRWG	0		
WPRWG	0		

Name	Default	Units	Description
PPRWG	0		
LPRWB	0		
WPRWB	0		
PPRWB	0		
LWR	0		
WWR	0		
PWR	0		
LPHIG1	0		
WPHIG1	0		
PPHIG1	0		
LPHIG2	0		
WPHIG2	0		
PPHIG2	0		
LNSD	0		
WNSD	0		
PNSD	0		
LNBODY	0		
WNBODY	0		
PNBODY	0		

Name	Default	Units	Description	
LCIT	0			
WCIT	0			
PCIT	0			
LCDSC	0			
WCDSC	0			
PCDSC	0			
LCDSCD	0			
WCDSCD	0			
PCDSCD	0			
LCBGCBG	0			
WCBGCBG	0			
PCBGCBG	0			
LDVT0	0			
WDVT0	0			
PDVT0	0			
LDVT1	0			
WDVT1	0			
PDVT1	0			

Name	Default	Units	Description	
LPHIN	0			
WPHIN	0			
PPHIN	0			
LETA0	0			
WETA0	0			
PETA0	0			
LETAB	0			
WETAB	0			
PETAB	0			
LDSUB	0			
WDSUB	0			
PDSUB	0			
LK1RSCE	0			
WK1RSCE	0			
PK1RSCE	0			
LLPE0	0			
WLPE0	0			
PLPE0	0			
LK0	0			

Name	Default	Units	Description	
WK0	0			
PK0	0			
LK01	0			
WK01	0			
PK01	0			
LK0SI	0			
WK0SI	0			
PK0SI	0			
LK0SI1	0			
WK0SI1	0			
PK0SI1	0			
LMEXP	0			
WMEXP	0			
PMEXP	0			
LPTWG	0			
WPTWG	0			
PPTWG	0			
LPTWGB	0			
WPTWGB	0			

Name	Default	Units	Description	
PPTWGB	0			
LPTWGB2	0			
WPTWGB2	0			
PPTWGB2	0			
LPTWGT	0			
WPTWGT	0			
PPTWGT	0			
LU0	0			
WU0	0			
PU0	0			
LUA	0			
WUA	0			
PUA	0			
LUC	0			
WUC	0			
PUC	0			
LUD	0			
WUD	0			

Name	Default	Units	Description	
PUD	0			
LUCS	0			
WUCS	0			
PUCS	0			
LEU	0			
WEU	0			
PEU	0			
LUTL	0			
WUTL	0			
PUTL	0			
LUTE	0			
WUTE	0			
PUTE	0			
LUA1	0			
WUA1	0			
PUA1	0			
LUD1	0			
WUD1	0			
PUD1	0			

Name	Default	Units	Description	
LUCSTE	0			
WUCSTE	0			
PUCSTE	0			
LAT	0			
WAT	0			
PAT	0			
LATB	0			
WATB	0			
PATB	0			
LPRT	0			
WPRT	0			
PPRT	0			
LIIT	0			
WIIT	0			
PIIT	0			
LTGIDL	0			
WTGIDL	0			
PTGIDL	0			
LTGISL	0			

Name	Default	Units	Description	
WTGISL	0			
PTGISL	0			
LIGT	0			
WIGT	0			
PIGT	0			
LPCLM	0			
WPCLM	0			
PPCLM	0			
LPCLMCV	0			
WPCLMCV	0			
PPCLMCV	0			
LDROUT	0			
WDROUT	0			
PDROUT	0			
LPDIBL1	0			
WPDIBL1	0			
PPDIBL1	0			
LPDIBL2	0			

Name	Default	Units	Description	
WPDIBL2	0			
PPDIBL2	0			
LPVAG	0			
WPVAG	0			
PPVAG	0			
LALPHA0	0			
WALPHA0	0			
PALPHA0	0			
LALPHA1	0			
WALPHA1	0			
PALPHA1	0			
LBETA0	0			
WBETA0	0			
PBETA0	0			
LAIGC	0			
WAIGC	0			
PAIGC	0			
LBIGC	0			

Name	Default	Units	Description	
WBIGC	0			
PBIGC	0			
LCIGC	0			
WCIGC	0			
PCIGC	0			
LPIGCD	0			
WPIGCD	0			
PPIGCD	0			
LAGIDL	0			
WAGIDL	0			
PAGIDL	0			
LBGIDL	0			
WBGIDL	0			
PBGIDL	0			
LEGIDL	0			
WEGIDL	0			
PEGIDL	0			
LPGIDL	0			
WPGIDL	0			

Name	Default	Units	Description
PPGIDL	0		
LAGISL	0		
WAGISL	0		
PAGISL	0		
LBGISL	0		
WBGISL	0		
PBGISL	0		
LEGISL	0		
WEGISL	0		
PEGISL	0		
LPGISL	0		
WPGISL	0		
PPGISL	0		
LAIGS	0		
WAIGS	0		
PAIGS	0		
LAIGD	0		
WAIGD	0		
PAIGD	0		

Name	Default	Units	Description
LBIGS	0		
WBIGS	0		
PBIGS	0		
LBIGD	0		
WBIGD	0		
PBIGD	0		
LCIGS	0		
WCIGS	0		
PCIGS	0		
LCIGD	0		
WCIGD	0		
PCIGD	0		
LNTOX	0		
WNTOX	0		
PNTOX	0		
LPOXEDGE	0		
WPOXEDGE	0		
PPOXEDGE	0		

Name	Default	Units	Description	
LLOVS	0			
WLOVS	0			
PLOVS	0			
LLOVD	0			
WLOVD	0			
PLOVD	0			
LCFS	0			
WCFS	0			
PCFS	0			
LCFD	0			
WCFD	0			
PCFD	0			
LVSAT	0			
WVSAT	0			
PVSAT	0			
LVSATB	0			
WVSATB	0			
PVSATB	0			
LVSAT1	0			

Name	Default	Units	Description	
WVSAT1	0			
PVSAT1	0			
LVSATCV	0			
WVSATCV	0			
PVSATCV	0			
LKSATIV	0			
WKSATIV	0			
PKSATIV	0			
LKSUBIV	0			
WKSUBIV	0			
PKSUBIV	0			
LUP	0			
WUP	0			
PUP	0			
LAIGBINV	0			
WAIGBINV	0			
PAIGBINV	0			

Name	Default	Units	Description	
LBIGBINV	0			
WBIGBINV	0			
PBIGBINV	0			
LCIGBINV	0			
WCIGBINV	0			
PCIGBINV	0			
LEIGBINV	0			
WEIGBINV	0			
PEIGBINV	0			
LNIGBINV	0			
WNIGBINV	0			
PNIGBINV	0			
LAIGBACC	0			
WAIGBACC	0			
PAIGBACC	0			

Name	Default	Units	Description
LBIGBACC	0		
WBIGBACC	0		
PBIGBACC	0		
LCIGBACC	0		
WCIGBACC	0		
PCIGBACC	0		
LNIGBACC	0		
WNIGBACC	0		
PNIGBACC	0		
DVTP0	0		Coefficient for Drain-Induced Vth Shift (DITS)
DVTP1	0		DITS exponent coefficient
ADVTP0	0.0		Pre-exponential Coefficient for DITS
BDVTP0	100.0e-9		Exponential coefficient for DITS
ADVTP1	0.0		Pre-exponential coefficient for DVTP1
BDVTP1	100.0e-9		Exponential coefficient for DVTP1
DVTP2	0.0		DITS Model Parameter
TMAXC	400.0	Celsius	Maximum Device Temperature

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development. The model is referenced differently depending on the language.

For ADS native syntax, the model is specified explicitly:

> *model modelName bsimimg1027 [parm=value]**

The model name is specified as bsimimg1027, bsimimg1028, bsimimg10291, or bsimimg10292.

In Spectre mode, the model family is supplied and the particular version is set by the `version=nnn` parameter:

> *simulator lang=spectre*
>
> *model modelName bsimimg version=102.7 [parm=value]**

Instance Parameters

Name (Alias)	Description
L	Designed Gate Length
D	Diameter of cylinder (for GEOMOD = 3)
TFIN	Body (fin) thickness
FPITCH	Fin Pitch
NF	Number of fingers
NFIN	Number of fins per finger
NGCON	Number of gate contacts
ASEO	Source to substrate overlap area through oxide (all fingers)
ADEO	Drain to substrate overlap area through oxide (all fingers)
PSEO	Perimeter of source to substrate overlap region through oxide (all fingers)
PDEO	Perimeter of drain to substrate overlap region through oxide (all fingers)

Name (Alias)	Description
ASEJ	Source junction area (all fingers; for bulk MuGFETs, BULKMOD = 1)
ADEJ	Drain junction area (all fingers; for bulk MuGFETs, BULKMOD = 1)
PSEJ	Source junction perimeter (all fingers; for bulk MuGFETs, BULKMOD = 1)
PDEJ	Drain junction perimeter (all fingers; for bulk MuGFETs, BULKMOD = 1)
CGSP	Constant gate to source fringe capacitance (for CGEOMOD = 1)
CGDP	Constant gate to drain fringe capacitance (for CGEOMOD = 1)
CDSP	Constant drain to source fringe capacitance
NRS	Number of source dffusion squares (for RGEOMOD = 0)
NRD	Number of drain dffusion squares (for RGEOMOD = 0)
LRSD	Length of the source/drain
LSP	Thickness of the gate sidewall spacer
XL	
DELVTRAND	
U0MULT	
IDS0MULT	

Instance Netlist Format

> *modelName [:InstanceName] d fg s bg*

where,

- d is the drain node
- fg is the front gate node
- s is the source node
- bg is the back gate node.

Example

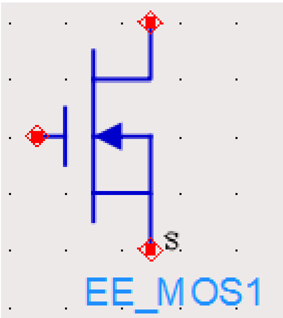
```
model Nch7 bsimimg1027
Nch7:M1 2 1 0 0 W=10u L=0.9u
```

For detailed information, refer to BSIMIMG manual.

EE MOS1, EE MOS1P (EEsof Nonlinear MOSFETs, N-Channel, P-Channel)

EE_MOS1, EE_MOS1P (EEsof Nonlinear MOSFETs, N-Channel, P-Channel)

Symbol



Parameters

Name	Description	Units	Default
Model	Model instance name	None	EEMOS1
Temp	device operating temperature	°C	25.0
Noise	noise generation: yes=1, no =0	None	yes
_M	number of devices in parallel	None	1

The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

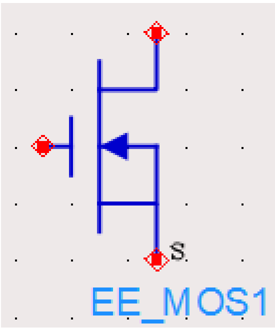
Name	Description	Units
Id	Drain current	amperes

Name	Description	Units
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
GmAc	Forward transconductance (dIds/dVgs + dIdb/dVgs)	siemens
GdsAc	Output conductance (dIds/dVds + dIdb/dVgd)	siemens
dIdb_dVgs	(dIdb/dVgs)	siemens
dIdb_dVgd	(dIdb/dVgd)	siemens
dIdb_dVds	(dIdb/dVds)	siemens
Cgc	Gate-source capacitance (dQgc/dVgc)	farads
Cgy	Gate-drain capacitance (dQgy/dVgy)	farads
Cds	Drain-source capacitance	farads
dQgc_dVgy	(dQgc/dVgy)	farads
dQgy_dVgc	(dQgy_dVgc)	farads
Vgs	Gate-source voltage	volts
Vds	Gate-drain voltage	volts

EE MOS1 (EEsof Nonlinear MOSFET, N-Channel)

EE_MOS1 (EEsof Nonlinear MOSFET, N-Channel)

Symbol



Parameters

Name	Description	Units	Default
Model	Model instance name	None	EEMOS1
Temp	device operating temperature	°C	25.0
Noise	noise generation: yes=1, no =0	None	yes
_M	number of devices in parallel	None	1

The following table lists the DC operating point parameters that can be sent to the dataset.

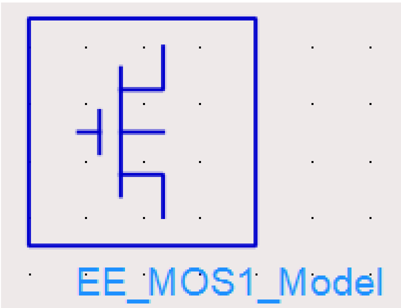
DC Operating Point Parameters

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
GmAc	Forward transconductance (dIds/dVgs + dIdb/dVgs)	siemens
GdsAc	Output conductance (dIds/dVds + dIdb/dVgd)	siemens
dIdb_dVgs	(dIdb/dVgs)	siemens
dIdb_dVgd	(dIdb/dVgd)	siemens
dIdb_dVds	(dIdb/dVds)	siemens
Cgc	Gate-source capacitance (dQgc/dVgc)	farads
Cgy	Gate-drain capacitance (dQgy/dVgy)	farads
Cds	Drain-source capacitance	farads
dQgc_dVgy	(dQgc/dVgy)	farads
dQgy_dVgc	(dQgy_dVgc)	farads
Vgs	Gate-source voltage	volts
Vds	Gate-drain voltage	volts

EE MOS1 Model (EEsof Nonlinear MOSFET Model)

EE_MOS1_Model (EEsof Nonlinear MOSFET Model)

Symbol



Description

EEMOS1 is an empirical analytic model that was developed by Keysight EEsof for the express purpose of fitting measured electrical behavior of 3-terminal n-channel MOSFETs intended for high-frequency analog applications. Unlike most physics-based MOSFET models found in SPICE programs, EEMOS1 contains no process or physical parameters. It does, however, accurately fit those electrical quantities that have direct bearing on the RF predictive abilities of the model, namely g_m vs. bias, g_{ds} vs. bias and, to a lesser degree, input and output capacitances vs. bias. The model includes the following features:

- Accurate drain-source current model fits measured current over gate and drain bias variations.
- Flexible transconductance formulation permits accurate fitting of g_m compression found in MOSFETs.
- Charge model that accurately tracks measured capacitance values.
- Dispersion model that permits simultaneous fitting of high-frequency conductances and DC characteristics.
- Well-behaved analytic expressions permit accurate extrapolations outside of the measurement range used to extract the model.
  The model equations were developed concurrently with parameter extraction techniques to ensure the model would contain only parameters that were extractable from measured data. Although the model is amenable to automated parameter extraction techniques, it was designed to consist of parameters that are easily estimated (visually) from measured data such as g_m–V_{gs} plots. Because the model equations are all well-behaved analytic expressions, EEMOS1 possesses no inherent limitations with respect to its usable power range. Keysight EEsof's IC-CAP program provides the user with the capability of extracting EEMOS1 models from measured data.

Parameters

Name	Description	Units	Default
Is	Substrate diode reverse saturation current	A	1.0e-14
N	Substrate diode ideality factor	None	1.0
Vbi	Substrate diode built-in potential	V	0.7
Mj	Junction grading coefficient	None	0.5
Fc	Substrate depletion capacitance linearization point	None	1.0e-4
Vbr	Breakdown onset voltage	V	1.0e-4
Kbo	Breakdown current coefficient	None	1.0e-4
Nbr	Breakdown current exponent	None	2.0
Vinfl	Inflection point in Cgs-Vgs characteristic	V	5.0
Deltds	Capacitance forward to reverse mode transition	V	1.0
Deltgs	Cgsth to Cgso transition voltage	V	1.0
Cgsmax	Maximum value of Cgs	F	1.0e-12
Vgo	Gate-source voltage where transconductance is a maximum	V	7.0
Vto	Zero-bias threshold	V	-1.0
Gamma	Drain-source dependent threshold	1/V	0.0
Gmmax	Peak transconductance	S	10.0e-03
Delt	transconductance tail-off rate	V	2.0
Vbreak	Voltage where transconductance tail-off begins	V	4.0

Name	Description	Units	Default
Lambda	Output conductance parameter	1/V	0.0
Vsatm	Maximum value of saturation voltage	V	10.0
Vgm	Gate-source volatge where saturation voltage is VSATM	V	5.0
Rdb	Dispersion source output impedence	Ohm	1.0e+9
Cbs	Dispersion source capacitance	F	1.6e-13
Gmmaxac	AC value of Gmmax	S	60.0e-03
Deltac	AC value of Delt	V	2.0
Vbreakac	AC value of Vbreak	V	4.0
Vgoac	AC value of Vgo	V	7.0
Lambdaac	AC value of Lambda	1/V	0.0
Vsatmac	AC value of VSATM	V	10.0
Vgmac	AC value of VGM	V	5.0
Gdbm	Additional d-b branch conductance at Vds=VDSM	None	0.0
Kdb	Controls Vds dependence of D-B branch conductance	None	0.0
Vdsm	Voltage where D-B branch conductance becomes constant	V	1.0
Rd	Drain contact resistance	Ohm	1.0
Rs	Source contact resistance	Ohm	1.0
Rg	Gate metallization resistance	Ohm	1.0
Ris	Source end channel resistance	Ohm	1.0

Name	Description	Units	Default
Rid	Drain end channel resistance	Ohm	1.0
wBvg	Gate oxide breakdown voltage (warning)	V	None
wBvds	Drain-source breakdown voltage (warning)	V	None
wIdsmax	Maximum drain-source current (warning)	A	None
wPmax	Maximum power dissipation (warning)	W	None
Cdso	Zero-bias output capacitance	F	0.0
Cgso	Constant portion of gate-source capacitance	F	1.0e-13
Cgdo	Constant portion of gate-drain capacitance	F	1.0e-13
AllParams	DataAccessComponent-based parameters	None	None

- Model parameters such as Ls, Ld, Lg (as well as other package-related parameters that are included as part of the model file output from the EEMOS1 IC-CAP kernel) are not used by EE_MOS in the simulator. Only those parameters listed are part of EE_MOS. Any extrinsic devices must be added externally by the user.
- To prevent numerical problems, the setting of some model parameters to 0 is trapped by the simulator. The parameter values are changed internally:

  $Rd = 10^{-4}$

  $Rs = 10^{-4}$

  $Rg = 10^{-4}$

  $Ris = 10^{-4}$

  $Rid = 10^{-4}$

  $Vgm = 0.1$

  $Vgmac = 0.1$

  $Vsatm = 0.1$

  $Vsatmac = 0.1$

  $Deltds = 0.1$
- TEMP parameter is only used to calculate the noise performance of this model. Temperature scaling of model parameters is not performed.
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.

- This device has no default artwork associated with it.

Channel Current

The channel current model in EEMOS1 is comprised of empirically derived analytic expressions and requires the specification of 9 parameter values. Because EEMOS1 is intended for large-signal analog applications, no attempt is made to characterize this channel current in the subthreshold or *weak* inversion region. The channel current expression is intended for use above V_t only. The equations were developed through examination of I_{ds} vs. bias and g_m vs. bias plots on a number of DMOS devices from various manufacturers. The equations are sufficiently flexible enough to handle either enhancement or depletion mode devices. The expressions below are given for V_{ds}>0.0V although the model is equally valid for V_{ds}<0.0V. The model assumes the device is symmetrical; simply replace V_{gs} with V_{gd} and V_{ds} with $-V_{ds}$ obtain the reverse region (V_{ds}<0.0V) equations. The g_m g_{ds} and I_{ds} equations take on take on two different forms depending on the value of V_{gs} relative to some of the model parameters. The I_{ds} expression is continuous through at least the second derivative everywhere except at V_t, where the second derivative is discontinuous.

The following voltages define regions of operation that are used in the current definitions:

$$V_t = Vto - Gamma \times V_{ds}$$

$$V_{gst} = V_{gs} - V_t$$

for $V_{gst} \le 0$

$$g_{mo} = 0.0$$

$$I_{dso} = 0.0$$

$$g_{dso} = 0.0$$

for $V_{gst} > 0$ and $V_{gs} \le V_{break}$

$$g_{mo} = g_{mm}(V_{gs}, V_{ds})$$

$$I_{dso} = I_{dsm}(V_{gs}, V_{ds})$$

$$g_{dso} = g_{dsm}(V_{gs}, V_{ds})$$

for $V_{gst} > 0$ and $V_{gs} > V_{break}$

$$g_{mo} = a(V_{gs} - V_{asym})^b$$

$$I_{dso} = I_{dsm}(Vbreak, V_{ds}) + \frac{a}{b+1}[(V_{gs} - V_{asym})^{b+1} - Delt^{b+1}]$$

$$g_{dso} = g_{dsm}(Vbreak, V_{ds})$$

where:

$$g_{mm}(V, V_{ds}) = Gmmax\left[1 - \left(\frac{V - Vgo}{V_t - Vgo}\right)^2\right]$$

$$I_{dsm}(V,V_{ds}) = \left(Gmmax \times \left[(V - Vgo)\left(1 - \frac{1}{3}\left(\frac{V - Vgo}{V_t - Vgo}\right)^2\right) - \frac{2}{3}(V_t - Vgo)\right]\right)$$

$$g_{dsm}(V, V_{ds}) = Gmmax \times \left[\frac{2 \times Gamma}{3}\left(1 - \left(\frac{V - Vgo}{V_t - Vgo}\right)^3\right)\right]$$

$$m_{g_{mm}} = \left.\frac{\partial g_{mm}}{\partial V}\right|_{V = Vbreak}$$

$$= -\frac{2 \times Gmmax}{V_t - Vgo}\left(\frac{Vbreak - Vgo}{V_t - Vgo}\right)$$

$$V_{asym} = Vbreak - Delt$$

$$b = \frac{m_{g_{mm}} \times Delt}{g_{mm}(Vbreak, V_{ds})}$$

$$a = \frac{g_{mm}(Vbreak, V_{ds})}{Delt^b}$$

If b = –1, then the integral of g_{mo} (I_{dso}) is comprised of natural log functions:

$$I_{dso} = I_{dsm}(Vbreak, V_{ds}) + a[\log(V_{gs} - V_{asym}) - \log(Delt)]$$

The current saturation mechanism in EEMOS1 is described empirically through the parameters Vgm and Vsatm. The drain voltage where the channel current saturates is dependent on V_{gs} through the following relation:

$$V_{sat} = Vsatm \times \tanh\left[\frac{3(V_{gs} - V_t)}{Vgm}\right]$$

The preceding relations for I_{dso}, g_{mo} and g_{dso} can now be substituted in the following equations that model the current saturation and output conductance. This portion of the model is similar to an approach described by Curtice for modeling MESFETs [1].

$$I_{ds} = I_{dso}(1 + Lambda \times V_{ds})\tanh\left(\frac{3V_{ds}}{V_{sat}}\right)$$

$$g_m = \left[g_{mo}\tanh\left(\frac{3V_{ds}}{V_{sat}}\right) - I_{dso}\operatorname{sech}^2\left(\frac{3V_{ds}}{V_{sat}}\right) \times \left[\frac{3V_{ds}}{V_{sat}^2}\frac{\partial V_{sat}}{\partial V_{gs}}\right]\right]$$

$$\times (1 + Lambda \times V_{ds})$$

$$g_{ds} = \{g_{dso}(1 + Lambda \times V_{ds}) + I_{dso}Lambda\}\tanh\left(\frac{3V_{ds}}{V_{sat}}\right)$$

$$+ I_{dso} \times \frac{3\left(V_{sat} - V_{ds}\frac{\partial V_{sat}}{\partial V_{ds}}\right)(1 + Lambda \times V_{ds})}{V_{sat}^2}\operatorname{sech}^2\left(\frac{3V_{ds}}{V_{sat}}\right)$$

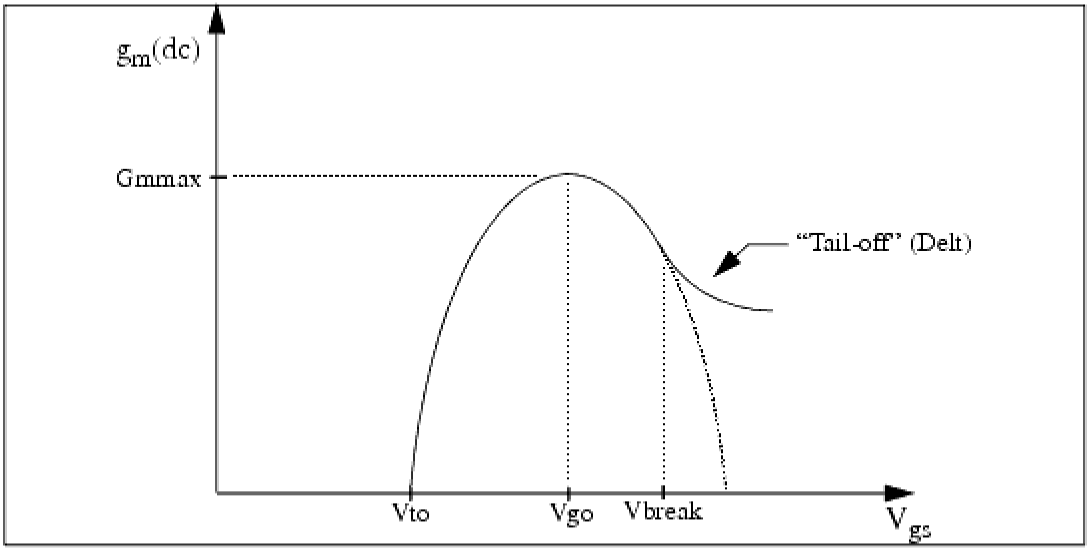
where:

$$\frac{\partial V_{sat}}{\partial V_{gs}} = \frac{3 \times Vsatm}{Vgm}\operatorname{sech}^2\left(\frac{3(V_{gs} - V_t)}{Vgm}\right)$$

$$\frac{\partial V_{sat}}{\partial V_{ds}} = -\frac{3 \times Vsatm \times Gamma}{Vgm}\operatorname{sech}^2\left(\frac{3(V_{gs} - V_t)}{Vgm}\right)$$

Qualitatively, the operation of the channel current model can be described as follows. The V_{ds} dependence of the equations is dominated by the parameters Vsatm, Vgm, Gamma, and Lambda. Output conductance is controlled by Gamma and Lambda. The parameter Vsatm represents the maximum drain-source voltage where the drain current saturates. Vgm is the gate voltage corresponding to the I-V trace where V_{sat}=Vsatm.

When Gamma=0, Vsatm=0 and Lambda=0, EEMOS1 becomes dependent on V_{gs} only. Under these simplified conditions, the parameters describing the g_m–V_{gs} dependence of the model are easily explained. Vto is the V_{gs} value where g_m becomes zero. The transconductance peaks at V_{gs}=VGO with a value of Gmmax. At V_{gs}=Vbreak, the model breaks from its quadratic g_m dependence and follows a hyperbolic dependence. The parameter Delt controls the voltage asymptote of this hyperbola. The shape of this tail-off region can be altered by tuning on the parameter Delt. EEMOS1 constrains the hyperbola to match the derivative of the quadratic function at V_{gs}=Vbreak. This ensures a continuous transition between the respective modeling regions for simulation. The parameter definitions are shown in the following illustration.



EEMOS1 g_m-V_{gs} Parameters

Dispersion Current (Idb)

The circuit used to model conductance dispersion consists of the elements Rdb, Cbs (these linear elements are also parameters) and the nonlinear source $I_{db}(V_{gs}, V_{ds})$. The model is a large-signal generalization of the dispersion model proposed by Golio et al. for MESFETs [2]. At DC, the drain-source current is just
the current I_{ds}. At high frequency (well above the transition frequency), the drain source current will be equal to I_{ds}(high frequency) = I_{ds}(dc) + I_{db}.

Linearization of the drain-source model yields the following expressions for y_{21} and y_{22} of the intrinsic EEMOS1 model:

$$y_{21} = g_{dsgs} + g_{dbgs} - \frac{g_{dbgs}}{1 + j\omega \times Cbs \times Rdb}$$

$$y_{22} = g_{dsds} + g_{dbds} + \frac{1}{Rdb} - \frac{\left(g_{dbds} + \frac{1}{Rdb}\right)}{1 + j\omega \times Cbs \times Rdb}$$

where:

$$g_{dsgs} = \frac{\partial I_{ds}}{\partial V_{gs}}$$

$$g_{dsds} = \frac{\partial I_{ds}}{\partial V_{ds}}$$

$$g_{dbgs} = \frac{\partial I_{db}}{\partial V_{gs}}$$

$$g_{dbds} = \frac{\partial I_{db}}{\partial V_{ds}}$$

Evaluating these expressions at the frequencies ω=0 and ω=infinity, produces the following results for transconductance and output conductance:
For ω = 0,

$$Re[y_{21}] = g_m = g_{dsgs}$$

$$Re[y_{22}] = g_{ds} = g_{dsds}$$

For ω = infinity,

$$Re[y_{21}] = g_m = g_{dsgs} + g_{dbgs}$$

$$Re[y_{22}] = g_{ds} = g_{dsds} + g_{dbds} + \frac{1}{Rdb}$$

Between these two extremes, the conductances make a smooth transition, the abruptness of that is governed by the time constant τdisp = Rdb × Cbs. The frequency f_0 at which the conductances are midway between these two extremes is defined as:

$$f_0 = \frac{1}{2\pi\tau_{disp}}$$

The parameter Rdb should be set large enough so that its contribution to the output conductance is negligible. Unless the user is specifically interested in simulating the device near f_0, the default values of Rdb and Cbs will be adequate for most RF applications.

The EEMOS1 I_{ds} model can be extracted to fit either DC or AC characteristics. In order to simultaneously fit both DC I-Vs and AC conductances, EEMOS1 uses a simple scheme for modeling the I_{db} current source whereby different values of the same parameters can be used in the I_{ds} equations. The DC and AC drain-source currents can be expressed as follows:

$$I_{ds}^{dc}(Voltages, Parameters) = I_{ds}(Voltages, Vto, Gamma, Vgo, Gmmax,$$

$$Delt, Vbreak, Lambda, Vsatm, Vgm$$

$$I_{ds}^{ac}(Voltages, Parameters) = I_{ds}(Voltages, Vto, Gamma, Vgoac,$$

$$Gmmaxac, Deltac, Vbreakac,$$
$$Lambdaac, Vsatmac, Vgmac$$

Parameters such as Vto that do not have an AC counterpart (there is no Vtoac parameter), have been found not to vary significantly between extractions using DC measurements versus those using AC measurements. The difference between the AC and DC values of I_{ds} plus an additional term that is a function of V_{ds} only gives the value of I_{db} for the dispersion model:

$$I_{db}(V_{gs}, V_{ds}) = I_{ds}^{ac}(V_{gs}, V_{ds}) - I_{ds}^{dc}(V_{gs}, V_{ds}) + I_{dbp}(V_{ds})$$

where I_{dbp} and its associated conductance are given by:

for V_{ds} > Vdsm and $Kdb \neq 0$:

$$I_{dbp} = \sqrt{\frac{Gdbm}{Kdb}}\tan^{-1}((V_{ds} - Vdsm)\sqrt{Kdb \times Gdbm}) + Gdbm \times Vdsm$$

$$g_{dbp} = \frac{Gdbm}{(Kdb(Gdbm(V_{ds} - Vdsm)^2 + 1))}$$

for V_{ds} < –Vdsm and $Kdb \neq 0$:

$$I_{dbp} = \sqrt{\frac{Gdbm}{Kdb}}\tan^{-1}((V_{ds} + Vdsm)\sqrt{Kdb \times Gdbm}) - Gdbm \times Vdsm$$

$$g_{dbp} = \frac{Gdbm}{Kdb \times Gdbm((V_{ds} + Vdsm)^2 + 1)}$$

for $-Vdsm \leq V_{ds} \leq Vdsm$ or $Kdb = 0$:

$$I_{dsm} = Gdbm \times V_{ds}$$

$$g_{dbm} = Gdbm$$

By setting the seven high-frequency parameters equal to their DC counterparts, the dispersion model reduces to I_{db} = I_{dbp}. Examination of the I_{dbp} expression reveals that the additional setting of

Gdbm to zero disables the dispersion model entirely. Because the I_{dbp} current is a function of V_{ds} only, it will impact output conductance only. However, the current function I_{ds}^{ac} will impact both g_m and g_{ds}. For this reason, the model is primarily intended to use g_m data as a means for tuning I_{ds}^{ac}. Once this *fitting* is accomplished, parameters Gdbm, Kdb and Vdsm can be tuned to optimize the g_{ds} fit.

Charge Model

The EEMOS1 charge model consists of three separate charge sources that model channel charge and charge associated with the substrate (output) diode. The channel charge is partitioned between the two charge sources q_{gc} and q_{gy} such that symmetry is maintained relative to V_{ds} = 0V. These expressions were empirically developed by Keysight EEsof such that their derivatives would fit measured capacitance data. The channel charge expressions are:

$$q_{gc} = \frac{Cgsmax}{4}\left[V_{gc} - Vinfl + \sqrt{(V_{gc} - Vinfl)^2 + Deltgs^2}\right]$$

$$' \times \left[1 + \tanh\left(\frac{3(V_{gc} - V_{gy})}{Deltds}\right)\right] + Cgso \times V_{gc}$$

$$q_{gy} = \frac{Cgsmax}{4}\left[V_{gy} - Vinfl + \sqrt{(V_{gy} - Vinfl)^2 + Deltgs^2}\right]$$

$$\times \left[1 - \tanh\left(\frac{3(V_{gy} - V_{gc})}{Deltds}\right)\right] + Cgdo \times V_{gy}$$

The output charge and its derivative are modeled using the standard junction diode depletion formula:

For $-V_{ds} < Fc \times Vbi$

$$q_{ds} = -\frac{Cdso \times Vbi}{1 - Mj}\left[1 - \left(1 + \frac{V_{ds}}{Vbi}\right)^{1 - Mj}\right]$$

$$C_{dsds} = \frac{\partial q_{ds}}{\partial V_{ds}} = \frac{Cdso}{\left[1 + \frac{V_{ds}}{Vbi}\right]^{Mj}}$$

For $-V_{ds} < -Fc \times Vbi$

the capacitance is extrapolated linearly from its value at Fc× Vbi according to the standard SPICE equation for a junction diode [3]. The charge derivatives are related to the small-signal capacitances through the following expressions:

$$C_{gs} \approx C_{gcgc} + C_{gygc}$$
$$C_{gd} \approx C_{gcgy} + C_{gygy}$$
$$C_{ds} \approx C_{dsds} - C_{gcgy}$$

where:

$$C_{gcgc} = \frac{\partial q_{gc}}{\partial V_{gc}}$$
$$C_{gcgy} = \frac{\partial q_{gc}}{\partial V_{gy}}$$
$$C_{gygy} = \frac{\partial q_{gy}}{\partial V_{gy}}$$
$$C_{gygc} = \frac{\partial q_{gy}}{\partial V_{gc}}$$

Substrate Diode and Breakdown

When the drain-source voltage is reverse-biased, the substrate diode conducts according to the standard diode relation:

$$I_{for}(V_{ds}) = Is \times \left[e^{\frac{-qV_{ds}}{nkT}} - 1 \right]$$

where q is the charge on an electron, k is Boltzmann's constant, and T is the junction temperature.

The EEMOS1 breakdown model is based on a simple power law expression. The model consists of three parameters that are easily optimized to measured data. The breakdown current is given by:

For V_{ds} > Vbr,

$$I_{bkdn}(V_{ds}) = Kbo(V_{ds} - Vbr)^{Nbr}$$

For V_{ds} ≤ Vbr

$$I_{bkdn}(V_{ds}) = 0$$

Total current flowing through the substrate (body) diode from source to drain is given by:

$$I_{sub}(V_{ds}) = I_{for}(V_{ds}) - I_{bkdn}(V_{ds}$$

Noise Model

Thermal noise generated by resistors Rg, Rs, Rd, Ris, Rid, and Rdb is characterized by the following spectral density.

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

Channel noise generated by the DC transconductance gm is characterized by the following spectral density:

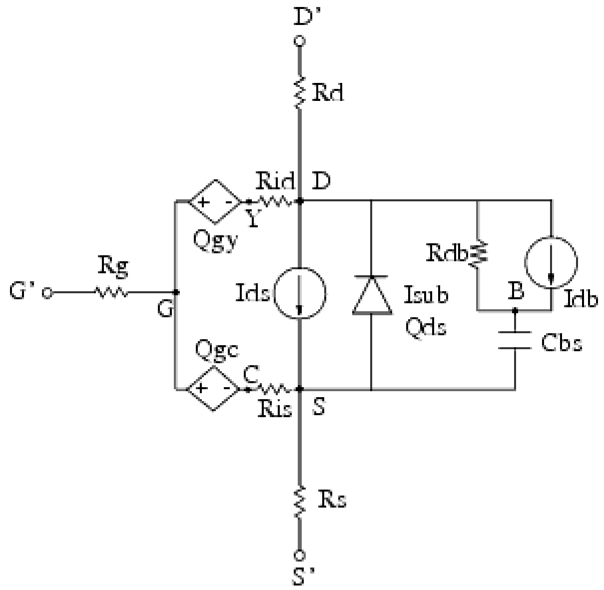
$$\frac{<i_{ds}^2>}{\Delta f} = \frac{8kTg_m}{3}$$

In the preceding expressions, *k* is Boltzmann's constant, *T* is the operating temperature in Kelvin, *q* is the electron charge, and Δ *f* is the noise bandwidth.

Flicker noise for this device is not modeled in this simulator version. However, the bias-dependent noise sources I_NoiseBD and V_NoiseBD (from the Sources library) can be connected external to the device to model flicker noise.

Additional Information

Equivalent Circuit



References

- W. R. Curtice, "A MESFET model for use in the design of GaAs integrated circuits," *IEEE Transactions of Microwave Theory and Techniques,* Vol. MTT-28, pp. 448-456, May 1980.
- J. M. Golio, M. Miller, G. Maracus, D. Johnson. "Frequency dependent electrical characteristics of GaAs MESFETs," *IEEE Trans. Elec. Devices* , vol. ED-37, pp. 1217-1227, May 1990.
- P. Antognetti and G. Massobrio. *Semiconductor Device Modeling with SPICE,* Second Edition, McGraw-Hill, Inc., 1993.

EEMOS1 is an empirical analytic model that was developed by Keysight EEsof for the express purpose of fitting measured electrical behavior of 3-terminal n-channel MOSFETs intended for high-frequency analog applications. Unlike most physics-based MOSFET models found in SPICE programs, EEMOS1 contains no process or physical parameters. It does, however, accurately fit those electrical quantities that have direct bearing on the RF predictive abilities of the model, namely g_m vs. bias, g_{ds} vs. bias and, to a lesser degree, input and output capacitances vs. bias. The model includes the following features:

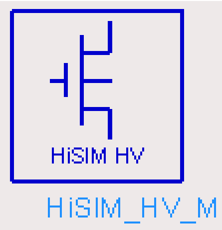
- Accurate drain-source current model fits measured current over gate and drain bias variations.
- Flexible transconductance formulation permits accurate fitting of g_m compression found in MOSFETs.
- Charge model that accurately tracks measured capacitance values.
- Dispersion model that permits simultaneous fitting of high-frequency conductances and DC characteristics.
- Well-behaved analytic expressions permit accurate extrapolations outside of the measurement range used to extract the model.
  The model equations were developed concurrently with parameter extraction techniques to ensure the model would contain only parameters that were extractable from measured data. Although the model is amenable to automated parameter extraction techniques, it was designed to consist of parameters that are easily estimated (visually) from measured data such as g_m–V_{gs} plots. Because the model equations are all well-behaved analytic expressions, EEMOS1 possesses no inherent limitations with respect to its usable power range. Keysight EEsof's IC-CAP program provides the user with the capability of extracting EEMOS1 models from measured data.

HiSIM_HV (MOSFET Model and Instance)

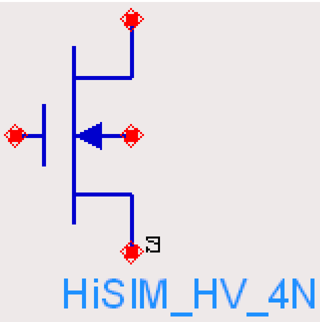
HiSIM_HV (HiSIM_HV MOSFET Model and Instance)

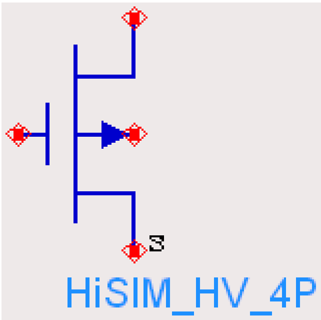
Symbol

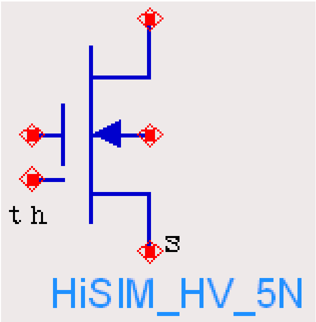
Model

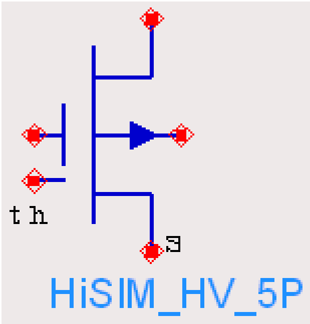


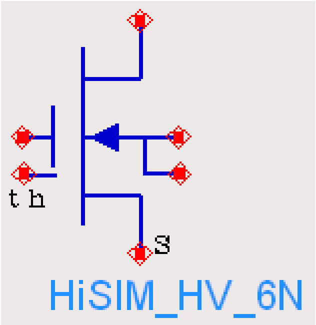
Instances (HiSIM_HV_4N, HiSIM_HV_4P, HiSIM_HV_5N, HiSIM_HV_5P, HiSIM_HV_6N, HiSIM_HV_6P)

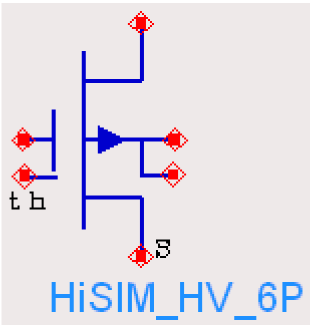












Supported Versions

- HiSIM_HV_1_11 (Version 1.11)
- HiSIM_HV_1_12 (Version 1.12)
- HiSIM_HV_1_2 (Version 1.2)
- HiSIM_HV_1_21 (Version 1.21)
- HiSIM_HV_1_22 (Version 1.22)
- HiSIM_HV_2_0 (Version 2.0)

Notes/Equations

1. For detailed information, refer to the HiSIM_HV manual provided by the Hiroshima university.
2. The following table lists the DC operating point parameters:

DC Operating Point Information

Name	Description	Units
Vds	Vds	V
Vgs	Vgs	V
Vbs	Vbs	V
Ids	Ids	A
Isub	Isub	A

Name	Description	Units
Igidl	Igidl	A
Igisl	Igisl	A
Igd	Igd	A
Igs	Igs	A
Igb	Igb	A
Ibs	Ibs	A
Ibd	Ibd	A
Gm	dIds_dVgsi	S
Gmt	dIds_dTi	S
Gds	dIds_dVdsi	S
Gmbs	dIds_dVbsi	S
Gbd	Gbd	S
Gbd	Gbs	S
Q	Qb	C
Qg	Qg	C
Qd	Qd	C
Cgg	Cgg	F
Cgd	Cgd	F
Cgs	Cgs	F

Name	Description	Units
Cdg	Cdg	F
Cdd	Cdd	F
Cds	Cds	F
Cbg	Cbg	F
Cbdb	Cbdb	F
Csbs	Csbs	F
Cgdo	Cgdo	F
Cgso	Cgso	F
Cgbo	Cgbo	F
CAPBD	CAPBD	F
CAPBS	CAPBS	F
Von	Von	V
VDSAT	VDSAT	V
Qbs	Qbs	C
Qbd	Qbd	C
m	multiplicity	

HiSIM_HV (HiSIM_HV Version 1.11, 1.12 Model and Instance)

HiSIM_HV (HiSIM_HV Version 1.11, 1.12 Model and Instance)

The following topic lists the HiSIM_HV 1.11 and 1.12 model and instance parameters.

Model Parameters

Name (Alias)	Description
Gender	+1=N-type, -1=P-type
Tnom	Parameter measurement temperature
Secured	Secured model parameters
Info	Information level (for debug, etc.)
Noise	Noise model selector
Version	Model version
Show	Show physical value
Corsrd	Handling of Rs and Rd
Corg	Activate gate resistance (1) or not (0)
Coiprv	Use ids_prv as initial guess of Ids (internal flag)
Copprv	Use ps{0/l}_prv as initial guess of Ps{0/l} (internal flag)
Coadov	Add overlap to intrisic
Coisub	Calculate isub
Coiigs	Calculate igate

Name (Alias)	Description
Cogidl	Calculate igidl
Coovlp	Calculate overlap charge on the drain side
Coovlps	Calculate overlap charge on the source side
Coflick	Calculate 1/f noise
Coisti	Calculate STI
Conqs	Calculate in nqs mode or qs mode
Corbnet	
Cothrml	Calculate thermal noise
Coign	Calculate induced gate noise
Codfm	Calculation of model for DFM
Coselfheat	Calculation of self heating model
Cosym	Model selector for symmetry device
Vbsmin	Minimum back bias voltage to be treated in hsmhveval [V]
Vmax	Saturation velocity [cm/s]
Bgtmp1	First order temp. coeff. for band gap [V/K]
Bgtmp2	Second order temp. coeff. for band gap [V/K^2]
Eg0	
Tox	Oxide thickness [m]
Xld	Lateral diffusion of S/D under the gate [m]

Name (Alias)	Description
Xldld	Lateral diffusion of Drain under the gate [m]
Lover	Overlap length on source side [m], alias for lovers
Lovers	Overlap length on source side [m]
Rdov11	Dependence coeff. for overlap length
Rdov12	Dependence coeff. for overlap length
Rdov13	Dependence coeff. for overlap length
Rdslp1	LDRIFT1 dependence of resistance for CORSRD=1,3
Rdict1	LDRIFT1 dependence of resistance for CORSRD=1,3
Rdslp2	LDRIFT2 dependence of resistance for CORSRD=1,3
Rdict2	LDRIFT2 dependence of resistance for CORSRD=1,3
Loverld	Overlap length on the drain side
Ldrift1	Drift region length-1 on the drain side[m]
Ldrift2	Drift region length-2 on the drain side[m]
Ldrift1s	Drift region length-1 on the source side[m]
Ldrift2s	Drift region length-2 on the source side[m]
Subld1	Impact-ionization current in the drift region [-]
Subld2	Impact-ionization current in the drift region [m^{-1}*V^{3/2}]
Ddltmax	
Ddltslp	

Name (Alias)	Description
Ddltict	
Vfbover	
Nover	
Novers	
Xwd	Lateral diffusion along the width dir. [m]
Xl	Gate length offset due to mask/etch effect [m]
Xw	Gate width offset due to mask/etch effect [m]
Saref	Reference distance from STI edge to Gate edge [m]
Sbref	Reference distance from STI edge to Gate edge [m]
Ll	Gate length parameter
Lld	Gate length parameter
Lln	Gate length parameter
Wl	Gate width parameter
Wl1	Gate width parameter
Wl1p	Gate width parameter
Wl2	Gate width parameter
Wl2p	Gate width parameter
Wld	Gate width parameter
Wln	Gate width parameter

Name (Alias)	Description
Xqy	[m]
Xqy1	[F m^{XQY2}]
Xqy2	[-]
Rs	Source contact resistance [ohm m]
Rd	Drain contact resistance [ohm m]
Rsh	Source/drain diffusion sheet resistance [ohm]
Rshg	Gate-elecrode sheet resistance
Vfbc	Constant part of Vfb [V]
Vbi	Built-in potential [V]
Nsubc	Constant part of Nsub [1/cm^3]
Parl2	Under diffusion [m]
Lp	Length of pocket potential [m]
Nsubp	[1/cm^3]
Nsubp0	Pocket implant parameter
Nsubwp	Pocket implant parameter
Scp1	Parameter for pocket [-]
Scp2	Parameter for pocket [1/V]
Scp3	Parameter for pocket [m/V]
Sc1	Parameter for SCE [-]

Name (Alias)	Description
Sc2	Parameter for SCE [1/V]
Sc3	Parameter for SCE [m/V]
Sc4	Parameter for SCE [1/V]
Pgd1	Parameter for gate-poly depletion [V]
Pgd2	Parameter for gate-poly depletion [V]
Pgd3	Parameter for gate-poly depletion [-]
Pgd4	Parameter for gate-poly depletion [-]
Ndep	Coeff. of Qbm for Eeff [-]
Ndepl	Coeff. of Qbm for Eeff [-]
Ndeplp	Coeff. of Qbm for Eeff [-]
Ninv	Coeff. of Qnm for Eeff [-]
Ninvd	Modification of Vdse dependence on Eeff [1/V]
Muecb0	Const. part of coulomb scattering [cm^2/Vs]
Muecb1	Coeff. for coulomb scattering [cm^2/Vs]
Mueph0	Power of Eeff for phonon scattering [-]
Mueph1	
Muephw	
Muepwp	Phonon scattering parameter
Muephl	Phonon scattering parameter

Name (Alias)	Description
Mueplp	Phonon scattering parameter
Muephs	
Muepsp	
Vtmp	
Wvth0	
Muesr0	Power of Eeff for S.R. scattering [-]
Muesr1	Coeff. for S.R. scattering [-]
Muesrl	Surface roughness parameter
Muesrw	Change of surface roughness related mobility
Mueswp	Change of surface roughness related mobility
Mueslp	Surface roughness parameter
Muetmp	Parameter for mobility [-]
Bb	Empirical mobility model coefficient [-]
Sub1	Parameter for Isub [1/V]
Sub2	Parameter for Isub [V]
Svgs	Coefficient for Vg of Psislsat
Svbs	Coefficient for Vbs of Psislsat
Svbsl	
Svds	

Name (Alias)	Description
Slg	
Sub1l	
Sub2l	
Fn1	
Fn2	
Fn3	
Fvbs	
Svgsl	
Svgslp	
Svgswp	
Svgsw	
Svbslp	
Slgl	
Slglp	
Sub1lp	
Nsti	Parameter for STI [1/cm^3]
Wsti	Parameter for STI [m]
Wstil	Parameter for STI [?]
Wstilp	Parameter for STI [?]

Name (Alias)	Description
Wstiw	Parameter for STI [?]
Wstiwp	Parameter for STI [?]
Scsti1	Parameter for STI [-]
Scsti2	Parameter for STI [1/V]
Vthsti	Parameter for STI
Vdsti	Parameter for STI [-]
Muesti1	STI Stress mobility parameter
Muesti2	STI Stress mobility parameter
Muesti3	STI Stress mobility parameter
Nsubpsti1	STI Stress pocket implant parameter
Nsubpsti2	STI Stress pocket implant parameter
Nsubpsti3	STI Stress pocket implant parameter
Lpext	Pocket extension
Npext	Pocket extension
Scp22	
Scp21	
Bs1	
Bs2	
Cgso	G-S overlap capacitance per unit W [F/m]

Name (Alias)	Description
Cgdo	G-D overlap capacitance per unit W [F/m]
Cgbo	G-B overlap capacitance per unit L [F/m]
Tpoly	Height of poly gate on the source side[m]
Js0	Saturation current density [A/m^2]
Js0sw	Side wall saturation current density [A/m]
Nj	Emission coefficient [-]
Njsw	Sidewall emission coefficient
Xti	Junction current temperature exponent coefficient [-]
Cj	Bottom junction capacitance per unit area at zero bias [F/m^2]
Cjsw	Source/drain sidewall junction capacitance grading coefficient per unit length at zero bias [F/m]
Cjswg	Source/drain gate sidewall junction capacitance per unit length at zero bias [F/m]
Mj	Bottom junction capacitance grading coefficient
Mjsw	Source/drain sidewall junction capacitance grading coefficient
Mjswg	Source/drain gate sidewall junction capacitance grading coefficient
Pb	Bottom junction build-in potential [V]
Pbsw	Source/drain sidewall junction build-in potential [V]
Pbswg	Source/drain gate sidewall junction build-in potential [V]
Xti2	Temperature coefficient [-]
Cisb	Reverse bias saturation current [-]

Name (Alias)	Description
Cvb	Bias dependence coefficient of cisb [-]
Ctemp	Temperature coefficient [-]
Cisbk	Reverse bias saturation current [A]
Cvbk	Bias dependence coefficient of cisb [-]
Divx	[1/V]
Clm1	Parameter for CLM [-]
Clm2	Parameter for CLM [1/m]
Clm3	Parameter for CLM [-]
Clm5	Parameter for CLM [-]
Clm6	Parameter for CLM [um^{-clm5}]
Vover	Parameter for overshoot [m^{voverp}]
Voverp	Parameter for overshoot [-]
Vovers	Parameter for overshoot [-]
Voversp	Parameter for overshoot [-]
Wfc	Parameter for narrow channel effect [m*F/(cm^2)]
Nsubcw	Parameter for narrow channel effect
Nsubcwp	Parameter for narrow channel effect
Qme1	Parameter for quantum effect [mV]
Qme2	Parameter for quantum effect [V]

Name (Alias)	Description
Qme3	Parameter for quantum effect [m]
Gidl1	Parameter for GIDL [?]
Gidl2	Parameter for GIDL [?]
Gidl3	Parameter for GIDL [?]
Gidl4	Parameter for GIDL [?]
Gidl5	Parameter for GIDL [?]
Glpart1	Parameter for gate current [-]
Gleak1	Parameter for gate current [A*V^(-3/2)/C]
Gleak2	Parameter for gate current [V^(-1/2)/m]
Gleak3	Parameter for gate current [-]
Gleak4	Parameter for gate current [1/m]
Gleak5	Parameter for gate current [V/m]
Gleak6	Parameter for gate current [V]
Gleak7	Parameter for gate current [m^2]
Glksd1	Parameter for gate current [A*m/V^2]
Glksd2	Parameter for gate current [1/(V*m)]
Glksd3	Parameter for gate current [1/m]
Glkb1	Parameter for gate current [A/V^2]
Glkb2	Parameter for gate current [m/V]

Name (Alias)	Description
Glkb3	Parameter for gate current [V]
Egig	Parameter for gate current [V]
Igtemp2	Parameter for gate current [V*k]
Igtemp3	Parameter for gate current [V*k^2]
Vzadd0	Vzadd at Vds=0 [V]
Pzadd0	Pzadd at Vds=0 [V]
Nftrp	
Nfalp	
Cit	
Falph	Parameter for 1/f noise
Kappa	Dielectric constant for high-k stacked gate
Pthrou	Modify subthreshold slope [-]
Vdiffj	Threshold voltage for S/D junction diode [V]
Dly1	Parameter for transit time [-]
Dly2	Parameter for transit time [-]
Dly3	Parameter for transforming bulk charge [s/F]
Dlyov	Parameter for transforming overlap charge [s/F]
Ovslp	
Ovmag	

Name (Alias)	Description
Gbmin	
Rbpb	
Rbpd	
Rbps	
Rbdb	
Rbsb	
Ibpc1	Parameter for impact-ionization induced bulk potential change
Ibpc2	Parameter for impact-ionization induced bulk potential change
Mphdfm	NSUBCDFM dependence of phonon scattering for DFM
Rdvg11	
Rdvg12	
Rth0	Thermal resistance
Cth0	Thermal capacitance
Powrat	
Tcjbd	Temperature dependence of cjbd
Tcjbs	Temperature dependence of cjbs
Tcjbdsw	Temperature dependence of cjbdsw
Tcjbssw	Temperature dependence of cjbssw
Tcjbdswg	Temperature dependence of cjbdswg

Name (Alias)	Description
Tcjbsswg	Temperature dependence of cjbsswg
Qdftvd	Qdrift Vd dependence
Rdvd	
Rdvb	
Rd20	
Rd21	
Rd22	
Rd22d	
Rd23	
Rd24	
Rd25	
Rd26	Alias for qovsm
Rdvdl	
Rdvdlp	
Rdvds	
Rdvdsp	
Rd23l	
Rd23lp	
Rd23s	

Name (Alias)	Description
Rd23sp	
Rds	
Rdsp	
Qovsm	Smoothing Qover at depletion/inversion transition
Ldrift	Alias for ldrift2
Rdtemp1	Temperature-dependence of Rd
Rdtemp2	Temperature-dependence of Rd
Rth0r	Heat radiation for SHE
Rdvdtemp1	Temperature-dependence of RDVD
Rdvdtemp2	Temperature-dependence of RDVD
Rth0w	Width-dependence of RTH0
Rth0wp	Width-dependence of RTH0
Rth0nf	nf-dependence of RTH0
Cvdsover	vds drop along the overlap
Lmin	Minimum length for the model
Lmax	Maximum length for the model
Wmin	Minimum width for the model
Wmax	Maximum width for the model
Lbinn	L modulation coefficient for binning

Name (Alias)	Description
Wbinn	W modulation coefficient for binning
Lvmax	Length dependence of vmax
Lbgtmp1	Length dependence of bgtmp1
Lbgtmp2	Length dependence of bgtmp2
Leg0	Length dependence of eg0
Lvfbover	Length dependence of vfbover
Lnover	Length dependence of nover
Lnovers	Length dependence of nover on source size
Lwl2	Length dependence of wl2
Lvfbc	Length dependence of vfbc
Lnsubc	Length dependence of nsubc
Lnsubp	Length dependence of nsubp
Lscp1	Length dependence of scp1
Lscp2	Length dependence of scp2
Lscp3	Length dependence of scp3
Lsc1	Length dependence of sc1
Lsc2	Length dependence of sc2
Lsc3	Length dependence of sc3
Lpgd1	Length dependence of pgd1

Name (Alias)	Description
Lpgd3	Length dependence of pgd3
Lndep	Length dependence of ndep
Lninv	Length dependence of ninv
Lmuecb0	Length dependence of muecb0
Lmuecb1	Length dependence of muecb1
Lmueph1	Length dependence of mueph1
Lvtmp	Length dependence of vtmp
Lwvth0	Length dependence of wvth0
Lmuesr1	Length dependence of muesr1
Lmuetmp	Length dependence of muetmp
Lsub1	Length dependence of sub1
Lsub2	Length dependence of sub2
Lsvds	Length dependence of svds
Lsvbs	Length dependence of svbs
Lsvgs	Length dependence of svgs
Lfn1	Length dependence of fn1
Lfn2	Length dependence of fn2
Lfn3	Length dependence of fn3
Lfvbs	Length dependence of fvbs

Name (Alias)	Description
Lnsti	Length dependence of nsti
Lwsti	Length dependence of wsti
Lscsti1	Length dependence of scsti1
Lscsti2	Length dependence of scsti2
Lvthsti	Length dependence of vthsti
Lmuesti1	Length dependence of muesti1
Lmuesti2	Length dependence of muesti2
Lmuesti3	Length dependence of muesti3
Lnsubpsti1	Length dependence of nsubpsti1
Lnsubpsti2	Length dependence of nsubpsti2
Lnsubpsti3	Length dependence of nsubpsti3
Lcgso	Length dependence of cgso
Lcgdo	Length dependence of cgdo
Ljs0	Length dependence of js0
Ljs0sw	Length dependence of js0sw
Lnj	Length dependence of nj
Lcisbk	Length dependence of cisbk
Lclm1	Length dependence of clm1
Lclm2	Length dependence of clm2

Name (Alias)	Description
Lclm3	Length dependence of clm3
Lwfc	Length dependence of wfc
Lgidl1	Length dependence of gidl1
Lgidl2	Length dependence of gidl2
Lgleak1	Length dependence of gleak1
Lgleak2	Length dependence of gleak2
Lgleak3	Length dependence of gleak3
Lgleak6	Length dependence of gleak6
Lglksd1	Length dependence of glksd1
Lglksd2	Length dependence of glksd2
Lglkb1	Length dependence of glkb1
Lglkb2	Length dependence of glkb2
Lnftrp	Length dependence of nftrp
Lnfalp	Length dependence of nfalp
Lpthrou	Length dependence of pthrou
Lvdiffj	Length dependence of vdiffj
Libpc1	Length dependence of ibpc1
Libpc2	Length dependence of ibpc2
Wvmax	Width dependence of vmax

Name (Alias)	Description
Wbgtmp1	Width dependence of bgtmp1
Wbgtmp2	Width dependence of bgtmp2
Weg0	Width dependence of eg0
Wvfbover	Width dependence of vfbover
Wnover	Width dependence of nover
Wnovers	Width dependence of novers on source size
Wwl2	Width dependence of wl2
Wvfbc	Width dependence of vfbc
Wnsubc	Width dependence of nsubc
Wnsubp	Width dependence of nsubp
Wscp1	Width dependence of scp1
Wscp2	Width dependence of scp2
Wscp3	Width dependence of scp3
Wsc1	Width dependence of sc1
Wsc2	Width dependence of sc2
Wsc3	Width dependence of sc3
Wpgd1	Width dependence of pgd1
Wpgd3	Width dependence of pgd3
Wndep	Width dependence of ndep

Name (Alias)	Description
Wninv	Width dependence of ninv
Wmuecb0	Width dependence of muecb0
Wmuecb1	Width dependence of muecb1
Wmueph1	Width dependence of mueph1
Wvtmp	Width dependence of vtmp
Wwvth0	Width dependence of wvth0
Wmuesr1	Width dependence of muesr1
Wmuetmp	Width dependence of muetmp
Wsub1	Width dependence of sub1
Wsub2	Width dependence of sub2
Wsvds	Width dependence of svds
Wsvbs	Width dependence of svbs
Wsvgs	Width dependence of svgs
Wfn1	Width dependence of fn1
Wfn2	Width dependence of fn2
Wfn3	Width dependence of fn3
Wfvbs	Width dependence of fvbs
Wnsti	Width dependence of nsti
Wwsti	Width dependence of wsti

Name (Alias)	Description
Wscsti1	Width dependence of scsti1
Wscsti2	Width dependence of scsti2
Wvthsti	Width dependence of vthsti
Wmuesti1	Width dependence of muesti1
Wmuesti2	Width dependence of muesti2
Wmuesti3	Width dependence of muesti3
Wnsubpsti1	Width dependence of nsubpsti1
Wnsubpsti2	Width dependence of nsubpsti2
Wnsubpsti3	Width dependence of nsubpsti3
Wcgso	Width dependence of cgso
Wcgdo	Width dependence of cgdo
Wjs0	Width dependence of js0
Wjs0sw	Width dependence of js0sw
Wnj	Width dependence of nj
Wcisbk	Width dependence of cisbk
Wclm1	Width dependence of clm1
Wclm2	Width dependence of clm2
Wclm3	Width dependence of clm3
Wwfc	Width dependence of wfc

Name (Alias)	Description
Wgidl1	Width dependence of gidl1
Wgidl2	Width dependence of gidl2
Wgleak1	Width dependence of gleak1
Wgleak2	Width dependence of gleak2
Wgleak3	Width dependence of gleak3
Wgleak6	Width dependence of gleak6
Wglksd1	Width dependence of glksd1
Wglksd2	Width dependence of glksd2
Wglkb1	Width dependence of glkb1
Wglkb2	Width dependence of glkb2
Wnftrp	Width dependence of nftrp
Wnfalp	Width dependence of nfalp
Wpthrou	Width dependence of pthrou
Wvdiffj	Width dependence of vdiffj
Wibpc1	Width dependence of ibpc1
Wibpc2	Width dependence of ibpc2
Pvmax	Cross-term dependence of vmax
Pbgtmp1	Cross-term dependence of bgtmp1
Pbgtmp2	Cross-term dependence of bgtmp2

Name (Alias)	Description
Peg0	Cross-term dependence of eg0
Pvfbover	Cross-term dependence of vfbover
Pnover	Cross-term dependence of nover
Pnovers	Cross-term dependence of nover on source size
Pwl2	Cross-term dependence of wl2
Pvfbc	Cross-term dependence of vfbc
Pnsubc	Cross-term dependence of nsubc
Pnsubp	Cross-term dependence of nsubp
Pscp1	Cross-term dependence of scp1
Pscp2	Cross-term dependence of scp2
Pscp3	Cross-term dependence of scp3
Psc1	Cross-term dependence of sc1
Psc2	Cross-term dependence of sc2
Psc3	Cross-term dependence of sc3
Ppgd1	Cross-term dependence of pgd1
Ppgd3	Cross-term dependence of pgd3
Pndep	Cross-term dependence of ndep
Pninv	Cross-term dependence of ninv
Pmuecb0	Cross-term dependence of muecb0

Name (Alias)	Description
Pmuecb1	Cross-term dependence of muecb1
Pmueph1	Cross-term dependence of mueph1
Pvtmp	Cross-term dependence of vtmp
Pwvth0	Cross-term dependence of wvth0
Pmuesr1	Cross-term dependence of muesr1
Pmuetmp	Cross-term dependence of muetmp
Psub1	Cross-term dependence of sub1
Psub2	Cross-term dependence of sub2
Psvds	Cross-term dependence of svds
Psvbs	Cross-term dependence of svbs
Psvgs	Cross-term dependence of svgs
Pfn1	Cross-term dependence of fn1
Pfn2	Cross-term dependence of fn2
Pfn3	Cross-term dependence of fn3
Pfvbs	Cross-term dependence of fvbs
Pnsti	Cross-term dependence of nsti
Pwsti	Cross-term dependence of wsti
Pscsti1	Cross-term dependence of scsti1
Pscsti2	Cross-term dependence of scsti2

Name (Alias)	Description
Pvthsti	Cross-term dependence of vthsti
Pmuesti1	Cross-term dependence of muesti1
Pmuesti2	Cross-term dependence of muesti2
Pmuesti3	Cross-term dependence of muesti3
Pnsubpsti1	Cross-term dependence of nsubpsti1
Pnsubpsti2	Cross-term dependence of nsubpsti2
Pnsubpsti3	Cross-term dependence of nsubpsti3
Pcgso	Cross-term dependence of cgso
Pcgdo	Cross-term dependence of cgdo
Pjs0	Cross-term dependence of js0
Pjs0sw	Cross-term dependence of js0sw
Pnj	Cross-term dependence of nj
Pcisbk	Cross-term dependence of cisbk
Pclm1	Cross-term dependence of clm1
Pclm2	Cross-term dependence of clm2
Pclm3	Cross-term dependence of clm3
Pwfc	Cross-term dependence of wfc
Pgidl1	Cross-term dependence of gidl1
Pgidl2	Cross-term dependence of gidl2

Name (Alias)	Description
Pgleak1	Cross-term dependence of gleak1
Pgleak2	Cross-term dependence of gleak2
Pgleak3	Cross-term dependence of gleak3
Pgleak6	Cross-term dependence of gleak6
Pglksd1	Cross-term dependence of glksd1
Pglksd2	Cross-term dependence of glksd2
Pglkb1	Cross-term dependence of glkb1
Pglkb2	Cross-term dependence of glkb2
Pnftrp	Cross-term dependence of nftrp
Pnfalp	Cross-term dependence of nfalp
Ppthrou	Cross-term dependence of pthrou
Pvdiffj	Cross-term dependence of vdiffj
Pibpc1	Cross-term dependence of ibpc1
Pibpc2	Cross-term dependence of ibpc2
Vgs_max	Maximum gate to source voltage (TSMC SOA warning)
Vgd_max	Maximum gate to drain voltage (TSMC SOA warning)
Vds_max	Maximum drain to source voltage (TSMC SOA warning)
Vbd_max	Maximum bulk to drain voltage (TSMC SOA warning)
Vbs_max	Maximum bulk to substrate voltage (TSMC SOA warning)

The following parameters are additionally available in HiSIM_HV 1.12 model:

Name (Alias)	Description
Coqovsm	Select smoothing method of Qover
Shemax	Maximum rise temperature for SHE [C]

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

> *model modelName HiSIM_HV [parm=value]**

Example:

> *model Nch HiSIM_HV Version=1.12 Tox=2.15e-9*

Instance Parameters

Name (Alias)	Description
Temp	Device operating temperature
Trise (Dtemp)	Temperature rise over ambient
Mode	Nonlinear spectral model on/off
Noise	Noise generation on/off
L	Length
W	Width
Ad	Drain area
As	Source area
Pd	Drain perimeter

Name (Alias)	Description
Ps	Source perimeter
Nrd	Number of squares in drain
Nrs	Number of squares in source
Off	Device is initially off
Corbnet	Activate body resistance (1) or not (0)
Rbpb	
Rbpd	
Rbps	
Rbdb	
Rbsb	
Corg	Activate gate resistance (1) or not (0)
Ngcon	Number of gate contacts
Xgw	Distance from gate contact to channel edge
Xgl	Offset of gate length due to variation in patterning
Nf	Number of fingers
Sa	Distance from STI edge to Gate edge [m]
Sb	Distance from STI edge to Gate edge \m]
Sd	Distance from Gate edge to Gate edge \m]
Nsubcdfm	Constant part of Nsub for DFM \1/cm^3]

Name (Alias)	Description
M	Multiplication factor [-]
Subld1	Parameter for impact-ionization current in the drift region [-]
Subld2	Parameter for impact-ionization current in the drift region [m^{-1}*V^{3/2}]
Lover	Overlap length on source side [m]
Lovers	Overlap length on source side [m]
Loverld	Overlap length on drain side [m]
Ldrift1	Parameter for drift region length-1 [m]
Ldrift2	Parameter for drift region length-2 [m]
Ldrift1s	Parameter for drift region length-1 on souce side[m]
Ldrift2s	Parameter for drift region length-2 on souce side[m]

Instance Netlist Format

> *modelName [:Name] d g s b*

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example

> *Nch7:M1 2 1 0 0 W=10u L=0.9u*

HiSIM_HV_1_2 (HiSIM_HV Version 1.2, 1.22 Model and Instance)

HiSIM_HV_1_2 (HiSIM_HV Version 1.2, 1.22 Model and Instance)

The following topic lists the HiSIM_HV 1.2 and 1.22 model and instance parameters.

Model Parameters

Name (Alias)	Description
Gender	+1=N-type, -1=P-type
Tnom	Parameter measurement temperature
Secured	Secured model parameters
Info	Information level (for debug, etc.)
Noise	Noise model selector
Version	Model version
Show	Show physical value
Corsrd	Handling of Rs and Rd
Corg	Activate gate resistance (1) or not (0)
Coiprv	Use ids_prv as initial guess of Ids (internal flag)
Copprv	Use ps{0/l}_prv as initial guess of Ps{0/l} (internal flag)
Coadov	Add overlap to intrisic
Coisub	Calculate isub
Coiigs	Calculate igate

Name (Alias)	Description
Cogidl	Calculate igidl
Coovlp	Calculate overlap charge on the drain side
Coovlps	Calculate overlap charge on the source side
Coflick	Calculate 1/f noise
Coisti	Calculate STI
Conqs	Calculate in nqs mode or qs mode
Corbnet	
Cothrml	Calculate thermal noise
Coign	Calculate induced gate noise
Codfm	Calculation of model for DFM
Coselfheat	Calculation of self heating model
Cosym	Model selector for symmetry device
Vbsmin	Minimum back bias voltage to be treated in hsmhveval [V]
Vmax	Saturation velocity [cm/s]
Bgtmp1	First order temp. coeff. for band gap [V/K]
Bgtmp2	Second order temp. coeff. for band gap [V/K^2]
Eg0	
Tox	Oxide thickness [m]
Xld	Lateral diffusion of S/D under the gate [m]

Name (Alias)	Description
Xldld	Lateral diffusion of Drain under the gate [m]
Lover	Overlap length on source side [m], alias for lovers
Lovers	Overlap length on source side [m]
Rdov11	Dependence coeff. for overlap length
Rdov12	Dependence coeff. for overlap length
Rdov13	Dependence coeff. for overlap length
Rdslp1	LDRIFT1 dependence of resistance for CORSRD=1,3
Rdict1	LDRIFT1 dependence of resistance for CORSRD=1,3
Rdslp2	LDRIFT2 dependence of resistance for CORSRD=1,3
Rdict2	LDRIFT2 dependence of resistance for CORSRD=1,3
Loverld	Overlap length on the drain side
Ldrift1	Drift region length-1 on the drain side[m]
Ldrift2	Drift region length-2 on the drain side[m]
Ldrift1s	Drift region length-1 on the source side[m]
Ldrift2s	Drift region length-2 on the source side[m]
Subld1	Impact-ionization current in the drift region [-]
Subld2	Impact-ionization current in the drift region [m^{-1}*V^{3/2}]
Ddltmax	
Ddltslp	

Name (Alias)	Description
Ddltict	
Vfbover	
Nover	
Novers	
Xwd	Lateral diffusion along the width dir. [m]
Xl	Gate length offset due to mask/etch effect [m]
Xw	Gate width offset due to mask/etch effect [m]
Saref	Reference distance from STI edge to Gate edge [m]
Sbref	Reference distance from STI edge to Gate edge [m]
Ll	Gate length parameter
Lld	Gate length parameter
Lln	Gate length parameter
Wl	Gate width parameter
Wl1	Gate width parameter
Wl1p	Gate width parameter
Wl2	Gate width parameter
Wl2p	Gate width parameter
Wld	Gate width parameter
Wln	Gate width parameter

Name (Alias)	Description
Xqy	[m]
Xqy1	[F m^{XQY2}]
Xqy2	[-]
Rs	Source contact resistance [ohm m]
Rd	Drain contact resistance [ohm m]
Rsh	Source/drain diffusion sheet resistance [ohm]
Rshg	Gate-elecrode sheet resistance
Vfbc	Constant part of Vfb [V]
Vbi	Built-in potential [V]
Nsubc	Constant part of Nsub [1/cm^3]
Parl2	Under diffusion [m]
Lp	Length of pocket potential [m]
Nsubp	[1/cm^3]
Nsubp0	Pocket implant parameter
Nsubwp	Pocket implant parameter
Scp1	Parameter for pocket [-]
Scp2	Parameter for pocket [1/V]
Scp3	Parameter for pocket [m/V]
Sc1	Parameter for SCE [-]

Name (Alias)	Description
Sc2	Parameter for SCE [1/V]
Sc3	Parameter for SCE [m/V]
Sc4	Parameter for SCE [1/V]
Pgd1	Parameter for gate-poly depletion [V]
Pgd2	Parameter for gate-poly depletion [V]
Pgd3	Parameter for gate-poly depletion [-]
Pgd4	Parameter for gate-poly depletion [-]
Ndep	Coeff. of Qbm for Eeff [-]
Ndepl	Coeff. of Qbm for Eeff [-]
Ndeplp	Coeff. of Qbm for Eeff [-]
Ninv	Coeff. of Qnm for Eeff [-]
Ninvd	Modification of Vdse dependence on Eeff [1/V]
Muecb0	Const. part of coulomb scattering [cm^2/Vs]
Muecb1	Coeff. for coulomb scattering [cm^2/Vs]
Mueph0	Power of Eeff for phonon scattering [-]
Mueph1	
Muephw	
Muepwp	Phonon scattering parameter
Muephl	Phonon scattering parameter

Name (Alias)	Description
Mueplp	Phonon scattering parameter
Muephs	
Muepsp	
Vtmp	
Wvth0	
Muesr0	Power of Eeff for S.R. scattering [-]
Muesr1	Coeff. for S.R. scattering [-]
Muesrl	Surface roughness parameter
Muesrw	Change of surface roughness related mobility
Mueswp	Change of surface roughness related mobility
Mueslp	Surface roughness parameter
Muetmp	Parameter for mobility [-]
Bb	Empirical mobility model coefficient [-]
Sub1	Parameter for Isub [1/V]
Sub2	Parameter for Isub [V]
Svgs	Coefficient for Vg of Psislsat
Svbs	Coefficient for Vbs of Psislsat
Svbsl	
Svds	

Name (Alias)	Description
Slg	
Sub1l	
Sub2l	
Fn1	
Fn2	
Fn3	
Fvbs	
Svgsl	
Svgslp	
Svgswp	
Svgsw	
Svbslp	
Slgl	
Slglp	
Sub1lp	
Nsti	Parameter for STI [1/cm^3]
Wsti	Parameter for STI [m]
Wstil	Parameter for STI [?]
Wstilp	Parameter for STI [?]

Name (Alias)	Description
Wstiw	Parameter for STI [?]
Wstiwp	Parameter for STI [?]
Scsti1	Parameter for STI [-]
Scsti2	Parameter for STI [1/V]
Vthsti	Parameter for STI
Vdsti	Parameter for STI [-]
Muesti1	STI Stress mobility parameter
Muesti2	STI Stress mobility parameter
Muesti3	STI Stress mobility parameter
Nsubpsti1	STI Stress pocket implant parameter
Nsubpsti2	STI Stress pocket implant parameter
Nsubpsti3	STI Stress pocket implant parameter
Lpext	Pocket extension
Npext	Pocket extension
Scp22	
Scp21	
Bs1	
Bs2	
Cgso	G-S overlap capacitance per unit W [F/m]

Name (Alias)	Description
Cgdo	G-D overlap capacitance per unit W [F/m]
Cgbo	G-B overlap capacitance per unit L [F/m]
Tpoly	Height of poly gate on the source side[m]
Js0	Saturation current density [A/m^2]
Js0sw	Side wall saturation current density [A/m]
Nj	Emission coefficient [-]
Njsw	Sidewall emission coefficient
Xti	Junction current temperature exponent coefficient [-]
Cj	Bottom junction capacitance per unit area at zero bias [F/m^2]
Cjsw	Source/drain sidewall junction capacitance grading coefficient per unit length at zero bias [F/m]
Cjswg	Source/drain gate sidewall junction capacitance per unit length at zero bias [F/m]
Mj	Bottom junction capacitance grading coefficient
Mjsw	Source/drain sidewall junction capacitance grading coefficient
Mjswg	Source/drain gate sidewall junction capacitance grading coefficient
Pb	Bottom junction build-in potential [V]
Pbsw	Source/drain sidewall junction build-in potential [V]
Pbswg	Source/drain gate sidewall junction build-in potential [V]
Xti2	Temperature coefficient [-]

Name (Alias)	Description
Cisb	Reverse bias saturation current [-]
Cvb	Bias dependence coefficient of cisb [-]
Ctemp	Temperature coefficient [-]
Cisbk	Reverse bias saturation current [A]
Cvbk	Bias dependence coefficient of cisb [-]
Divx	[1/V]
Clm1	Parameter for CLM [-]
Clm2	Parameter for CLM [1/m]
Clm3	Parameter for CLM [-]
Clm5	Parameter for CLM [-]
Clm6	Parameter for CLM [um^{-clm5}]
Vover	Parameter for overshoot [m^{voverp}]
Voverp	Parameter for overshoot [-]
Vovers	Parameter for overshoot [-]
Voversp	Parameter for overshoot [-]
Wfc	Parameter for narrow channel effect [m*F/(cm^2)]
Nsubcw	Parameter for narrow channel effect
Nsubcwp	Parameter for narrow channel effect
Qme1	Parameter for quantum effect [mV]

Name (Alias)	Description
Qme2	Parameter for quantum effect [V]
Qme3	Parameter for quantum effect [m]
Gidl1	Parameter for GIDL [?]
Gidl2	Parameter for GIDL [?]
Gidl3	Parameter for GIDL [?]
Gidl4	Parameter for GIDL [?]
Gidl5	Parameter for GIDL [?]
Glpart1	Parameter for gate current [-]
Gleak1	Parameter for gate current [A*V^(-3/2)/C]
Gleak2	Parameter for gate current [V^(-1/2)/m]
Gleak3	Parameter for gate current [-]
Gleak4	Parameter for gate current [1/m]
Gleak5	Parameter for gate current [V/m]
Gleak6	Parameter for gate current [V]
Gleak7	Parameter for gate current [m^2]
Glksd1	Parameter for gate current [A*m/V^2]
Glksd2	Parameter for gate current [1/(V*m)]
Glksd3	Parameter for gate current [1/m]
Glkb1	Parameter for gate current [A/V^2]

Name (Alias)	Description
Glkb2	Parameter for gate current [m/V]
Glkb3	Parameter for gate current [V]
Egig	Parameter for gate current [V]
Igtemp2	Parameter for gate current [V*k]
Igtemp3	Parameter for gate current [V*k^2]
Vzadd0	Vzadd at Vds=0 [V]
Pzadd0	Pzadd at Vds=0 [V]
Nftrp	
Nfalp	
Cit	
Falph	Parameter for 1/f noise
Kappa	Dielectric constant for high-k stacked gate
Pthrou	Modify subthreshold slope [-]
Vdiffj	Threshold voltage for S/D junction diode [V]
Dly1	Parameter for transit time [-]
Dly2	Parameter for transit time [-]
Dly3	Parameter for transforming bulk charge [s/F]
Dlyov	Parameter for transforming overlap charge [s/F]
Ovslp	

Name (Alias)	Description
Ovmag	
Gbmin	
Rbpb	
Rbpd	
Rbps	
Rbdb	
Rbsb	
Ibpc1	Parameter for impact-ionization induced bulk potential change
Ibpc2	Parameter for impact-ionization induced bulk potential change
Mphdfm	NSUBCDFM dependence of phonon scattering for DFM
Rdvg11	
Rdvg12	
Rth0	Thermal resistance
Cth0	Thermal capacitance
Powrat	
Tcjbd	Temperature dependence of cjbd
Tcjbs	Temperature dependence of cjbs
Tcjbdsw	Temperature dependence of cjbdsw
Tcjbssw	Temperature dependence of cjbssw

Name (Alias)	Description
Tcjbdswg	Temperature dependence of cjbdswg
Tcjbsswg	Temperature dependence of cjbsswg
Qdftvd	Qdrift Vd dependence
Rdvd	
Rdvb	
Rd20	
Rd21	
Rd22	
Rd22d	
Rd23	
Rd24	
Rd25	
Rd26	alias for qovsm
Rdvdl	
Rdvdlp	
Rdvds	
Rdvdsp	
Rd23l	
Rd23lp	

Name (Alias)	Description
Rd23s	
Rd23sp	
Rds	
Rdsp	
Qovsm	Smoothing Qover at depletion/inversion transition
Ldrift	alias for ldrift2
Rdtemp1	Temperature-dependence of Rd
Rdtemp2	Temperature-dependence of Rd
Rth0r	Heat radiation for SHE
Rdvdtemp1	Temperature-dependence of RDVD
Rdvdtemp2	Temperature-dependence of RDVD
Rth0w	Width-dependence of RTH0
Rth0wp	Width-dependence of RTH0
Rth0nf	nf-dependence of RTH0
Cvdsover	vds drop along the overlap
Lmin	Minimum length for the model
Lmax	Maximum length for the model
Wmin	Minimum width for the model
Wmax	Maximum width for the model

Name (Alias)	Description
Lbinn	L modulation coefficient for binning
Wbinn	W modulation coefficient for binning
Lvmax	Length dependence of vmax
Lbgtmp1	Length dependence of bgtmp1
Lbgtmp2	Length dependence of bgtmp2
Leg0	Length dependence of eg0
Lvfbover	Length dependence of vfbover
Lnover	Length dependence of nover
Lnovers	Length dependence of nover on source size
Lwl2	Length dependence of wl2
Lvfbc	Length dependence of vfbc
Lnsubc	Length dependence of nsubc
Lnsubp	Length dependence of nsubp
Lscp1	Length dependence of scp1
Lscp2	Length dependence of scp2
Lscp3	Length dependence of scp3
Lsc1	Length dependence of sc1
Lsc2	Length dependence of sc2
Lsc3	Length dependence of sc3

Name (Alias)	Description
Lpgd1	Length dependence of pgd1
Lpgd3	Length dependence of pgd3
Lndep	Length dependence of ndep
Lninv	Length dependence of ninv
Lmuecb0	Length dependence of muecb0
Lmuecb1	Length dependence of muecb1
Lmueph1	Length dependence of mueph1
Lvtmp	Length dependence of vtmp
Lwvth0	Length dependence of wvth0
Lmuesr1	Length dependence of muesr1
Lmuetmp	Length dependence of muetmp
Lsub1	Length dependence of sub1
Lsub2	Length dependence of sub2
Lsvds	Length dependence of svds
Lsvbs	Length dependence of svbs
Lsvgs	Length dependence of svgs
Lfn1	Length dependence of fn1
Lfn2	Length dependence of fn2
Lfn3	Length dependence of fn3

Name (Alias)	Description
Lfvbs	Length dependence of fvbs
Lnsti	Length dependence of nsti
Lwsti	Length dependence of wsti
Lscsti1	Length dependence of scsti1
Lscsti2	Length dependence of scsti2
Lvthsti	Length dependence of vthsti
Lmuesti1	Length dependence of muesti1
Lmuesti2	Length dependence of muesti2
Lmuesti3	Length dependence of muesti3
Lnsubpsti1	Length dependence of nsubpsti1
Lnsubpsti2	Length dependence of nsubpsti2
Lnsubpsti3	Length dependence of nsubpsti3
Lcgso	Length dependence of cgso
Lcgdo	Length dependence of cgdo
Ljs0	Length dependence of js0
Ljs0sw	Length dependence of js0sw
Lnj	Length dependence of nj
Lcisbk	Length dependence of cisbk
Lclm1	Length dependence of clm1

Name (Alias)	Description
Lclm2	Length dependence of clm2
Lclm3	Length dependence of clm3
Lwfc	Length dependence of wfc
Lgidl1	Length dependence of gidl1
Lgidl2	Length dependence of gidl2
Lgleak1	Length dependence of gleak1
Lgleak2	Length dependence of gleak2
Lgleak3	Length dependence of gleak3
Lgleak6	Length dependence of gleak6
Lglksd1	Length dependence of glksd1
Lglksd2	Length dependence of glksd2
Lglkb1	Length dependence of glkb1
Lglkb2	Length dependence of glkb2
Lnftrp	Length dependence of nftrp
Lnfalp	Length dependence of nfalp
Lpthrou	Length dependence of pthrou
Lvdiffj	Length dependence of vdiffj
Libpc1	Length dependence of ibpc1
Libpc2	Length dependence of ibpc2

Name (Alias)	Description
Wvmax	Width dependence of vmax
Wbgtmp1	Width dependence of bgtmp1
Wbgtmp2	Width dependence of bgtmp2
Weg0	Width dependence of eg0
Wvfbover	Width dependence of vfbover
Wnover	Width dependence of nover
Wnovers	Width dependence of novers on source size
Wwl2	Width dependence of wl2
Wvfbc	Width dependence of vfbc
Wnsubc	Width dependence of nsubc
Wnsubp	Width dependence of nsubp
Wscp1	Width dependence of scp1
Wscp2	Width dependence of scp2
Wscp3	Width dependence of scp3
Wsc1	Width dependence of sc1
Wsc2	Width dependence of sc2
Wsc3	Width dependence of sc3
Wpgd1	Width dependence of pgd1
Wpgd3	Width dependence of pgd3

Name (Alias)	Description
Wndep	Width dependence of ndep
Wninv	Width dependence of ninv
Wmuecb0	Width dependence of muecb0
Wmuecb1	Width dependence of muecb1
Wmueph1	Width dependence of mueph1
Wvtmp	Width dependence of vtmp
Wwvth0	Width dependence of wvth0
Wmuesr1	Width dependence of muesr1
Wmuetmp	Width dependence of muetmp
Wsub1	Width dependence of sub1
Wsub2	Width dependence of sub2
Wsvds	Width dependence of svds
Wsvbs	Width dependence of svbs
Wsvgs	Width dependence of svgs
Wfn1	Width dependence of fn1
Wfn2	Width dependence of fn2
Wfn3	Width dependence of fn3
Wfvbs	Width dependence of fvbs
Wnsti	Width dependence of nsti

Name (Alias)	Description
Wwsti	Width dependence of wsti
Wscsti1	Width dependence of scsti1
Wscsti2	Width dependence of scsti2
Wvthsti	Width dependence of vthsti
Wmuesti1	Width dependence of muesti1
Wmuesti2	Width dependence of muesti2
Wmuesti3	Width dependence of muesti3
Wnsubpsti1	Width dependence of nsubpsti1
Wnsubpsti2	Width dependence of nsubpsti2
Wnsubpsti3	Width dependence of nsubpsti3
Wcgso	Width dependence of cgso
Wcgdo	Width dependence of cgdo
Wjs0	Width dependence of js0
Wjs0sw	Width dependence of js0sw
Wnj	Width dependence of nj
Wcisbk	Width dependence of cisbk
Wclm1	Width dependence of clm1
Wclm2	Width dependence of clm2
Wclm3	Width dependence of clm3

Name (Alias)	Description
Wwfc	Width dependence of wfc
Wgidl1	Width dependence of gidl1
Wgidl2	Width dependence of gidl2
Wgleak1	Width dependence of gleak1
Wgleak2	Width dependence of gleak2
Wgleak3	Width dependence of gleak3
Wgleak6	Width dependence of gleak6
Wglksd1	Width dependence of glksd1
Wglksd2	Width dependence of glksd2
Wglkb1	Width dependence of glkb1
Wglkb2	Width dependence of glkb2
Wnftrp	Width dependence of nftrp
Wnfalp	Width dependence of nfalp
Wpthrou	Width dependence of pthrou
Wvdiffj	Width dependence of vdiffj
Wibpc1	Width dependence of ibpc1
Wibpc2	Width dependence of ibpc2
Pvmax	Cross-term dependence of vmax
Pbgtmp1	Cross-term dependence of bgtmp1

Name (Alias)	Description
Pbgtmp2	Cross-term dependence of bgtmp2
Peg0	Cross-term dependence of eg0
Pvfbover	Cross-term dependence of vfbover
Pnover	Cross-term dependence of nover
Pnovers	Cross-term dependence of nover on source size
Pwl2	Cross-term dependence of wl2
Pvfbc	Cross-term dependence of vfbc
Pnsubc	Cross-term dependence of nsubc
Pnsubp	Cross-term dependence of nsubp
Pscp1	Cross-term dependence of scp1
Pscp2	Cross-term dependence of scp2
Pscp3	Cross-term dependence of scp3
Psc1	Cross-term dependence of sc1
Psc2	Cross-term dependence of sc2
Psc3	Cross-term dependence of sc3
Ppgd1	Cross-term dependence of pgd1
Ppgd3	Cross-term dependence of pgd3
Pndep	Cross-term dependence of ndep
Pninv	Cross-term dependence of ninv

Name (Alias)	Description
Pmuecb0	Cross-term dependence of muecb0
Pmuecb1	Cross-term dependence of muecb1
Pmueph1	Cross-term dependence of mueph1
Pvtmp	Cross-term dependence of vtmp
Pwvth0	Cross-term dependence of wvth0
Pmuesr1	Cross-term dependence of muesr1
Pmuetmp	Cross-term dependence of muetmp
Psub1	Cross-term dependence of sub1
Psub2	Cross-term dependence of sub2
Psvds	Cross-term dependence of svds
Psvbs	Cross-term dependence of svbs
Psvgs	Cross-term dependence of svgs
Pfn1	Cross-term dependence of fn1
Pfn2	Cross-term dependence of fn2
Pfn3	Cross-term dependence of fn3
Pfvbs	Cross-term dependence of fvbs
Pnsti	Cross-term dependence of nsti
Pwsti	Cross-term dependence of wsti
Pscsti1	Cross-term dependence of scsti1

Name (Alias)	Description
Pscsti2	Cross-term dependence of scsti2
Pvthsti	Cross-term dependence of vthsti
Pmuesti1	Cross-term dependence of muesti1
Pmuesti2	Cross-term dependence of muesti2
Pmuesti3	Cross-term dependence of muesti3
Pnsubpsti1	Cross-term dependence of nsubpsti1
Pnsubpsti2	Cross-term dependence of nsubpsti2
Pnsubpsti3	Cross-term dependence of nsubpsti3
Pcgso	Cross-term dependence of cgso
Pcgdo	Cross-term dependence of cgdo
Pjs0	Cross-term dependence of js0
Pjs0sw	Cross-term dependence of js0sw
Pnj	Cross-term dependence of nj
Pcisbk	Cross-term dependence of cisbk
Pclm1	Cross-term dependence of clm1
Pclm2	Cross-term dependence of clm2
Pclm3	Cross-term dependence of clm3
Pwfc	Cross-term dependence of wfc
Pgidl1	Cross-term dependence of gidl1

Name (Alias)	Description
Pgidl2	Cross-term dependence of gidl2
Pgleak1	Cross-term dependence of gleak1
Pgleak2	Cross-term dependence of gleak2
Pgleak3	Cross-term dependence of gleak3
Pgleak6	Cross-term dependence of gleak6
Pglksd1	Cross-term dependence of glksd1
Pglksd2	Cross-term dependence of glksd2
Pglkb1	Cross-term dependence of glkb1
Pglkb2	Cross-term dependence of glkb2
Pnftrp	Cross-term dependence of nftrp
Pnfalp	Cross-term dependence of nfalp
Ppthrou	Cross-term dependence of pthrou
Pvdiffj	Cross-term dependence of vdiffj
Pibpc1	Cross-term dependence of ibpc1
Pibpc2	Cross-term dependence of ibpc2
Cosubnode (Cotemp)	Switch tempNode to subNode
Coldrift	selector for Ldrift parameter
Vmaxt1	Saturation velocity coeff. [-]
Vmaxt2	Saturation velocity coeff. [-]

Name (Alias)	Description
Xwdld	Xwdld
Xwdc	Lateral diffusion along the width dir. for capacitance [m]
Ninvdw	Coeff of modification of Vdse dependence on Eeff [-]
Ninvdwp	Coeff of modification of Vdse dependence on Eeff [-]
Ninvdt1	Coeff of modification of Vdse dependence on Eeff [-]
Ninvdt2	Coeff of modification of Vdse dependence on Eeff [-]
Rthtemp1	Thermal Resistance
Rthtemp2	Thermal Resistance
Prattemp1	Prattemp1
Prattemp2	Prattemp2
Rdvsub	model parameter for the substrate effect
Rdvdsub	model parameter for the substrate effect
Ddrift	model parameter for the substrate effect
Vbisub	model parameter for the substrate effect
Nsubsub	model parameter for the substrate effect
Lcgbo	Length dependence of cgbo
Lcvdsover	Length dependence of cvdsover
Lfalph	Length dependence of falph
Lnpext	Length dependence of npext

Name (Alias)	Description
Lpowrat	Length dependence of powrat
Lrd	Length dependence of rd
Lrd22	Length dependence of rd22
Lrd23	Length dependence of rd23
Lrd24	Length dependence of rd24
Lrdict1	Length dependence of rdict1
Lrdov13	Length dependence of rdov13
Lrdslp1	Length dependence of rdslp1
Lrdvb	Length dependence of rdvb
Lrdvd	Length dependence of rdvd
Lrdvg11	Length dependence of rdvg11
Lrs	Length dependence of rs
Lrth0	Length dependence of rth0
Lvover	Length dependence of vover
Wcgbo	Width dependence of cgbo
Wcvdsover	Width dependence of cvdsover
Wfalph	Width dependence of falph
Wnpext	Width dependence of npext
Wpowrat	Width dependence of powrat

Name (Alias)	Description
Wrd	Width dependence of rd
Wrd22	Width dependence of rd22v
Wrd23	Width dependence of rd23
Wrd24	Width dependence of rd24
Wrdict1	Width dependence of rdict1
Wrdov13	Width dependence of rdov13
Wrdslp1	Width dependence of rdslp1
Wrdvb	Width dependence of rdvb
Wrdvd	Width dependence of rdvd
Wrdvg11	Width dependence of rdvg11
Wrs	Width dependence of rs
Wrth0	Width dependence of rth0
Wvover	Width dependence of vover
Pcgbo	Cross-term dependence of cgbo
Pcvdsover	Cross-term dependence of cvdsover
Pfalph	Cross-term dependence of falph
Pnpext	Cross-term dependence of npext
Ppowrat	Cross-term dependence of powrat
Prd	Cross-term dependence of rd

Name (Alias)	Description
Prd22	Cross-term dependence of rd22
Prd23	Cross-term dependence of rd23
Prd24	Cross-term dependence of rd24
Prdict1	Cross-term dependence of rdict1
Prdov13	Cross-term dependence of rdov13
Prdslp1	Cross-term dependence of rdslp1
Prdvb	Cross-term dependence of rdvb
Prdvd	Cross-term dependence of rdvd
Prdvg11	Cross-term dependence of rdvg11
Prs	Cross-term dependence of rs
Prth0	Cross-term dependence of rth0
Pvover	Cross-term dependence of vover
Vgs_max	Maximum gate to source voltage (TSMC SOA warning)
Vgd_max	Maximum gate to drain voltage (TSMC SOA warning)
Vds_max	Maximum drain to source voltage (TSMC SOA warning)
Vbd_max	Maximum bulk to drain voltage (TSMC SOA warning)
Vbs_max	Maximum bulk to substrate voltage (TSMC SOA warning)
Coqovsm	Select smoothing method of Qover
Shemax	Maximum rise temperature for SHE [C]

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName HiSIM_HV [parm=value]*
```

Example:

> *model Nch HiSIM_HV_1_2 Tox=2.15e-9*

Instance Parameters

Name (Alias)	Description
Temp	Device operating temperature
Trise (Dtemp)	Temperature rise over ambient
Mode	Nonlinear spectral model on/off
Noise	Noise generation on/off
L	Length
W	Width
Ad	Drain area
As	Source area
Pd	Drain perimeter
Ps	Source perimeter
Nrd	Number of squares in drain
Nrs	Number of squares in source
Off	Device is initially off

Name (Alias)	Description
Corbnet	Activate body resistance (1) or not (0)
Rbpb	
Rbpd	
Rbps	
Rbdb	
Rbsb	
Corg	Activate gate resistance (1) or not (0)
Ngcon	Number of gate contacts
Xgw	Distance from gate contact to channel edge
Xgl	Offset of gate length due to variation in patterning
Nf	Number of fingers
Sa	Distance from STI edge to Gate edge [m]
Sb	Distance from STI edge to Gate edge [m]
Sd	Distance from Gate edge to Gate edge [m]
Nsubcdfm	Constant part of Nsub for DFM [1/cm^3]
M	Multiplication factor [-]
Subld1	Parameter for impact-ionization current in the drift region [-]
Subld2	Parameter for impact-ionization current in the drift region [m^{-1}*V^{3/2}]
Lover	Overlap length on source side [m]

Name (Alias)	Description
Lovers	Overlap length on source side [m]
Loverld	Overlap length on drain side [m]
Ldrift1	Parameter for drift region length-1 [m]
Ldrift2	Parameter for drift region length-2 [m]
Ldrift1s	Parameter for drift region length-1 on source side[m]
Ldrift2s	Parameter for drift region length-2 on source side[m]
Coselfheat	Calculation of self heating model
Cosubnode	Switch tempNode to subNode

Instance Netlist Format

```
modelName [:Name] d g s b
```

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example

> *Nch7:M1 2 1 0 0 W=10u L=0.9u*

HiSIM_HV_2_0 (HiSIM_HV Version 2.0 Model and Instance)

HiSIM_HV_2_0 (HiSIM_HV Version 2.0 Model and Instance)

The following topic lists the HiSIM_HV 2.0 model and instance parameters.

Model Parameters

Name (Alias)	Description
Gender	+1=N-type, -1=P-type
TnomC	Parameter measurement temperature
Secured	Secured model parameters
Info	Information level (for debug, etc.)
Noise	Noise model selector
Version	Model version
Show	Show physical value
Corsrd	Handling of Rs and Rd
Corg	Activate gate resistance (1) or not (0)
Coiprv	Use ids_prv as initial guess of Ids (internal flag)
Copprv	Use ps{0/l}_prv as initial guess of Ps{0/l} (internal flag)
Coadov	Add overlap to intrisic
Coisub	Calculate isub
Coiigs	Calculate igate

Name (Alias)	Description
Cogidl	Calculate igidl
Coovlp	Calculate overlap charge on the drain side
Coovlps	Calculate overlap charge on the source side
Coflick	Calculate 1/f noise
Coisti	Calculate STI
Conqs	Calculate in nqs mode or qs mode
Corbnet	
Cothrml	Calculate thermal noise
Coign	Calculate induced gate noise
Codfm	Calculation of model for DFM
Coselfheat	Calculation of self heating model
Cosym	Model selector for symmetry device
Vbsmin	Minimum back bias voltage to be treated in hsmhveval [V]
Vmax	Saturation velocity [cm/s]
Bgtmp1	First order temp. coeff. for band gap [V/K]
Bgtmp2	Second order temp. coeff. for band gap [V/K^2]
Eg0	
Tox	Oxide thickness [m]
Xld	Lateral diffusion of S/D under the gate [m]

Name (Alias)	Description
Xldld	Lateral diffusion of Drain under the gate [m]
Lover	Overlap length on source side [m], alias for lovers
Lovers	Overlap length on source side [m]
Rdov11	Dependence coeff. for overlap length
Rdov12	Dependence coeff. for overlap length
Rdov13	Dependence coeff. for overlap length
Rdslp1	LDRIFT1 dependence of resistance for CORSRD=1,3
Rdict1	LDRIFT1 dependence of resistance for CORSRD=1,3
Rdslp2	LDRIFT2 dependence of resistance for CORSRD=1,3
Rdict2	LDRIFT2 dependence of resistance for CORSRD=1,3
Loverld	Overlap length on the drain side
Ldrift1	Drift region length-1 on the drain side[m]
Ldrift2	Drift region length-2 on the drain side[m]
Ldrift1s	Drift region length-1 on the source side[m]
Ldrift2s	Drift region length-2 on the source side[m]
Subld1	Impact-ionization current in the drift region [-]
Subld2	Impact-ionization current in the drift region [m^{-1}*V^{3/2}]
Ddltmax	
Ddltslp	

Name (Alias)	Description
Ddltict	
Vfbover	
Nover	
Novers	
Xwd	Lateral diffusion along the width dir. [m]
Xl	Gate length offset due to mask/etch effect [m]
Xw	Gate width offset due to mask/etch effect [m]
Saref	Reference distance from STI edge to Gate edge [m]
Sbref	Reference distance from STI edge to Gate edge [m]
Ll	Gate length parameter
Lld	Gate length parameter
Lln	Gate length parameter
Wl	Gate width parameter
Wl1	Gate width parameter
Wl1p	Gate width parameter
Wl2	Gate width parameter
Wl2p	Gate width parameter
Wld	Gate width parameter
Wln	Gate width parameter

Name (Alias)	Description
Xqy	[m]
Xqy1	[F m^{XQY2}]
Xqy2	[-]
Rs	Source contact resistance [ohm m]
Rd	Drain contact resistance [ohm m]
Rsh	Source/drain diffusion sheet resistance [ohm]
Rshg	Gate-elecrode sheet resistance
Vfbc	Constant part of Vfb [V]
Vbi	Built-in potential [V]
Nsubc	Constant part of Nsub [1/cm^3]
Parl2	Under diffusion [m]
Lp	Length of pocket potential [m]
Nsubp	[1/cm^3]
Nsubp0	Pocket implant parameter
Nsubwp	Pocket implant parameter
Scp1	Parameter for pocket [-]
Scp2	Parameter for pocket [1/V]
Scp3	Parameter for pocket [m/V]
Sc1	Parameter for SCE [-]

Name (Alias)	Description
Sc2	Parameter for SCE [1/V]
Sc3	Parameter for SCE [m/V]
Sc4	Parameter for SCE [1/V]
Pgd1	Parameter for gate-poly depletion [V]
Pgd2	Parameter for gate-poly depletion [V]
Pgd4	Parameter for gate-poly depletion [-]
Ndep	Coeff. of Qbm for Eeff [-]
Ndepl	Coeff. of Qbm for Eeff [-]
Ndeplp	Coeff. of Qbm for Eeff [-]
Ninv	Coeff. of Qnm for Eeff [-]
Ninvd	Modification of Vdse dependence on Eeff [1/V]
Muecb0	Const. part of coulomb scattering [cm^2/Vs]
Muecb1	Coeff. for coulomb scattering [cm^2/Vs]
Mueph0	Power of Eeff for phonon scattering [-]
Mueph1	
Muephw	
Muepwp	Phonon scattering parameter
Muephl	Phonon scattering parameter
Mueplp	Phonon scattering parameter

Name (Alias)	Description
Muephs	
Muepsp	
Vtmp	
Wvth0	
Muesr0	Power of Eeff for S.R. scattering [-]
Muesr1	Coeff. for S.R. scattering [-]
Muesrl	Surface roughness parameter
Muesrw	Change of surface roughness related mobility
Mueswp	Change of surface roughness related mobility
Mueslp	Surface roughness parameter
Muetmp	Parameter for mobility [-]
Bb	Empirical mobility model coefficient [-]
Sub1	Parameter for Isub [1/V]
Sub2	Parameter for Isub [V]
Svgs	Coefficient for Vg of Psislsat
Svbs	Coefficient for Vbs of Psislsat
Svbsl	
Svds	
Slg	

Name (Alias)	Description
Sub1l	
Sub2l	
Fn1	
Fn2	
Fn3	
Fvbs	
Svgsl	
Svgslp	
Svgswp	
Svgsw	
Svbslp	
Slgl	
Slglp	
Sub1lp	
Nsti	Parameter for STI [1/cm^3]
Wsti	Parameter for STI [m]
Wstil	Parameter for STI [?]
Wstilp	Parameter for STI [?]
Wstiw	Parameter for STI [?]

Name (Alias)	Description
Wstiwp	Parameter for STI [?]
Scsti1	Parameter for STI [-]
Scsti2	Parameter for STI [1/V]
Vthsti	Parameter for STI
Vdsti	Parameter for STI [-]
Muesti1	STI Stress mobility parameter
Muesti2	STI Stress mobility parameter
Muesti3	STI Stress mobility parameter
Nsubpsti1	STI Stress pocket implant parameter
Nsubpsti2	STI Stress pocket implant parameter
Nsubpsti3	STI Stress pocket implant parameter
Lpext	Pocket extension
Npext	Pocket extension
Scp22	
Scp21	
Bs1	
Bs2	
Cgso	G-S overlap capacitance per unit W [F/m]
Cgdo	G-D overlap capacitance per unit W [F/m]

Name (Alias)	Description
Cgbo	G-B overlap capacitance per unit L [F/m]
Tpoly	Height of poly gate on the source side[m]
Js0	Saturation current density [A/m^2]
Js0sw	Side wall saturation current density [A/m]
Nj	Emission coefficient [-]
Njsw	Sidewall emission coefficient
Xti	Junction current temperature exponent coefficient [-]
Cj	Bottom junction capacitance per unit area at zero bias [F/m^2]
Cjsw	Source/drain sidewall junction capacitance grading coefficient per unit length at zero bias [F/m]
Cjswg	Source/drain gate sidewall junction capacitance per unit length at zero bias [F/m]
Mj	Bottom junction capacitance grading coefficient
Mjsw	Source/drain sidewall junction capacitance grading coefficient
Mjswg	Source/drain gate sidewall junction capacitance grading coefficient
Pb	Bottom junction build-in potential [V]
Pbsw	Source/drain sidewall junction build-in potential [V]
Pbswg	Source/drain gate sidewall junction build-in potential [V]
Xti2	Temperature coefficient [-]
Cisb	Reverse bias saturation current [-]

Name (Alias)	Description
Cvb	Bias dependence coefficient of cisb [-]
Ctemp	Temperature coefficient [-]
Cisbk	Reverse bias saturation current [A]
Cvbk	Bias dependence coefficient of cisb [-]
Divx	[1/V]
Clm1	Parameter for CLM [-]
Clm2	Parameter for CLM [1/m]
Clm3	Parameter for CLM [-]
Clm5	Parameter for CLM [-]
Clm6	Parameter for CLM [um^{-clm5}]
Vover	Parameter for overshoot [m^{voverp}]
Voverp	Parameter for overshoot [-]
Vovers	Parameter for overshoot [-]
Voversp	Parameter for overshoot [-]
Wfc	Parameter for narrow channel effect [m*F/(cm^2)]
Nsubcw	Parameter for narrow channel effect
Nsubcwp	Parameter for narrow channel effect
Qme1	Parameter for quantum effect [mV]
Qme2	Parameter for quantum effect [V]

Name (Alias)	Description
Qme3	Parameter for quantum effect [m]
Gidl1	Parameter for GIDL [?]
Gidl2	Parameter for GIDL [?]
Gidl3	Parameter for GIDL [?]
Gidl4	Parameter for GIDL [?]
Gidl5	Parameter for GIDL [?]
Glpart1	Parameter for gate current [-]
Gleak1	Parameter for gate current [A*V^(-3/2)/C]
Gleak2	Parameter for gate current [V^(-1/2)/m]
Gleak3	Parameter for gate current [-]
Gleak4	Parameter for gate current [1/m]
Gleak5	Parameter for gate current [V/m]
Gleak6	Parameter for gate current [V]
Gleak7	Parameter for gate current [m^2]
Glksd1	Parameter for gate current [A*m/V^2]
Glksd2	Parameter for gate current [1/(V*m)]
Glksd3	Parameter for gate current [1/m]
Glkb1	Parameter for gate current [A/V^2]
Glkb2	Parameter for gate current [m/V]

Name (Alias)	Description
Glkb3	Parameter for gate current [V]
Egig	Parameter for gate current [V]
Igtemp2	Parameter for gate current [V*k]
Igtemp3	Parameter for gate current [V*k^2]
Vzadd0	Vzadd at Vds=0 [V]
Pzadd0	Pzadd at Vds=0 [V]
Nftrp	
Nfalp	
Cit	
Falph	Parameter for 1/f noise
Kappa	Dielectric constant for high-k stacked gate
Vdiffj	Threshold voltage for S/D junction diode [V]
Dly1	Parameter for transit time [-]
Dly2	Parameter for transit time [-]
Dly3	Parameter for transforming bulk charge [s/F]
Dlyov	Parameter for transforming overlap charge [s/F]
Ovslp	
Ovmag	
Gbmin	

Name (Alias)	Description
Rbpb	
Rbpd	
Rbps	
Rbdb	
Rbsb	
Ibpc1	Parameter for impact-ionization induced bulk potential change
Ibpc2	Parameter for impact-ionization induced bulk potential change
Mphdfm	NSUBCDFM dependence of phonon scattering for DFM
Rdvg11	
Rdvg12	
Rth0	Thermal resistance
Cth0	Thermal capacitance
Powrat	
Tcjbd	Temperature dependence of cjbd
Tcjbs	Temperature dependence of cjbs
Tcjbdsw	Temperature dependence of cjbdsw
Tcjbssw	Temperature dependence of cjbssw
Tcjbdswg	Temperature dependence of cjbdswg
Tcjbsswg	Temperature dependence of cjbsswg

Name (Alias)	Description
Qdftvd	Qdrift Vd dependence
Rdvd	
Rdvb	
Rd20	
Rd21	
Rd22	
Rd22d	
Rd23	
Rd24	
Rd25	
Rdvdl	
Rdvdlp	
Rdvds	
Rdvdsp	
Rd23l	
Rd23lp	
Rd23s	
Rd23sp	
Rds	

Name (Alias)	Description
Rdsp	
Qovsm	Smoothing Qover at depletion/inversion transition
Ldrift	alias for ldrift2
Rdtemp1	Temperature-dependence of Rd
Rdtemp2	Temperature-dependence of Rd
Rth0r	Heat radiation for SHE
Rdvdtemp1	Temperature-dependence of RDVD
Rdvdtemp2	Temperature-dependence of RDVD
Rth0w	Width-dependence of RTH0
Rth0wp	Width-dependence of RTH0
Rth0nf	nf-dependence of RTH0
Cvdsover	vds drop along the overlap
Lmin	Minimum length for the model
Lmax	Maximum length for the model
Wmin	Minimum width for the model
Wmax	Maximum width for the model
Lbinn	L modulation coefficient for binning
Wbinn	W modulation coefficient for binning
Lvmax	Length dependence of vmax

Name (Alias)	Description
Lbgtmp1	Length dependence of bgtmp1
Lbgtmp2	Length dependence of bgtmp2
Leg0	Length dependence of eg0
Lvfbover	Length dependence of vfbover
Lnover	Length dependence of nover
Lnovers	Length dependence of nover on source size
Lwl2	Length dependence of wl2
Lvfbc	Length dependence of vfbc
Lnsubc	Length dependence of nsubc
Lnsubp	Length dependence of nsubp
Lscp1	Length dependence of scp1
Lscp2	Length dependence of scp2
Lscp3	Length dependence of scp3
Lsc1	Length dependence of sc1
Lsc2	Length dependence of sc2
Lsc3	Length dependence of sc3
Lpgd1	Length dependence of pgd1
Lndep	Length dependence of ndep
Lninv	Length dependence of ninv

Name (Alias)	Description
Lmuecb0	Length dependence of muecb0
Lmuecb1	Length dependence of muecb1
Lmueph1	Length dependence of mueph1
Lvtmp	Length dependence of vtmp
Lwvth0	Length dependence of wvth0
Lmuesr1	Length dependence of muesr1
Lmuetmp	Length dependence of muetmp
Lsub1	Length dependence of sub1
Lsub2	Length dependence of sub2
Lsvds	Length dependence of svds
Lsvbs	Length dependence of svbs
Lsvgs	Length dependence of svgs
Lfn1	Length dependence of fn1
Lfn2	Length dependence of fn2
Lfn3	Length dependence of fn3
Lfvbs	Length dependence of fvbs
Lnsti	Length dependence of nsti
Lwsti	Length dependence of wsti
Lscsti1	Length dependence of scsti1

Name (Alias)	Description
Lscsti2	Length dependence of scsti2
Lvthsti	Length dependence of vthsti
Lmuesti1	Length dependence of muesti1
Lmuesti2	Length dependence of muesti2
Lmuesti3	Length dependence of muesti3
Lnsubpsti1	Length dependence of nsubpsti1
Lnsubpsti2	Length dependence of nsubpsti2
Lnsubpsti3	Length dependence of nsubpsti3
Lcgso	Length dependence of cgso
Lcgdo	Length dependence of cgdo
Ljs0	Length dependence of js0
Ljs0sw	Length dependence of js0sw
Lnj	Length dependence of nj
Lcisbk	Length dependence of cisbk
Lclm1	Length dependence of clm1
Lclm2	Length dependence of clm2
Lclm3	Length dependence of clm3
Lwfc	Length dependence of wfc
Lgidl1	Length dependence of gidl1

Name (Alias)	Description
Lgidl2	Length dependence of gidl2
Lgleak1	Length dependence of gleak1
Lgleak2	Length dependence of gleak2
Lgleak3	Length dependence of gleak3
Lgleak6	Length dependence of gleak6
Lglksd1	Length dependence of glksd1
Lglksd2	Length dependence of glksd2
Lglkb1	Length dependence of glkb1
Lglkb2	Length dependence of glkb2
Lnftrp	Length dependence of nftrp
Lnfalp	Length dependence of nfalp
Lvdiffj	Length dependence of vdiffj
Libpc1	Length dependence of ibpc1
Libpc2	Length dependence of ibpc2
Wvmax	Width dependence of vmax
Wbgtmp1	Width dependence of bgtmp1
Wbgtmp2	Width dependence of bgtmp2
Weg0	Width dependence of eg0
Wvfbover	Width dependence of vfbover

Name (Alias)	Description
Wnover	Width dependence of nover
Wnovers	Width dependence of novers on source size
Wwl2	Width dependence of wl2
Wvfbc	Width dependence of vfbc
Wnsubc	Width dependence of nsubc
Wnsubp	Width dependence of nsubp
Wscp1	Width dependence of scp1
Wscp2	Width dependence of scp2
Wscp3	Width dependence of scp3
Wsc1	Width dependence of sc1
Wsc2	Width dependence of sc2
Wsc3	Width dependence of sc3
Wpgd1	Width dependence of pgd1
Wndep	Width dependence of ndep
Wninv	Width dependence of ninv
Wmuecb0	Width dependence of muecb0
Wmuecb1	Width dependence of muecb1
Wmueph1	Width dependence of mueph1
Wvtmp	Width dependence of vtmp

Name (Alias)	Description
Wwvth0	Width dependence of wvth0
Wmuesr1	Width dependence of muesr1
Wmuetmp	Width dependence of muetmp
Wsub1	Width dependence of sub1
Wsub2	Width dependence of sub2
Wsvds	Width dependence of svds
Wsvbs	Width dependence of svbs
Wsvgs	Width dependence of svgs
Wfn1	Width dependence of fn1
Wfn2	Width dependence of fn2
Wfn3	Width dependence of fn3
Wfvbs	Width dependence of fvbs
Wnsti	Width dependence of nsti
Wwsti	Width dependence of wsti
Wscsti1	Width dependence of scsti1
Wscsti2	Width dependence of scsti2
Wvthsti	Width dependence of vthsti
Wmuesti1	Width dependence of muesti1
Wmuesti2	Width dependence of muesti2

Name (Alias)	Description
Wmuesti3	Width dependence of muesti3
Wnsubpsti1	Width dependence of nsubpsti1
Wnsubpsti2	Width dependence of nsubpsti2
Wnsubpsti3	Width dependence of nsubpsti3
Wcgso	Width dependence of cgso
Wcgdo	Width dependence of cgdo
Wjs0	Width dependence of js0
Wjs0sw	Width dependence of js0sw
Wnj	Width dependence of nj
Wcisbk	Width dependence of cisbk
Wclm1	Width dependence of clm1
Wclm2	Width dependence of clm2
Wclm3	Width dependence of clm3
Wwfc	Width dependence of wfc
Wgidl1	Width dependence of gidl1
Wgidl2	Width dependence of gidl2
Wgleak1	Width dependence of gleak1
Wgleak2	Width dependence of gleak2
Wgleak3	Width dependence of gleak3

Name (Alias)	Description
Wgleak6	Width dependence of gleak6
Wglksd1	Width dependence of glksd1
Wglksd2	Width dependence of glksd2
Wglkb1	Width dependence of glkb1
Wglkb2	Width dependence of glkb2
Wnftrp	Width dependence of nftrp
Wnfalp	Width dependence of nfalp
Wvdiffj	Width dependence of vdiffj
Wibpc1	Width dependence of ibpc1
Wibpc2	Width dependence of ibpc2
Pvmax	Cross-term dependence of vmax
Pbgtmp1	Cross-term dependence of bgtmp1
Pbgtmp2	Cross-term dependence of bgtmp2
Peg0	Cross-term dependence of eg0
Pvfbover	Cross-term dependence of vfbover
Pnover	Cross-term dependence of nover
Pnovers	Cross-term dependence of nover on source size
Pwl2	Cross-term dependence of wl2
Pvfbc	Cross-term dependence of vfbc

Name (Alias)	Description
Pnsubc	Cross-term dependence of nsubc
Pnsubp	Cross-term dependence of nsubp
Pscp1	Cross-term dependence of scp1
Pscp2	Cross-term dependence of scp2
Pscp3	Cross-term dependence of scp3
Psc1	Cross-term dependence of sc1
Psc2	Cross-term dependence of sc2
Psc3	Cross-term dependence of sc3
Ppgd1	Cross-term dependence of pgd1
Pndep	Cross-term dependence of ndep
Pninv	Cross-term dependence of ninv
Pmuecb0	Cross-term dependence of muecb0
Pmuecb1	Cross-term dependence of muecb1
Pmueph1	Cross-term dependence of mueph1
Pvtmp	Cross-term dependence of vtmp
Pwvth0	Cross-term dependence of wvth0
Pmuesr1	Cross-term dependence of muesr1
Pmuetmp	Cross-term dependence of muetmp
Psub1	Cross-term dependence of sub1

Name (Alias)	Description
Psub2	Cross-term dependence of sub2
Psvds	Cross-term dependence of svds
Psvbs	Cross-term dependence of svbs
Psvgs	Cross-term dependence of svgs
Pfn1	Cross-term dependence of fn1
Pfn2	Cross-term dependence of fn2
Pfn3	Cross-term dependence of fn3
Pfvbs	Cross-term dependence of fvbs
Pnsti	Cross-term dependence of nsti
Pwsti	Cross-term dependence of wsti
Pscsti1	Cross-term dependence of scsti1
Pscsti2	Cross-term dependence of scsti2
Pvthsti	Cross-term dependence of vthsti
Pmuesti1	Cross-term dependence of muesti1
Pmuesti2	Cross-term dependence of muesti2
Pmuesti3	Cross-term dependence of muesti3
Pnsubpsti1	Cross-term dependence of nsubpsti1
Pnsubpsti2	Cross-term dependence of nsubpsti2
Pnsubpsti3	Cross-term dependence of nsubpsti3

Name (Alias)	Description
Pcgso	Cross-term dependence of cgso
Pcgdo	Cross-term dependence of cgdo
Pjs0	Cross-term dependence of js0
Pjs0sw	Cross-term dependence of js0sw
Pnj	Cross-term dependence of nj
Pcisbk	Cross-term dependence of cisbk
Pclm1	Cross-term dependence of clm1
Pclm2	Cross-term dependence of clm2
Pclm3	Cross-term dependence of clm3
Pwfc	Cross-term dependence of wfc
Pgidl1	Cross-term dependence of gidl1
Pgidl2	Cross-term dependence of gidl2
Pgleak1	Cross-term dependence of gleak1
Pgleak2	Cross-term dependence of gleak2
Pgleak3	Cross-term dependence of gleak3
Pgleak6	Cross-term dependence of gleak6
Pglksd1	Cross-term dependence of glksd1
Pglksd2	Cross-term dependence of glksd2
Pglkb1	Cross-term dependence of glkb1

Name (Alias)	Description
Pglkb2	Cross-term dependence of glkb2
Pnftrp	Cross-term dependence of nftrp
Pnfalp	Cross-term dependence of nfalp
Pvdiffj	Cross-term dependence of vdiffj
Pibpc1	Cross-term dependence of ibpc1
Pibpc2	Cross-term dependence of ibpc2
Cosubnode	Switch tempNode to subNode
Cotemp	Model flag for temperature dependence
Coldrift	selector for Ldrift parameter
Vmaxt1	Saturation velocity coeff. [-]
Vmaxt2	Saturation velocity coeff. [-]
Xwdld	Xwdld
Xwdc	Lateral diffusion along the width dir. for capacitance [m]
Ninvdw	Coeff of modification of Vdse dependence on Eeff [-]
Ninvdwp	Coeff of modification of Vdse dependence on Eeff [-]
Ninvdt1	Coeff of modification of Vdse dependence on Eeff [-]
Ninvdt2	Coeff of modification of Vdse dependence on Eeff [-]
Rthtemp1	Thermal Resistance
Rthtemp2	Thermal Resistance

Name (Alias)	Description
Prattemp1	Prattemp1
Prattemp2	Prattemp2
Rdvsub	model parameter for the substrate effect
Rdvdsub	model parameter for the substrate effect
Ddrift	model parameter for the substrate effect
Vbisub	model parameter for the substrate effect
Nsubsub	model parameter for the substrate effect
Lcgbo	Length dependence of cgbo
Lcvdsover	Length dependence of cvdsover
Lfalph	Length dependence of falph
Lnpext	Length dependence of npext
Lpowrat	Length dependence of powrat
Lrd	Length dependence of rd
Lrd22	Length dependence of rd22
Lrd23	Length dependence of rd23
Lrd24	Length dependence of rd24
Lrdict1	Length dependence of rdict1
Lrdov13	Length dependence of rdov13
Lrdslp1	Length dependence of rdslp1

Name (Alias)	Description
Lrdvb	Length dependence of rdvb
Lrdvd	Length dependence of rdvd
Lrdvg11	Length dependence of rdvg11
Lrs	Length dependence of rs
Lrth0	Length dependence of rth0
Lvover	Length dependence of vover
Wcgbo	Width dependence of cgbo
Wcvdsover	Width dependence of cvdsover
Wfalph	Width dependence of falph
Wnpext	Width dependence of npext
Wpowrat	Width dependence of powrat
Wrd	Width dependence of rd
Wrd22	Width dependence of rd22v
Wrd23	Width dependence of rd23
Wrd24	Width dependence of rd24
Wrdict1	Width dependence of rdict1
Wrdov13	Width dependence of rdov13
Wrdslp1	Width dependence of rdslp1
Wrdvb	Width dependence of rdvb

Name (Alias)	Description
Wrdvd	Width dependence of rdvd
Wrdvg11	Width dependence of rdvg11
Wrs	Width dependence of rs
Wrth0	Width dependence of rth0
Wvover	Width dependence of vover
Pcgbo	Cross-term dependence of cgbo
Pcvdsover	Cross-term dependence of cvdsover
Pfalph	Cross-term dependence of falph
Pnpext	Cross-term dependence of npext
Ppowrat	Cross-term dependence of powrat
Prd	Cross-term dependence of rd
Prd22	Cross-term dependence of rd22
Prd23	Cross-term dependence of rd23
Prd24	Cross-term dependence of rd24
Prdict1	Cross-term dependence of rdict1
Prdov13	Cross-term dependence of rdov13
Prdslp1	Cross-term dependence of rdslp1
Prdvb	Cross-term dependence of rdvb
Prdvd	Cross-term dependence of rdvd

Name (Alias)	Description
Prdvg11	Cross-term dependence of rdvg11
Prs	Cross-term dependence of rs
Prth0	Cross-term dependence of rth0
Pvover	Cross-term dependence of vover
Vgs_max	Maximum gate to source voltage (TSMC SOA warning)
Vgd_max	Maximum gate to drain voltage (TSMC SOA warning)
Vds_max	Maximum drain to source voltage (TSMC SOA warning)
Vbd_max	Maximum bulk to drain voltage (TSMC SOA warning)
Vbs_max	Maximum bulk to substrate voltage (TSMC SOA warning)
Coqovsm	
Shemax	Maximum rise temperature for SHE [C]
Cordrift	selector for Rdrift parameter
Coerrrep	selector for error reporting
Subld1l	Impact-ionization current in the drift region [um^{subld1lp}]
Subld1lp	Impact-ionization current in the drift region [-]
Xpdv	Impact-ionization current in the drift region [m^{-1}]
Xpvdth	Impact-ionization current in the drift region [V]
Xpvdthg	Impact-ionization current in the drift region [V^{-1}]
Ibpc1l	Parameter for impact-ionization induced bulk potential change

Name (Alias)	Description
Ibpc1lp	Parameter for impact-ionization induced bulk potential change
Ptl	
Ptp	
Pt2	
Ptlp	
Gdl	
Gdlp	
Gdld	
Pt4	
Pt4p	
Rdrmue	
Rdrvmax	
Rdrmuetmp	
Rdrvtmp	
Rdrcx	
Rdrcar	
Rdrdl1	
Rdrdl2	
Rdrvmaxw	

Name (Alias)	Description
Rdrvmaxwp	
Rdrvmaxl	
Rdrvmaxlp	
Rdrmuel	
Rdrmuelp	
Rdrqover	
Js0d	Saturation current density for drain junction [A/m^2]
Js0swd	Side wall saturation current density for drain junction [A/m]
Njd	Emission coefficient for drain junction [-]
Njswd	Sidewall emission coefficient for drain junction [ ]
Xtid	Junction current temperature exponent coefficient for drain junction [-]
Cjd	Bottom junction capacitance per unit area at zero bias for drain junction [F/m^2]
Cjswd	Sidewall junction capacitance grading coefficient per unit length at zero bias for drain junction [F/m]
Cjswgd	Gate sidewall junction capacitance per unit length at zero bias for drain junction [F/m]
Mjd	Bottom junction capacitance grading coefficient for drain junction [ ]
Mjswd	Sidewall junction capacitance grading coefficient for drain junction [ ]
Mjswgd	Gate sidewall junction capacitance grading coefficient for drain junction [ ]
Pbd	Bottom junction build-in potential for drain junction [V]

Name (Alias)	Description
Pbswd	Sidewall junction build-in potential for drain junction [V]
Pbswgd	Gate sidewall junction build-in potential for drain junction [V]
Xti2d	Temperature coefficient for drain junction [-]
Cisbd	Reverse bias saturation current for drain junction [-]
Cvbd	Bias dependence coefficient of cisb for drain junction [-]
Ctempd	Temperature coefficient for drain junction [-]
Cisbkd	Reverse bias saturation current for drain junction [A]
Divxd	Reverse coefficient coefficient for drain junction [1/V]
Vdiffjd	Threshold voltage for junction diode for drain junction [V]
Js0s	Saturation current density for source junction [A/m^2]
Js0sws	Side wall saturation current density for source junction [A/m]
Njs	Emission coefficient for source junction [-]
Njsws	Sidewall emission coefficient for source junction [ ]
Xtis	Junction current temperature exponent coefficient for source junction [-]
Cjs	Bottom junction capacitance per unit area at zero bias for source junction [F/m^2]
Cjsws	Sidewall junction capacitance grading coefficient per unit length at zero bias for source junction [F/m]
Cjswgs	Gate sidewall junction capacitance per unit length at zero bias for source junction [F/m]
Mjs	Bottom junction capacitance grading coefficient for source junction [ ]

Name (Alias)	Description
Mjsws	Sidewall junction capacitance grading coefficient for source junction [ ]
Mjswgs	Gate sidewall junction capacitance grading coefficient for source junction [ ]
Pbs	Bottom junction build-in potential for source junction [V]
Pbsws	Sidewall junction build-in potential for source junction [V]
Pbswgs	Gate sidewall junction build-in potential for source junction [V]
Xti2s	Temperature coefficient for source junction [-]
Cisbs	Reverse bias saturation current for source junction [-]
Cvbs	Bias dependence coefficient of cisb for source junction [-]
Ctemps	Temperature coefficient for source junction [-]
Cisbks	Reverse bias saturation current for source junction [A]
Divxs Reverse coefficient coefficient for source junction [1/V]	
Vdiffjs	Threshold voltage for junction diode for source junction [V]
Vgsmin	minimal/maximal expected Vgs (NMOS/PMOS) [V]
Gdsleak	Channel leakage conductance [A/V]
Ljs0d	Length dependence of js0d
Ljs0swd	Length dependence of js0swd
Lnjd	Length dependence of njd
Lcisbkd	Length dependence of cisbkd

Name (Alias)	Description
Lvdiffjd	Length dependence of vdiffjd
Ljs0s	Length dependence of js0s
Ljs0sws	Length dependence of js0sws
Lnjs	Length dependence of njs
Lcisbks	Length dependence of cisbks
Lvdiffjs	Length dependence of vdiffjs
Ljs0d	Length dependence of js0d
Ljs0swd	Length dependence of js0swd
Lnjd	Length dependence of njd
Lcisbkd	Length dependence of cisbkd
Lvdiffjd	Length dependence of vdiffjd
Ljs0s	Length dependence of js0s
Ljs0sws	Length dependence of js0sws
Lnjs	Length dependence of njs
Lcisbks	Length dependence of cisbks
Lvdiffjs	Length dependence of vdiffjs
Wjs0d	Width dependence of js0d
Wjs0swd	Width dependence of js0swd
Wnjd	Width dependence of njd

Name (Alias)	Description
Wcisbkd	Width dependence of cisbkd
Wvdiffjd	Width dependence of vdiffjd
Wjs0s	Width dependence of js0s
Wjs0sws	Width dependence of js0sws
Wnjs	Width dependence of njs
Wcisbks	Width dependence of cisbks
Wvdiffjs	Width dependence of vdiffjs
Pjs0d	Cross-term dependence of js0d
Pjs0swd	Cross-term dependence of js0swd
Pnjd	Cross-term dependence of njd
Pcisbkd	Cross-term dependence of cisbkd
Pvdiffjd	Cross-term dependence of vdiffjd
Pjs0s	Cross-term dependence of js0s
Pjs0sws	Cross-term dependence of js0sws
Pnjs	Cross-term dependence of njs
Pcisbks	Cross-term dependence of cisbks
Pvdiffjs	Cross-term dependence of vdiffjs
Rdrdjunc	

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName HiSIM_HV [parm=value]*
```

Example:

> *model Nch HiSIM_HV_2_0 Tox=2.15e-9*

Instance Parameters

Name (Alias)	Description
Temp	Device operating temperature
Trise (Dtemp)	Temperature rise over ambient
Mode	Nonlinear spectral model on/off
Noise	Noise generation on/off
L	Length
W	Width
Ad	Drain area
As	Source area
Pd	Drain perimeter
Ps	Source perimeter
Nrd	Number of squares in drain
Nrs	Number of squares in source
Off	Device is initially off
Corbnet	Activate body resistance (1) or not (0)

Name (Alias)	Description
Rbpb	
Rbpd	
Rbps	
Rbdb	
Rbsb	
Corg	Activate gate resistance (1) or not (0)
Ngcon	Number of gate contacts
Xgw	Distance from gate contact to channel edge
Xgl	Offset of gate length due to variation in patterning
Nf	Number of fingers
Sa	Distance from STI edge to Gate edge [m]
Sb	Distance from STI edge to Gate edge [m]
Sd	Distance from Gate edge to Gate edge [m]
Nsubcdfm	Constant part of Nsub for DFM [1/cm^3]
M	Multiplication factor [-]
Subld1	Parameter for impact-ionization current in the drift region [-]
Subld2	Parameter for impact-ionization current in the drift region [m^{-1}*V^{3/2}]
Lover	Overlap length on source side [m]
Lovers	Overlap length on source side [m]

Name (Alias)	Description
Loverld	Overlap length on drain side [m]
Ldrift1	Parameter for drift region length-1 [m]
Ldrift2	Parameter for drift region length-2 [m]
Ldrift1s	Parameter for drift region length-1 on source side[m]
Ldrift2s	Parameter for drift region length-2 on source side[m]
Coselfheat	Calculation of self heating model
Cosubnode	Switch tempNode to subNode

Instance Netlist Format

`modelName [:Name] d g s b`

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example

> *Nch7:M1 2 1 0 0 W=10u L=0.9u*

HiSIM (HiSIM MOSFET Model and Instance)

HiSIM (HiSIM MOSFET Model and Instance)

The following topic lists the supported versions and the HiSIM model and instance parameters.

Supported Versions

- HiSIM 2.31
- HiSIM 2.41
- HiSIM 2.51 (MOSFET Model and Instance)
- HiSIM 2.60
- HiSIM 2.61
- HiSIM 2.70
- HiSIM 2.91

Model Parameters

Name	Description	Units	Default
Version	model version		231
Gender	transistor type: 1 (N-type) and -1 (P-type)		1
Tox	physical oxide thickness	m	3n
Xld	gate-overlap length	m	0
Xwd	gate-overlap width	m	0
Tpoly	height of the gate poly-Si for fringing capacitance	m	200×10^{-9}
Ll	coefficient of gate length modification		0
Lld	coefficient of gate length modification	m	0
Lln	coefficient of gate length modification		0

Name	Description	Units	Default
Wl	coefficient of gate width modification		0
Wld	coefficient of gate width modification	m	0
Wln	coefficient of gate width modification		0
Nsubc	substrate-impurity concentration	cm^{-3}	5×10^{17}
Nsubp	maximum pocket concentration	cm^{-3}	1×10^{18}
Lp	pocket penetration length	m	15n
Npext	maximum concentration of pocket tail	cm^{-3}	5×10^{17}
Lpext	extension length of pocket tail	m	1×10^{-50}
Vfbc	flat-band voltage	V	-1.0
Vbi	built-in potential	V	1.0
Kappa	dielectric constant for gate dielectric	–	3.9
Eg0	bandgap	eV	1.1785
Bgtmp1	temperature dependence of bandgap	$eV\ K^{-1}$	90.25µ
Bgtmp2	temperature dependence of bandgap	$eV\ K^{-2}$	0.1µ
Tnom	temperature selected as a nominal temperature value	°C	27
Vmax	saturation velocity	$cm\ s^{-1}$	10MEG
Vover	velocity overshoot effect	cm^{Voverp}	0.3
Voverp	L_{eff} dependence of velocity overshoot	–	0.3

Name	Description	Units	Default
Vtmp	temperature dependence of the saturation velocity	cm s^{-1}	0
Qme1	V_{gs} dependence of quantum mechanical effect	V^{-2} m	0
Qme2	V_{gs} dependence of quantum mechanical effect	V	1.0
Qme3	minimum T_{ox} modification	m	0
Pgd1	strength of poly-depletion effect	V	1.0e-4
Pgd2	threshold voltage of poly-depletion effect	V	1.0
Pgd3	V_{ds} dependence of poly-depletion effect	–	0.8
Pgd4	L_{gate} dependence of poly-depletion effect	–	0
Parl2	depletion width of channel/contact junction	m	10n
Sc1	magnitude of short-channel effect	–	1.0
Sc2	V_{bs} dependence of short-channel effect	V^{-1}	1.0
Sc3	V_{bs} dependence of short-channel effect	$V^{-1}m$	0
Scp1	magnitude of short-channel effect due to pocket	–	1.0
Scp2	V_{ds} dependence of short-channel due to pocket	V^{-1}	0.1
Scp3	V_{bs} dependence of short-channel effect due to pocket	$V^{-1}m$	0
Scp21	short-channel-effect modification for small V_{ds}	V	0
Scp22	short-channel-effect modification for small V_{ds}	V^4	0
Bs1	body-coeffcient modifcation by impurity profile	V^2	0

Name	Description	Units	Default
Bs2	body-coeffcient modifcation by impurity profile	V	0.9
Muecb0	Coulomb scattering	$cm^2V^{-1}s^{-1}$	1K
Muecb1	Coulomb scattering	$cm^2V^{-1}s^{-1}$	100
Mueph0	phonon scattering	–	0.3
Mueph1	phonon scattering	$cm^2V^{-1}s^{-1}(V\ cm^{-1})^{Mueph0}$	25K(nMOS), 9K(pMOS)
Muetmp	temperature dependence of phonon scattering	–	1.5
Muephl	length dependence of phonon mobility reduction	–	0
Mueplp	length dependence of phonon mobility reduction	–	1.0
Muesr0	surface-roughness scattering	–	2.0
Muesr1	surface-roughness scattering	$cm^2V^{-1}s^{-1}(V\ cm^{-1})^{Muesr0}$	1×10^{15}
Muesrl	length dependence of surface roughness mobility reduction		0
Mueslp	length dependence of surface roughness mobility reduction		1.0
Ndep	depletion charge contribution on effective-electric field	–	1.0
Ninv	inversion charge contribution on effective-electric field	–	0.5
Bb	high-field-mobility degradation	–	2.0(nMOS), 1.0(pMOS)
Wfc	threshold voltage change due to capacitance change	$F\ cm^{-2}m^{-1}$	0

Name	Description	Units	Default
Wvth0	threshold voltage shift		0
Nsubp0	modification of pocket concentration for narrow width	cm^{-3}	0
Nsubwp	modification of pocket concentration for narrow width		1.0
Muephw	phonon related mobility reduction		0
Muepwp	phonon related mobility reduction		1.0
Muesrw	change of surface roughness related mobility		0
Mueswp	change of surface roughness related mobility		1.0
Vthst1	threshold voltage shift due to Sti		0
Scsti1	the same effect as Sc1 but at Sti edge		0
Scsti2	the same effect as Sc2 but at Sti edge		0
Scsti3	the same effect as Sc3 but at Sti edge		0
Nsti	substrate-impurity concentration at the Sti edge	cm^{-3}	1×10^{17}
Wsti	width of the high-field region at Sti edge	m	0
Wstil	channel-length dependence of Wsti		0
Wstilp	channel-length dependence of Wsti		1.0
Wl1	threshold volatge shift of Sti leakage due to small size effect		0
Wl2	threshold volatge shift of Sti leakage due to small size effect		1.0
Nsubpsti1	pocket concentration change due to diffusion-region length between gate and Sti	m	0

Name	Description	Units	Default
Nsubpsti2	pocket concentration change due to diffusion-region length between gate and Sti	m	0
Nsubpsti3	pocket concentration change due to diffusion-region length between gate and Sti	m	1.0
Muesti1	mobility change due to diffusion-region length between gate and Sti		0
Muesti2	mobility change due to diffusion-region length between gate and Sti		0
Muesti3	mobility change due to diffusion-region length between gate and Sti		1.0
Wl2	threshold volatge shift due to small size effect		0
Wl2p	threshold volatge shift due to small size effect		1.0
Muephs	mobility modification due to small size		0
Muepsp	mobility modification due to small size		1.0
Vovers	modification of maximum velocity due to small size	–	0
Voversp	modification of maximum velocity due to small size	–	0
Clm1	hardness coeffcient of channel/contact junction	–	0.7
Clm2	coeffcient for Q_B contribution	–	2.0
Clm3	coeffcient for Q_I contribution	–	1.0
Clm4	smoothing coeffcient for g_{ds}	V	500×10^{-6}
Clm5	effect of pocket implantation	–	1.0
Clm6	effect of pocket implantation	–	0

Name	Description	Units	Default
Sub1	substrate current coeffcient of magnitude	V^{-1}	10
Sub1l	L_{gate} dependence Sub1	m	2.5×10^{-3}
Sub1lp	L_{gate} dependence Sub1	–	1.0
Sub2	substrate current coeffcient of exponential term	V	25.0
Sub2l	L_{gate} dependence of Sub2	m	2×10^{-6}
Svds	substrate current dependence on V_{ds}	–	0.8
Slg	substrate current dependence on L_{gate}	m	3×10^{-8}
Slgl	substrate current dependence on L_{gate}	m^{Slglp}	0
Slglp	substrate current dependence on L_{gate}	–	1.0
Svbs	substrate current dependence on V_{bs}	–	0.5
Svbsl	L_{gate} dependence of Svbs	m^{Svbslp}	0
Svbslp	L_{gate} dependence of Svbs	–	1.0
Svgs	substrate current dependence on V_{gs}	–	0.8
Svgsl	L_{gate} dependence of Svgs	m^{Svgslp}	0
Svgslp	L_{gate} dependence of Svgs	–	1.0
Svgsw	W_{gate} dependence of Svgs	m^{Svgswp}	0
Svgswp	W_{gate} dependence of Svgs	–	1.0
Ibpc1	impact-ionization induced bulk potential change	$V\ A^{-1}$	0

Name	Description	Units	Default
Ibpc2	impact-ionization induced bulk potential change	V^{-1}	0
Gleak1	gate to channel current coefficient	$A\ V^{-3/2}\ C^{-1}$	50
Gleak2	gate to channel current coefficient	$V^{-1/2}\ m^{-1}$	10MEG
Gleak3	gate to channel current coefficient	–	60×10^{-3}
Gleak4	gate to channel current coefficient	m^{-1}	4.0
Gleak5	gate to channel current coefficient (short channel correction)	$V\ m^{-1}$	7.5×10^{3}
Gleak6	gate to channel current coefficient (V_{ds} dependence correction)	V	250×10^{-3}
Gleak7	gate to channel current coefficient (gate length and width dependence correction)	m^2	1×10^{-6}
Igtemp1	temperature dependence of gate leakage	V	0
Igtemp2	temperature dependence of gate leakage	VK	0
Igtemp3	temperature dependence of gate leakage	VK^2	0
Glksd1	gate to source/drain current coefficient	AmV^{-2}	1f
Glksd2	gate to source/drain current coefficient	$V^{-1}\ m^{-1}$	5MEG
Glksd3	gate to source/drain current coefficient	m^{-1}	-5MEG
Glkb1	gate to bulk current coefficient	$A\ V^{-2}$	5×10^{-16}
Glkb2	gate to bulk current coefficient	$M\ V^{-1}$	1.0
Glpart1	partitioning ratio of gate leakage current	–	0.5

Name	Description	Units	Default
Fn1	coefficient of Fowler-Nordheim current contribution	$V^{-1.5}{\times}m^{2}$	50
Fn2	coefficient of Fowler-Nordheim current contribution	$V^{-0.5}{\times}m^{-1}$	$170{\times}10^{-6}$
Fn3	coefficient of Fowler-Nordheim current contribution	V	0
Fvbs	V_{bs} dependence of Fowler-Nordheim current	–	$12{\times}10^{-3}$
Gidl1	magnitude of Gidl	A $V^{-3/2}$ C^{-1} m	2.0
Gidl2	Field dependence of Gidl	V^{-2} m^{-1} $F^{-3/2}$	$3{\times}10^{7}$
Gidl3	V_{ds} dependence of Gidl	–	0.9
Gidl4	threshold of V_{ds} dependence	V	0.9
Gidl5	correction of high-field contribution	–	0.2
Vzadd0	symmetry conservation coefficient	V	10m
Pzadd0	symmetry conservation coefficient	V	5m
Js0	saturation current density	A m^{-2}	$0.5{\times}10^{-6}$
Js0sw	sidewall saturation current density	A m^{-2}	0
Nj	emission coefficient	–	1.0
Njsw	sidewall emission coefficient	–	1.0
Xti	temperature coefficient for forward current densities	–	2.0
Xti2	temperature coefficient for reverse current densities	–	0

Name	Description	Units	Default
Divx	reverse current coefficient	V^{-1}	0
Ctemp	temperature coefficient of reverse currents	–	0
Cisb	reverse biased saturation current	–	0
Cisbk	reverse biased saturation current (at low temperature)	A	0
Cvb	bias dependence coefficient of Cisb	–	0
Cvbk	bias dependence coefficient of Cisb (at low temperature)	–	0
Cj	bottom junction capacitance per unit area at zero bias	F m^{-2}	$5{\times}10^{-4}$
Cjsw	source/drain sidewall junction cap. grading coefficient per unit length at zero bias	F m^{-1}	$5{\times}10^{-10}$
Cjswg	source/drain sidewall junction capacitance per unit length at zero bias	F m^{-1}	$5{\times}10^{-10}$
Mj	bottom junction capacitance grading coefficient	–	0.5
Mjsw	source/drain sidewall junction capacitance grading coefficient	–	0.33
Mjswg	source/drain gate sidewall junction capacitance grading coefficient	–	0.33
Pb	bottom junction build-in potential	V	1.0
Pbsw	source/drain sidewall junction build-in potential	V	1.0
Pbswg	source/drain gate sidewall junction build-in potential	V	1.0
Vdiffj	diode threshold voltage between source/drain and substrate	V	$0.6{\times}10^{-3}$
Nfalp	contribution of the mobility fluctuation	cm s	$1{\times}10^{-19}$

Name	Description	Units	Default
Nftrp	ratio of trap density to attenuation coefficient	V^{-1} cm^{-2}	10G
Cit	capacitance caused by the interface trapped carriers	F cm^{-2}	0
Pthrou	correction for subthreshold swing	–	0
Dly1	coefficient for delay due to diffusion of carriers	s	100×10^{-12}
Dly2	coefficient for delay due to conduction of carriers	–	0.7
Dly3	coefficient for RC delay of bulk carriers	Ω	0.8×10^{-6}
Xqy	distance from drain junction to maximum electric field point	m	0
Lover	overlap length	m	50n
Ovslp	coefficient for overlap capacitance	–	2.1×10^{-7}
Ovmag	coefficient for overlap capacitance	V	0.6
Cgso	gate-to-source overlap capacitance	F m^{-1}	
Cgdo	gate-to-drain overlap capacitance	F m^{-1}	
Cgbo	gate-to-bulk overlap capacitance	F m^{-1}	0
Rs	source-contact resistance in Ldd region	V A^{-1m}	0
Rd	drain-contact resistance in Ldd region	V A^{-1m}	0
Rsh	source/drain sheet resistance	V $A^{-1square}$	0
Rshg	gate sheet resistance	V $A^{-1square}$	0
Gbmin	substrate resistance network	–	1×10^{-12}

Name	Description	Units	Default
Rbpb	substrate resistance network	Ω	50
Rbpd	substrate resistance network	Ω	50
Rbps	substrate resistance network	Ω	50
Rbdb	substrate resistance network	Ω	50
Rbsb	substrate resistance network	Ω	50

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelName hisim [parm=value]*
```

The model statement starts with the required keyword model. It is followed by the modelName that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is hisim. Use the parameter gender to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

```
model Nch7 hisim Gender=1 Version=231 Tox=2.15e-9
```

Instance Parameters

Name	Description	Units	Default
L	gate length (L_{gate})	m	5μ
W	gate width (W_{gate})	m	5μ

Name	Description	Units	Default
Ad	area of drain junction	m^2	0
As	area of source junction	m^2	0
Pd	perimeter of drain junction	m	0
Ps	perimeter of source junction	m	0
Nrs	number of source squares	m	1
Nrd	number of drain squares	m	1
Xgw	distance from the gate contact to the channel edge	m	0
Xgl	offset of the gate length	m	0
Nf	number of gate fingers	m	1
Ngcon	number of gate contacts	m	1
Corg	gate-contact resistance included		0
Lod	length of diffusion between gate and STI	m	10µ
Temp	device temperature (T)	°C	27
Trise	temperature rise over ambient	°C	0
Corbnet	substrate resistance network invoked		0
Rbpb	substrate resistance network	Ω	50
Rbpd	substrate resistance network	Ω	50
Rbps	substrate resistance network	Ω	50
Rbdb	substrate resistance network	Ω	50

Name	Description	Units	Default
Rbsb	substrate resistance network	Ω	50

Instance Netlist Format

modelName:instanceName D G S B [parm=value]

where D is the drain node, G is the gate node, S is the source node, B is the body (substrate) node.

Example:

Nch7:M1 2 1 0 0 W=10u L=0.9u

Notes/Equations

1. HiSIM model is developed jointly by Hiroshima University and STARC, Copyright 2006. Complete HiSIM user's documentation can be requested from STARC.
2. This hisim model is based on SPICE source code of HiSIM version 2.3.1 provided by STARC. Only version 2.3.1 is available. The Non-Quasi-Static mode is not implemented currently. HiSIM2 source code, and all copyrights, trade secrets or other intellectual property rights in and to the source code in its entirety, is owned by Hiroshima University and STARC.
3. The following table lists the DC operating point parameters that can be sent to the dataset:
   DC Operating Point Parameters

Name	Description	Units
Id	Drain current	A
Ig	Gate current	A
Is	Source current	A
Ib	Body current	A
Power	Total dissipated power	W
Vds	External drain-source voltage	V
Vgs	External gate-source voltage	V
Vbs	External body-source voltage	V

Name	Description	Units
Ids	Internal drain-source current	A
Ibd	Internal body-drain diode current	A
Ibs	Internal body-source diode current	A
Isub	Internal substrate current	A
Igidl	Internal Gate-Induced Drain Leakage current	A
Igs	Internal gate-source current	A
Igd	Internal gate-drain current	A
Igb	Internal gate-body current	A
Vdsat	Drain-source saturation voltage	V
Vth	Threshold voltage	V
Qg	Internal gate charge	C
Qb	Internal body charge	C
Qd	Internal drain charge	C
Qs	Internal source charge	C
Gmbs	Body effect transconductance	S
Gm	Forward transconductance	S
Gmids	Gm/Ids	1/V
Gds	Channel conductance	S
Cgg	dQg/dVgb	F

Name	Description	Units
Cgd	dQg/dVdb	F
Cgs	dQg/dVsb	F
Cbg	dQb/dVgb	F
Cbd	dQb/dVdb	F
Cbs	dQb/dVsb	F
Cdg	dQd/dVgb	F
Cdd	dQd/dVdb	F
Cds	dQd/dVsb	F

HiSIM 2 (HiSIM 2.31 and 2.41 Model and Instance)

HiSIM 2 (HiSIM 2.31 and 2.41 Model and Instance)

Model Parameters

The following topic lists the HiSIM 2.31 and 2.41 model and instance parameters.

The maximum and minimum limits of the model parameter are recommended values. These values may be violated in some specific cases.
Items with * indicate minor parameters.

Basic Device Parameters

Parameter	Description	Units	Min	Max	Default	Remarks
TOX	physical oxide thickness	m			3n	
XL	difference between real and drawn gate length	m			0	
XW	difference between real and drawn gate width	m			0	
XLD	gate-overlap length	m	0	50n	0	
XWD	gate-overlap length	m	-10n	100n	0	
TPOLY	height of the gate poly-Si for fringing capacitance	m			200×10^{-9}	
LL	coefficient of gate length modification				0	
LLD	coefficient of gate length modification	m			0	
LLN	coefficient of gate length modification				0	
WL	coefficient of gate width modification				0	

Parameter	Description	Units	Min	Max	Default	Remarks
WLD	coefficient of gate width modification	m			0	
WLN	coefficient of gate width modification				0	
NSUBC	substrate-impurity concentration	cm^{-3}	1×10^{16}	1×10^{19}	5×10^{17}	
NSUBP	maximum pocket concentration	cm^{-3}	1×10^{16}	1×10^{19}	1×10^{18}	
LP	pocket penetration length	m	0	300n	15n	
*NPEXT	maximum concentration of pocket tail	cm^{-3}	1×10^{16}	1×10^{18}	5×10^{17}	
*LPEXT	extension length of pocket tail	m	1×10^{-50}	10×10^{-6}	1×10^{-50}	
VFBC	flat-band voltage	V	-1.2	-0.8	-1.0	
VBI	built-in potential	V	1.0	1.2	1.1	
KAPPA	dielectric constant for gate dielectric	–			3.9	
EG0	bandgap	eV	1.0	1.3	1.1785	
BGTMP1	temperature dependence of bandgap	eVK^{-1}	50×10^{-6}	100×10^{-6}	90.25µ	fixed
BGTMP2	temperature dependence of bandgap	eVK^{-2}	-1µ	1µ	0.1µ	
TNOM	temperature selected as a nominal temperature value	°C	22	32	27	

Velocity

Parameter	Description	Units	Min	Max	Default	Remarks
VMAX	saturation velocity	cm s^{-1}	1MEG	20MEG	10MEG	
VOVER	velocity overshoot effect	cm^{VOVERP}	0	1.0	0.3	
VOVERP	L_{eff} dependence of velocity overshoot	–	0	2	0.3	
*VTMP	temperature dependence of the saturation velocity	cm s^{-1}	-2.0	1.0	0	

Quantum Mechanical Effect

Parameter	Description	Units	Min	Max	Default	Remarks
QME1	V_{gs} dependence of quantum mechanical effect	V^{-2} m	0	300n	0	
QME2	V_{gs} dependence of quantum mechanical effect	V	0	3.0	1.0	
QME3	minimum T_{ox} modification	m	0	800p	0	

Poly-Silicon Gate Depletion Effect

Parameter	Description	Units	Min	Max	Default	Remarks
PGD1	strength of poly-depletion effect	V	0	50m	0	
PGD2	threshold voltage of poly-depletion effect	V	0	1.5	1.0	
PGD3	V_{ds} dependence of poly-depletion effect	–	0	1.0	0.8	
*PGD4	L_{gate} dependence of poly-depletion effect	–	0	3.0	0	

Short Channel Effect

Parameter	Description	Units	Min	Max	Default	Remarks
PARL2	depletion width of channel/contact junction	m	0	50n	10n	
SC1	magnitude of short-channel effect	–	0	200	1.0	
SC2	V_{ds} dependence of short-channel effect	V^{-1}	0	50	1.0	
*SC3	V_{bs} dependence of short-channel effect	V^{-1} m	0	1m	0	
SCP1	magnitude of short-channel effect due to pocket	–	0	50	1.0	
SCP2	V_{ds} dependence of short-channel due to pocket	V^{-1}	0	50	0.1	
*SCP3	V_{bs} dependence of short-channel effect due to pocket	V^{-1} m	0	1m	0	
*SCP21	short-channel-effect modification for small V_{ds}	V	0	5.0	0	
*SCP22	short-channel-effect modification for small V_{ds}	V^4	0	50m	0	
*BS1	body-coefficient modification by impurity profile	V^2	0	100m	0	
*BS2	body-coefficient modification by impurity profile	V	0.5	1.0	0.9	

Mobility

Parameter	Description	Units	Min	Max	Default	Remarks
MUECB0	coulomb scattering	$cm^2\ V^{-1}\ s^{-1}$	100	100K	1K	
MUECB1	coulomb scattering	$cm^2\ V^{-1}\ s^{-1}$	15	10K	100	

Parameter	Description	Units	Min	Max	Default	Remarks
MUEPH0	phonon scattering	–	0.25	0.35	0.3	fixed
MUEPH1	phonon scattering	$cm^2\ V^{-1}\ s^{-1}$ $(V\ cm^{-1})^{MUEPH0}$	2K	30K	25K(nMOS),9K(pMOS)	
MUETMP	temperature dependence of phonon scattering	–	0.5	2.0	1.5	
*MUEPHL	length dependence of phonon mobility reduction	–			0	
*MUEPLP	length dependence of phonon mobility reduction	–			1.0	
MUESR0	surface-roughness scattering	–	1.8	2.2	2.0	
MUESR1	surface-roughness scattering	$cm^2\ V^{-1}\ s^{-1}$ $(V\ cm^{-1})^{MUESR0}$	1×10^{14}	1×10^{16}	1×10^{15}	
*MUESRL	length dependence of surface roughness mobility reduction				0	
*MUESLP	length dependence of surface roughness mobility reduction				1.0	
NDEP	depletion charge contribution on effective-electric field	–	0	1.0	1.0	
*NDEPL	modification of Q_B contribution for short-channel case	–			0	

Parameter	Description	Units	Min	Max	Default	Remarks
*NDEPLP	modification of Q_B contribution for short-channel case	–			1.0	
NINV	inversion charge contribution on effective-electric field	–	0	1.0	0.5	
BB	high-field-mobility degradation	–			2.0(nMOS),1.0(pMOS)	fixed

Channel-Length Modulation

Parameter	Description	Units	Min	Max	Default	Remarks
CLM1	hardness coefficient of channel/contact junction	–	0.5	1.0	0.7	
CLM2	coefficient for Q_B contribution	–	1.0	2.0	2.0	
CLM3	coefficient for Q_I contribution	–	1.0	5.0	1.0	
*CLM4	no longer used					
*CLM5	effect of pocket implantation	–	0	5.0	1.0	
*CLM6	effect of pocket implantation	–	0	5.0	0	

Narrow Channel Effect

Parameter	Description	Units	Min	Max	Default	Remarks
WFC	threshold voltage change due to capacitance change	F cm^{-2} m^{-1}	-5.0×10^{-15}	1×10^{-6}	0	
*WVTH0	threshold voltage shift				0	

Parameter	Description	Units	Min	Max	Default	Remarks
*NSUBP0	modification of pocket concentration for narrow width	cm^{-3}			0	
*NSUBWP	modification of pocket concentration for narrow width				1.0	
*MUEPHW	phonon related mobility reduction				0	
*MUEPWP	phonon related mobility reduction				1.0	
*MUESRW	change of surface roughness related mobility				0	
*MUESWP	change of surface roughness related mobility				1.0	
*VTHSTI	threshold voltage shift due to STI				0	
*VDSTI	V_{ds} dependence of STI subthreshold				0	
*SCSTI1	the same effect as SC1 but at STI edge				0	
*SCSTI2	the same effect as SC2 but at STI edge				0	
NSTI	substrate-impurity concentration at the STI edge	cm^{-3}	1×10^{16}	1×10^{19}	5×10^{17}	
WSTI	width of the high-field region at STI edge	m			0	
*WSTIL	channel-length dependence of WSTI				0	
*WSTILP	channel-length dependence of WSTI				1.0	
*WSTIW	channel-width dependence of WSTI				0	

Parameter	Description	Units	Min	Max	Default	Remarks
*WSTIWP	channel-width dependence of WSTI				1.0	
WL1	threshold voltage shift of STI leakage due to small size effect				0	
WL1P	threshold voltage shift of STI leakage due to small size effect				1.0	
NSUBPSTI1	pocket concentration change due to diffusion-region length between gate and STI	m			0	
NSUBPSTI2	pocket concentration change due to diffusion-region length between gate and STI	m			0	
NSUBPSTI3	pocket concentration change due to diffusion-region length between gate and STI	m			1.0	
MUESTI1	mobility change due to diffusion-region length between gate and STI				0	
MUESTI2	mobility change due to diffusion-region length between gate and STI				0	
MUESTI3	mobility change due to diffusion-region length between gate and STI				1.0	
SAREF	reference length of diffusion between gate and STI	m			1.0×10^{-6}	
SBREF	reference length of diffusion between gate and STI	m			1.0×10^{-6}	

Small Size Effect

Parameter	Description	Units	Min	Max	Default	Remarks
WL2	threshold voltage shift due to small size effect				0	
WL2P	threshold voltage shift due to small size effect				1.0	
*MUEPHS	mobility modification due to small size				0	
*MUEPSP	mobility modification due to small size				1.0	
*VOVERS	modification of maximum velocity due to small size	–			0	
*VOVERSP	modification of maximum velocity due to small size	–			0	

Substrate Current

Parameter	Description	Units	Min	Max	Default	Remarks
SUB1	substrate current coefficient of magnitude	V^{-1}			10	
SUB1L	L_{gate} dependence SUB1	m			2.5×10^{-3}	
SUB1LP	L_{gate} dependence SUB1	–			1.0	
SUB2	substrate current coefficient of exponential term	V			25.0	
SUB2L	L_{gate} dependence of SUB2	m	0	1.0	2×10^{-6}	
SVDS	substrate current dependence on V_{ds}	–			0.8	
SLG	substrate current dependence on L_{gate}	m			3×10^{-8}	
SLGL	substrate current dependence on L_{gate}	m^{SLGLP}			0	

Parameter	Description	Units	Min	Max	Default	Remarks
SLGLP	substrate current dependence on L_{gate}	–			1.0	
SVBS	substrate current dependence on V_{bs}	–			0.5	
SVBSL	L_{gate} dependence of SVBS	$m^{SV BSLP}$			0	
SVBSLP	L_{gate} dependence of SVBS	–			1.0	
SVGS	substrate current dependence on V_{gs}	–			0.8	
SVGSL	L_{gate} dependence of SVGS	$m^{SV GSLP}$			0	
SVGSLP	L_{gate} dependence of SVGS	–			1.0	
SVGSW	W_{gate} dependence of SVGS	$m^{SV GSWP}$			0	
SVGSWP	W_{gate} dependence of SVGS	–			1.0	

Subthreshold Swing

Parameter	Description	Units	Min	Max	Default	Remarks
*PTHROU	correction for subthreshold swing	–	0	50m	0	

Impact-ionization Induced Bulk Potential Change

Parameter	Description	Units	Min	Max	Default	Remarks
IBPC1	impact-ionization induced bulk potential change	VA^{-1}	0	1.0×10^{12}	0	
IBPC2	impact-ionization induced bulk potential change	V^{-1}	0	1.0×10^{12}	0	

Gate Leakage Current

Parameter	Description	Units	Min	Max	Default	Remarks
GLEAK1	gate to channel current coefficient	$AV^{-3/2}$ C^{-1}			50	
GLEAK2	gate to channel current coefficient	$V^{-1/2}$ m^{-1}			10M	
GLEAK3	gate to channel current coefficient	–			60×10^{-3}	
GLEAK4	gate to channel current coefficient	m^{-1}			4.0	
*GLEAK5	gate to channel current coefficient (short channel correction)	V m^{-1}			7.5×10^{3}	
*GLEAK6	gate to channel current coefficient (V_{ds} dependence correction)	V			250×10^{-3}	
*GLEAK7	gate to channel current coefficient (gate length and width dependence correction)	m^2			1×10^{-6}	
*EGIG	temperature dependence of gate leakage	V			0.0	
*IGTEMP2	temperature dependence of gate leakage	V K			0	
*IGTEMP3	temperature dependence of gate leakage	V K^2			0	
GLKSD1	gate to source/drain current coefficient	A m V^{-2}			1f	
GLKSD2	gate to source/drain current coefficient	V^{-1} m^{-1}			5M	
GLKSD3	gate to source/drain current coefficient	m^{-1}			-5M	
GLKB1	gate to bulk current coefficient	A V^{-2}			5×10^{-16}	
GLKB2	gate to bulk current coefficient	m V^{-1}			1.0	
*GLKB3	flat-bans shift for gate to bulk current	V			0	

Parameter	Description	Units	Min	Max	Default	Remarks
GLPART1	partitioning ratio of gate leakage current	–	0	1.0	0.5	
FN1	coefficient of Fowler-Nordheim-current contribution	$V^{-1.5}$ - m^2			50	
FN2	coefficient of Fowler-Nordheim-current contribution	$V^{-0.5}$ - m^{-1}			170×10^{-6}	
FN3	coefficient of Fowler-Nordheim-current contribution	V			0	
FVBS	V_{bs} dependence of Fowler-Nordheim current	–			12×10^{-3}	

GIDL Current

Parameter	Description	Units	Min	Max	Default	Remarks
GIDL1	magnitude of GIDL	A $V^{-3/2}$ C^{-1} m			2.0	
GIDL2	field dependence of GIDL	V^{-2} m^{-1} $F^{-3/2}$			3×10^{7}	
GIDL3	V_{ds} dependence of GIDL	–			0.9	
*GIDL4	threshold of V_{ds} dependence	V			0	
*GIDL5	correction of high-field contribution	–			0.2	

Conservation of the Symmetry at Vds = 0 for Short-Channel MOSFETs

Parameter	Description	Units	Min	Max	Default	Remarks
VZADD0	symmetry conservation coefficient	V			10m	fixed

Parameter	Description	Units	Min	Max	Default	Remarks
PZADD0	symmetry conservation coefficient	V			5m	fixed

Smoothing coefficient between linear and saturation region

Parameter	Description	Units	Min	Max	Default	Remarks
*DDLTMAX	smoothing coefficient for V_{ds}		0	20	10	
*DDLTSLP	L_{gate} dependence of smoothing coefficient		0	20	0	
*DDLTICT	L_{gate} dependence of smoothing coefficient		-3	20	10	

Source/Bulk and Drain/Bulk Diodes

Parameter	Description	Units	Min	Max	Default	Remarks
JS0	saturation current density	A m^{-2}			0.5×10^{-6}	
JS0SW	sidewall saturation current density	A m^{-1}			0	
NJ	emission coefficient	–			1.0	
NJSW	sidewall emission coefficient	–			1.0	
XTI	temperature coefficient for forward current densities	–			2.0	
XTI2	temperature coefficient for reverse current densities	–			0	
DIVX	reverse current coefficient	V^{-1}			0	
CTEMP	temperature coefficient of reverse currents	–			0	
CISB	reverse biased saturation current	–			0	

Parameter	Description	Units	Min	Max	Default	Remarks
CISBK	reverse biased saturation current (at low temperature)	A			0	
CVB	bias dependence coefficient of CISB	–			0	
CVBK	bias dependence coefficient of CISB (at low temperature)	–			0	
CJ	bottom junction capacitance per unit area at zero bias	F m^{-2}			5×10^{-4}	
CJSW	source/drain sidewall junction cap. grading coefficient per unit length at zero bias	F m^{-1}			5×10^{-10}	
CJSWG	source/drain sidewall junction capacitance per unit length at zero bias	F m^{-1}			5×10^{-10}	
MJ	bottom junction capacitance grading coefficient	–			0.5	
MJSW	source/drain sidewall junction capacitance grading coefficient	–			0.33	
MJSWG	source/drain gate sidewall junction capacitance grading coefficient	–			0.33	
PB	bottom junction build-in potential	V			1.0	
PBSW	source/drain sidewall junction build-in potential	V			1.0	
PBSWG	source/drain gate sidewall junction build-in potential	V			1.0	
VDIFFJ	diode threshold voltage between source/ drain and substrate	V			0.6×10^{-3}	

1/f Noise

Parameter	Description	Units	Min	Max	Default	Remarks
NFALP	contribution of the mobility fluctuation	cm s			1×10^{-19}	
NFTRP	ratio of trap density to attenuation coefficient	V^{-1} cm^{-2}			10G	
*CIT	capacitance caused by the interface trapped carriers	F cm^{-2}			0	

DFM Support

Parameter	Description	Units	Min	Max	Default	Remarks
MPHDFM	mobility dependence on NSUBC due to phonon		-3	3	-0.3	

Non-Quasi-Static Model

Parameter	Description	Units	Min	Max	Default	Remarks
DLY1	coefficient for delay due to diffusion of carriers	s			100×10^{-12}	
DLY2	coefficient for delay due to conduction of carriers	–			0.7	
DLY3	coefficient for RC delay of bulk carriers	Ω			0.8×10^{-6}	

Capacitance

Parameter	Description	Units	Min	Max	Default	Remarks
XQY	distance from drain junction to maximum electric field point	m	0	50n	0	
*XQY1	V_{bs} dependence of Q_y	F-μm^{XQY2-1}	0		0	

Parameter	Description	Units	Min	Max	Default	Remarks
*XQY2	L_{gate} dependence of Q_y	–	0		2	
LOVER	overlap length	m			30n	
NOVER	impurity concentration in overlap region	cm^{-3}			0	
VFBOVER	flat-band voltage in overlap region	V			-0.5	
OVSLP	coefficient for overlap capacitance	–			2.1×10^{-7}	
OVMAG	coefficient for overlap capacitance	V			0.6	
CGSO	gate-to-source overlap capacitance	Fm^{-1}	0	100nm × C_{ox}		to be set by user
CGDO	gate-to-drain overlap capacitance	Fm^{-1}	0	100nm × C_{ox}		to be set by user
CGBO	gate-to-bulk overlap capacitance	Fm^{-1}	0		0	

Parasitic Resistances

Parameter	Description	Units	Min	Max	Default	Remarks
RS	source-contact resistance in LDD region	Ωm	0	10m	0	
RD	drain-contact resistance in LDD region	Ωm	0	10m	0	
RSH	source/drain sheet resistance	$V\,A^{-1}$ square	0	1m	0	

Parameter	Description	Units	Min	Max	Default	Remarks
RSHG	gate sheet resistance	V A^{-1} square	0	100µ	0	
GBMIN	substrate resistance network	–			1×10^{-12}	requested by circuit sim.
RBPB	substrate resistance network	Ω			50	treated also as an instance p.
RBPD	substrate resistance network	Ω			50	treated also as an instance p.
RBPS	substrate resistance network	Ω			50	treated also as an instance p.
RBDB	substrate resistance network	Ω			50	treated also as an instance p.
RBSB	substrate resistance network	Ω			50	treated also as an instance p.

Binning Model

Parameter	Description	Units	Min	Max	Default	Remarks
LBINN	power of L_{drawn} dependence	–			1	
WBINN	power of W_{drawn} dependence	–			1	
LMAX	maximum length of L_{drawn} valid	µm				
LMIN	minimum length of L_{drawn} valid	µm				
WMAX	maximum length of W_{drawn} valid	µm				
WMIN	minimum length of W_{drawn} valid	µm				

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName hisim2 version=241 [parm=value]*
```

Example:
model Nch7 hisim2 Gender=1 Version=241 Tox=2.15e-9

Instance Parameters

Partly the same instance-parameter names and their definitions as in the BSIM3/4 models are adopted for the convenience of HiSIM users.

The maximum and minimum limits of the instance parameters are recommended values. These values
may be violated in individual cases.

Name	Description	Units	Min	Max	Default	Remarks
L	gate length (L_{gate})	m			5µ	
W	gate width (W_{gate})	m			5µ	
Diode						
AD	area of drain junction	m^2			0	
AS	area of source junction	m^2			0	
PD	perimeter of drain junction	m			0	
PS	perimeter of source junction	m			0	
Source/Drain Resistance						
NRS	number of source squares	m			1	

Name	Description	Units	Min	Max	Default	Remarks
NRD	number of drain squares	m			1	
Gate Resistance						
XGW	distance from the gate contact to the channel edge	m			0	
XGL	offset of the gate length	m			0	
NF	number of gate fingers	–			1	
M	multiplication factor					
NGCON	number of gate contacts	m			1	
Substrate Network						
RBPB	substrate resistance network	Ω			50	treated also as a model parameter
RBPD	substrate resistance network	Ω			50	treated also as a model parameter
RBPS	substrate resistance network	Ω			50	treated also as a model parameter
RBDB	substrate resistance network	Ω			50	treated also as a model parameter
RBSB	substrate resistance network	Ω			50	treated also as a model parameter
Length of Diffusion						

Name	Description	Units	Min	Max	Default	Remarks
SA	length of diffusion between gate and STI	m			0	
SB	length of diffusion between gate and STI	m			0	
SD	length of diffusion between gate and gate	m			0	
Temperature						
TEMP	device temperature (*T*)	°C			27	
DTEMP	device temperature change	°C			0	
Design for Manufacturability						
NSUBCDFM	substrate impurity concentration	cm^{-3}	1.0×10^{16}	1.0×10^{19}		

Instance Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
modelName [:Name] d g s b
```

Example:

```
Nch7:M1 2 1 0 0 W=10u L=0.9u
```

- To exclude specific modeled effects, following parameter settings should be chosen:

Short-Channel Effect	SC1 = SC2 = SC3 = 0
Reverse-Short-Channel Effect	LP = 0

Quantum-Mechanical Effect	QME1 = QME3 = 0
Poly-Depletion Effect	PGD1 = PGD2 = PGD3 = 0
Channel-Length Modulation	CLM1 = CLM2 = CLM3 = 0
Narrow-Channel Effect	WFC = MUEPHW = WL1 = 0
Small-Size Effect	WL2 = 0

Following flags are prepared to select required model options.

- Contact resistances R_s and R_d are included:

> *CORSRD = 0: no (default)*
> *CORSRD = 1 & RS/RD ≠ 0: yes, as internal resistances of HiSIM*
> *CORSRD = 2 & RD ≠ 0: yes, simple analytical formulation*
> *CORSRD = -1 & RS/RD ≠ 0: yes, as external resistances of HiSIM*

- Overlap capacitance model is selected as:

> *COOVLP = 0: constant overlap capacitance (default)*
> *either given LOVER plus CGS0/CGD0 or LOVER only*
> *COOVLP = 1: yes*
> *selecting a model either by defining NOVER value or not*

- Substrate current I_{sub} is calculated:

> *COISUB = 0: no (default)*
> *COISUB = 1: yes*

- Gate current I_{gate} is calculated:

> *COIIGS = 0: no (default)*
> *COIIGS = 1: yes*

- GIDL current I_{GIDL} is calculated:

> *COGIDL = 0: no (default)*
> *COGIDL = 1: yes*

- STI leakage current $I_{ds,STI}$ is calculated:

> *COISTI = 0: no (default)*
> *COISTI = 1: yes*

- Lateral field induced and overlap charges/capacitances are added to intrinsic ones:

> *COADOV = 0: no*
> *COADOV = 1: yes (default)*

- Non-quasi-static mode is invoked:

> *CONQS = 0: no (default)*
> *CONQS = 1: yes*

- Gate-contact resistance is included (This flag can also be given as a instance parameter.):
  > *CORG = 0: no (default)*
  > *CORG = 1: yes*
- Substrate resistance network is invoked (This flag can also be given as a instance parameter.):
  > *CORBNET = 0: no (default)*
  > *CORBNET = 1: yes*
- 1/f noise is calculated:
  > *COFLICK = 0: no (default)*
  > *COFLICK = 1: yes*
- Thermal noise is calculated:
  > *COTHRML = 0: no (default)*
  > *COTHRML = 1: yes*
- Induced gate and cross correlation noise are calculated:
  > *COIGN = 0 || COTHRML = 0: no (default)*
  > *COIGN = 1 & COTHRML = 1: yes*
- Previous Ids is used for calculating source/drain resistance effect (R_s and/or $R_d \neq 0$):
  > *COIPRV = 0: no*
  > *COIPRV = 1: yes (default)*
- Previous Φ_S is used for the iteration:
  > *COPPRV = 0: no*
  > *COPPRV = 1: yes (default)*
- Parameter variations for the DFM support is considered:
  > *CODFM = 0: no (default)*
  > *CODFM = 1: yes*

HiSIM 251 (MOSFET Model and Instance)

HiSIM 251 (MOSFET Model and Instance)

The following topic lists the HiSIM 251 model and instance parameters.

Model Parameters

Name (Alias)	Description
Gender	+1=N-type, -1=P-type
TnomC	Parameter measurement temperature
Secured	Secured model parameters
Info	Information level (for debug, etc.)
Noise	Noise model selector
Version	Model version
Show	Show physical value
Corsrd	Handling of Rs and Rd
Corg	Activate gate resistance (1) or not (0)
Coiprv	Use ids_prv as initial guess of Ids (internal flag)
Copprv	Use ps{0/l}_prv as initial guess of Ps{0/l} (internal flag)
Coadov	Add overlap to intrisic
Coisub	Calculate isub
Coiigs	Calculate igate

Name (Alias)	Description
Cogidl	Calculate igidl
Coovlp	Calculate overlap charge on the drain side
Coflick	Calculate 1/f noise
Coisti	Calculate STI
Conqs	Calculate in nqs mode or qs mode
Corbnet	
Cothrml	Calculate thermal noise
Coign	Calculate induced gate noise
Codfm	Calculation of model for DFM
Vmax	Saturation velocity [cm/s]
Bgtmp1	First order temp. coeff. for band gap [V/K]
Bgtmp2	Second order temp. coeff. for band gap [V/K^2]
Eg0	Bandgap
Tox	Oxide thickness [m]
Xld	Lateral diffusion of S/D under the gate [m]
Lover	Overlap length
Ddltmax	Smoothing coefficient for Vds
Ddltslp	Lgate dependence of smoothing coefficient
Ddltict	Lgate dependence of smoothing coefficient

Name (Alias)	Description
Vfbover	Flat-band voltage in overlap region
Nover	Impurity concentration in overlap region
Xwd	Lateral diffusion along the width dir. [m]
Xl	Gate length offset due to mask/etch effect [m]
Xw	Gate width offset due to mask/etch effect [m]
Saref	Reference distance from STI edge to Gate edge [m]
Sbref	Reference distance from STI edge to Gate edge [m]
Ll	Gate length parameter
Lld	Gate length parameter
Lln	Gate length parameter
Wl	Gate width parameter
Wl1	Gate width parameter
Wl1p	Gate width parameter
Wl2	Gate width parameter
Wl2p	Gate width parameter
Wld	Gate width parameter
Wln	Gate width parameter
Xqy	Distance from drain junction to maximum electric field point [m]
Xqy1	Vbs dependence of Qy [F m^{XQY2}]

Name (Alias)	Description
Xqy2	Lgate dependence of Qy [-]
Rs	Source contact resistance [ohm m]
Rd	Drain contact resistance [ohm m]
Rsh	Source/drain diffusion sheet resistance [ohm]
Rshg	Gate-electrode sheet resistance
Vfbc	Constant part of Vfb [V]
Vbi	Built-in potential [V]
Nsubc	Constant part of Nsub [1/cm^3]
Parl2	Under diffusion [m]
Lp	Length of pocket potential [m]
Nsubp	Maximum pocket concentration [1/cm^3]
Nsubpw	Pocket implant parameter
Nsubpwp	Pocket implant parameter
Scp1	Parameter for pocket [-]
Scp2	Parameter for pocket [1/V]
Scp3	Parameter for pocket [m/V]
Sc1	Parameter for SCE [-]
Sc2	Parameter for SCE [1/V]
Sc3	Parameter for SCE [m/V]

Name (Alias)	Description
Pgd1	Parameter for gate-poly depletion [V]
Pgd2	Parameter for gate-poly depletion [V]
Pgd4	Parameter for gate-poly depletion [-]
Ndep	Coeff. of Qbm for Eeff [-]
Ndepl	Coeff. of Qbm for Eeff [-]
Ndeplp	Coeff. of Qbm for Eeff [-]
Ninv	Coeff. of Qnm for Eeff [-]
Muecb0	Const. part of coulomb scattering [cm^2/Vs]
Muecb1	Coeff. for coulomb scattering [cm^2/Vs]
Mueph0	Power of Eeff for phonon scattering [-]
Mueph1	Phonon scattering
Muephw	Width dependence of phonon mobility reduction
Muepwp	Phonon scattering parameter
Muephl	Phonon scattering parameter
Mueplp	Phonon scattering parameter
Muephs	Mobility modification due to small size
Muepsp	Mobility modification due to small size
Vtmp	Temperature dependence of the saturation velocity
Wvth0	Threshold voltage shift

Name (Alias)	Description
Muesr0	Power of Eeff for S.R. scattering [-]
Muesr1	Coeff. for S.R. scattering [-]
Muesrl	Surface roughness parameter
Muesrw	Change of surface roughness related mobility
Mueswp	Change of surface roughness related mobility
Mueslp	Surface roughness parameter
Muetmp	Parameter for mobility [-]
Bb	Empirical mobility model coefficient [-]
Sub1	Parameter for Isub [1/V]
Sub2	Parameter for Isub [V]
Svgs	Coefficient for Vg of Psislsat
Svbs	Coefficient for Vbs of Psislsat
Svgsw	Wgate dependence of SVGS
Svgswp	Wgate dependence of SVGS
Svbsl	Lgate dependence of SVBS
Svds	Substrate current dependence on Vds
Slg	Substrate current dependence on Lgate
Sub1l	Lgate dependence SUB1
Sub2l	Lgate dependence SUB2

Name (Alias)	Description
Svgsl	Lgate dependence of SVGS
Svgslp	Lgate dependence of SVGS
Svbslp	Lgate dependence of SVBS
Slgl	Substrate current dependence on Lgate
Slglp	Substrate current dependence on Lgate
Sub1lp	Lgate dependence SUB1
Nsti	Parameter for STI [1/cm^3]
Wsti	Parameter for STI [m]
Wstil	Parameter for STI [?]
Wstilp	Parameter for STI [?]
Wstiw	Parameter for STI [?]
Wstiwp	Parameter for STI [?]
Scsti1	Parameter for STI [-]
Scsti2	Parameter for STI [1/V]
Vthsti	Parameter for STI
Vdsti	Parameter for STI [-]
Muesti1	STI Stress mobility parameter
Muesti2	STI Stress mobility parameter
Muesti3	STI Stress mobility parameter

Name (Alias)	Description
Nsubpsti1	STI Stress pocket implant parameter
Nsubpsti2	STI Stress pocket implant parameter
Nsubpsti3	STI Stress pocket implant parameter
Lpext	Pocket extension
Npext	Pocket extension
Scp22	Short-channel-effect modification for small Vds
Scp21	Short-channel-effect modification for small Vds
Bs1	Body-coefficient modification by impurity profile
Bs2	Body-coefficient modification by impurity profile
Cgso	G-S overlap capacitance per unit W [F/m]
Cgdo	G-D overlap capacitance per unit W [F/m]
Cgbo	G-B overlap capacitance per unit L [F/m]
Tpoly	Height of poly gate on the source side[m]
Js0	Saturation current density [A/m^2]
Js0sw	Side wall saturation current density [A/m]
Nj	Emission coefficient [-]
Njsw	Sidewall emission coefficient
Xti	Junction current temperature exponent coefficient [-]
Cj	Bottom junction capacitance per unit area at zero bias [F/m^2]

Name (Alias)	Description
Cjsw	Source/drain sidewall junction capacitance grading coefficient per unit length at zero bias [F/m]
Cjswg	Source/drain gate sidewall junction capacitance per unit length at zero bias [F/m]
Mj	Bottom junction capacitance grading coefficient
Mjsw	Source/drain sidewall junction capacitance grading coefficient
Mjswg	Source/drain gate sidewall junction capacitance grading coefficient
Pb	Bottom junction build-in potential [V]
Pbsw	Source/drain sidewall junction build-in potential [V]
Pbswg	Source/drain gate sidewall junction build-in potential [V]
Xti2	Temperature coefficient [-]
Cisb	Reverse bias saturation current [-]
Cvb	Bias dependence coefficient of cisb [-]
Ctemp	Temperature coefficient [-]
Cisbk	Reverse bias saturation current [A]
Cvbk	Bias dependence coefficient of cisb [-]
Divx	Reverse current coefficient [1/V]
Clm1	Parameter for CLM [-]
Clm2	Parameter for CLM [1/m]
Clm3	Parameter for CLM [-]
Clm5	Parameter for CLM [-]

Name (Alias)	Description
Clm6	Parameter for CLM [um^{-clm5}]
Vover	Parameter for overshoot [m^{voverp}]
Voverp	Parameter for overshoot [-]
Vovers	Parameter for overshoot [-]
Voversp	Parameter for overshoot [-]
Wfc	Parameter for narrow channel effect [m*F/(cm^2)]
Qme1	Parameter for quantum effect [mV]
Qme2	Parameter for quantum effect [V]
Qme3	Parameter for quantum effect [m]
Gidl1	Parameter for GIDL [?]
Gidl2	Parameter for GIDL [?]
Gidl3	Parameter for GIDL [?]
Gidl4	Parameter for GIDL [?]
Gidl5	Parameter for GIDL [?]
Glpart1	Parameter for gate current [-]
Gleak1	Parameter for gate current [A*V^(-3/2)/C]
Gleak2	Parameter for gate current [V^(-1/2)/m]
Gleak3	Parameter for gate current [-]
Gleak4	Parameter for gate current [1/m]

Name (Alias)	Description
Gleak5	Parameter for gate current [V/m]
Gleak6	Parameter for gate current [V]
Gleak7	Parameter for gate current [m^2]
Glksd1	Parameter for gate current [A*m/V^2]
Glksd2	Parameter for gate current [1/(V*m)]
Glksd3	Parameter for gate current [1/m]
Glkb1	Parameter for gate current [A/V^2]
Glkb2	Parameter for gate current [m/V]
Glkb3	Parameter for gate current [V]
Egig	Parameter for gate current [V]
Igtemp2	Parameter for gate current [V*k]
Igtemp3	Parameter for gate current [V*k^2]
Vzadd0	Vzadd at Vds=0 [V]
Pzadd0	Pzadd at Vds=0 [V]
Nftrp	Ratio of trap density to attenuation coefficient
Nfalp	Contribution of the mobility fluctuation
Cit	Capacitance caused by the interface trapped carriers
Kappa	Dielectric constant for high-k stacked gate
Vdiffj	Threshold voltage for S/D junction diode [V]

Name (Alias)	Description
Dly1	Parameter for transit time [-]
Dly2	Parameter for transit time [-]
Dly3	Parameter for transforming bulk charge [s/F]
Ovslp	Coefficient for overlap capacitance
Ovmag	Coefficient for overlap capacitance
Gbmin	Substrate resistance network
Rbpb	Substrate resistance network
Rbpd	Substrate resistance network
Rbps	Substrate resistance network
Rbdb	Substrate resistance network
Rbsb	Substrate resistance network
Ibpc1	Parameter for impact-ionization induced bulk potential change
Ibpc2	Parameter for impact-ionization induced bulk potential change
Mphdfm	NSUBCDFM dependence of phonon scattering for DFM
Lmin	Minimum length for the model
Lmax	Maximum length for the model
Wmin	Minimum width for the model
Wmax	Maximum width for the model
Lbinn	L modulation coefficient for binning

Name (Alias)	Description
Wbinn	W modulation coefficient for binning
Lvmax	Length dependence of vmax
Lbgtmp1	Length dependence of bgtmp1
Lbgtmp2	Length dependence of bgtmp2
Leg0	Length dependence of eg0
Llover	Length dependence of lover
Lvfbover	Length dependence of vfbover
Lnover	Length dependence of nover
Lwl2	Length dependence of wl2
Lvfbc	Length dependence of vfbc
Lnsubc	Length dependence of nsubc
Lnsubp	Length dependence of nsubp
Lscp1	Length dependence of scp1
Lscp2	Length dependence of scp2
Lscp3	Length dependence of scp3
Lsc1	Length dependence of sc1
Lsc2	Length dependence of sc2
Lsc3	Length dependence of sc3
Lpgd1	Length dependence of pgd1

Name (Alias)	Description
Lndep	Length dependence of ndep
Lninv	Length dependence of ninv
Lmuecb0	Length dependence of muecb0
Lmuecb1	Length dependence of muecb1
Lmueph1	Length dependence of mueph1
Lvtmp	Length dependence of vtmp
Lwvth0	Length dependence of wvth0
Lmuesr1	Length dependence of muesr1
Lmuetmp	Length dependence of muetmp
Lsub1	Length dependence of sub1
Lsub2	Length dependence of sub2
Lsvds	Length dependence of svds
Lsvbs	Length dependence of svbs
Lsvgs	Length dependence of svgs
Lnsti	Length dependence of nsti
Lwsti	Length dependence of wsti
Lscsti1	Length dependence of scsti1
Lscsti2	Length dependence of scsti2
Lvthsti	Length dependence of vthsti

Name (Alias)	Description
Lmuesti1	Length dependence of muesti1
Lmuesti2	Length dependence of muesti2
Lmuesti3	Length dependence of muesti3
Lnsubpsti1	Length dependence of nsubpsti1
Lnsubpsti2	Length dependence of nsubpsti2
Lnsubpsti3	Length dependence of nsubpsti3
Lcgso	Length dependence of cgso
Lcgdo	Length dependence of cgdo
Ljs0	Length dependence of js0
Ljs0sw	Length dependence of js0sw
Lnj	Length dependence of nj
Lcisbk	Length dependence of cisbk
Lclm1	Length dependence of clm1
Lclm2	Length dependence of clm2
Lclm3	Length dependence of clm3
Lwfc	Length dependence of wfc
Lgidl1	Length dependence of gidl1
Lgidl2	Length dependence of gidl2
Lgleak1	Length dependence of gleak1

Name (Alias)	Description
Lgleak2	Length dependence of gleak2
Lgleak3	Length dependence of gleak3
Lgleak6	Length dependence of gleak6
Lglksd1	Length dependence of glksd1
Lglksd2	Length dependence of glksd2
Lglkb1	Length dependence of glkb1
Lglkb2	Length dependence of glkb2
Lnftrp	Length dependence of nftrp
Lnfalp	Length dependence of nfalp
Lvdiffj	Length dependence of vdiffj
Libpc1	Length dependence of ibpc1
Libpc2	Length dependence of ibpc2
Wvmax	Width dependence of vmax
Wbgtmp1	Width dependence of bgtmp1
Wbgtmp2	Width dependence of bgtmp2
Weg0	Width dependence of eg0
Wlover	Width dependence of lover
Wvfbover	Width dependence of vfbover
Wnover	Width dependence of nover

Name (Alias)	Description
Wwl2	Width dependence of wl2
Wvfbc	Width dependence of vfbc
Wnsubc	Width dependence of nsubc
Wnsubp	Width dependence of nsubp
Wscp1	Width dependence of scp1
Wscp2	Width dependence of scp2
Wscp3	Width dependence of scp3
Wsc1	Width dependence of sc1
Wsc2	Width dependence of sc2
Wsc3	Width dependence of sc3
Wpgd1	Width dependence of pgd1
Wndep	Width dependence of ndep
Wninv	Width dependence of ninv
Wmuecb0	Width dependence of muecb0
Wmuecb1	Width dependence of muecb1
Wmueph1	Width dependence of mueph1
Wvtmp	Width dependence of vtmp
Wwvth0	Width dependence of wvth0
Wmuesr1	Width dependence of muesr1

Name (Alias)	Description
Wmuetmp	Width dependence of muetmp
Wsub1	Width dependence of sub1
Wsub2	Width dependence of sub2
Wsvds	Width dependence of svds
Wsvbs	Width dependence of svbs
Wsvgs	Width dependence of svgs
Wnsti	Width dependence of nsti
Wwsti	Width dependence of wsti
Wscsti1	Width dependence of scsti1
Wscsti2	Width dependence of scsti2
Wvthsti	Width dependence of vthsti
Wmuesti1	Width dependence of muesti1
Wmuesti2	Width dependence of muesti2
Wmuesti3	Width dependence of muesti3
Wnsubpsti1	Width dependence of nsubpsti1
Wnsubpsti2	Width dependence of nsubpsti2
Wnsubpsti3	Width dependence of nsubpsti3
Wcgso	Width dependence of cgso
Wcgdo	Width dependence of cgdo

Name (Alias)	Description
Wjs0	Width dependence of js0
Wjs0sw	Width dependence of js0sw
Wnj	Width dependence of nj
Wcisbk	Width dependence of cisbk
Wclm1	Width dependence of clm1
Wclm2	Width dependence of clm2
Wclm3	Width dependence of clm3
Wwfc	Width dependence of wfc
Wgidl1	Width dependence of gidl1
Wgidl2	Width dependence of gidl2
Wgleak1	Width dependence of gleak1
Wgleak2	Width dependence of gleak2
Wgleak3	Width dependence of gleak3
Wgleak6	Width dependence of gleak6
Wglksd1	Width dependence of glksd1
Wglksd2	Width dependence of glksd2
Wglkb1	Width dependence of glkb1
Wglkb2	Width dependence of glkb2
Wnftrp	Width dependence of nftrp

Name (Alias)	Description
Wnfalp	Width dependence of nfalp
Wvdiffj	Width dependence of vdiffj
Wibpc1	Width dependence of ibpc1
Wibpc2	Width dependence of ibpc2
Pvmax	Cross-term dependence of vmax
Pbgtmp1	Cross-term dependence of bgtmp1
Pbgtmp2	Cross-term dependence of bgtmp2
Peg0	Cross-term dependence of eg0
Plover	Cross-term dependence of lover
Pvfbover	Cross-term dependence of vfbover
Pnover	Cross-term dependence of nover
Pwl2	Cross-term dependence of wl2
Pvfbc	Cross-term dependence of vfbc
Pnsubc	Cross-term dependence of nsubc
Pnsubp	Cross-term dependence of nsubp
Pscp1	Cross-term dependence of scp1
Pscp2	Cross-term dependence of scp2
Pscp3	Cross-term dependence of scp3
Psc1	Cross-term dependence of sc1

Name (Alias)	Description
Psc2	Cross-term dependence of sc2
Psc3	Cross-term dependence of sc3
Ppgd1	Cross-term dependence of pgd1
Pndep	Cross-term dependence of ndep
Pninv	Cross-term dependence of ninv
Pmuecb0	Cross-term dependence of muecb0
Pmuecb1	Cross-term dependence of muecb1
Pmueph1	Cross-term dependence of mueph1
Pvtmp	Cross-term dependence of vtmp
Pwvth0	Cross-term dependence of wvth0
Pmuesr1	Cross-term dependence of muesr1
Pmuetmp	Cross-term dependence of muetmp
Psub1	Cross-term dependence of sub1
Psub2	Cross-term dependence of sub2
Psvds	Cross-term dependence of svds
Psvbs	Cross-term dependence of svbs
Psvgs	Cross-term dependence of svgs
Pnsti	Cross-term dependence of nsti
Pwsti	Cross-term dependence of wsti

Name (Alias)	Description
Pscsti1	Cross-term dependence of scsti1
Pscsti2	Cross-term dependence of scsti2
Pvthsti	Cross-term dependence of vthsti
Pmuesti1	Cross-term dependence of muesti1
Pmuesti2	Cross-term dependence of muesti2
Pmuesti3	Cross-term dependence of muesti3
Pnsubpsti1	Cross-term dependence of nsubpsti1
Pnsubpsti2	Cross-term dependence of nsubpsti2
Pnsubpsti3	Cross-term dependence of nsubpsti3
Pcgso	Cross-term dependence of cgso
Pcgdo	Cross-term dependence of cgdo
Pjs0	Cross-term dependence of js0
Pjs0sw	Cross-term dependence of js0sw
Pnj	Cross-term dependence of nj
Pcisbk	Cross-term dependence of cisbk
Pclm1	Cross-term dependence of clm1
Pclm2	Cross-term dependence of clm2
Pclm3	Cross-term dependence of clm3
Pwfc	Cross-term dependence of wfc

Name (Alias)	Description
Pgidl1	Cross-term dependence of gidl1
Pgidl2	Cross-term dependence of gidl2
Pgleak1	Cross-term dependence of gleak1
Pgleak2	Cross-term dependence of gleak2
Pgleak3	Cross-term dependence of gleak3
Pgleak6	Cross-term dependence of gleak6
Pglksd1	Cross-term dependence of glksd1
Pglksd2	Cross-term dependence of glksd2
Pglkb1	Cross-term dependence of glkb1
Pglkb2	Cross-term dependence of glkb2
Pnftrp	Cross-term dependence of nftrp
Pnfalp	Cross-term dependence of nfalp
Pvdiffj	Cross-term dependence of vdiffj
Pibpc1	Cross-term dependence of ibpc1
Pibpc2	Cross-term dependence of ibpc2
Corecip	Capacitance reciprocity takes first priority
Coqy	Calculate lateral-field-induced charge/capacitance
Coqovsm	Select smoothing method of Qover
Qyrat	Partitioning ratio of Qy between source and drain

Name (Alias)	Description
Nsubpl	Gate-length dependence of NSUBP
Nsubpfac	Gate-length dependence of NSUBP
Sc4	parameter for SCE []
Ndepw	Coefficient of Qbm for Eeff[-]
Ndepwp	Coefficient of Qbm for Eeff[-]
Ninvd	Modification of Vdse dependence on Eeff [-]
Muepwd	Phonon scattering parameter
Muepld	Phonon scattering parameter
Npextw	New model parameter NPEXTW
Npextwp	New model parameter NPEXTWP
Tcjbd	Temperature dependence of czbd
Tcjbs	Temperature dependence of czbs
Tcjbdsw	Temperature dependence of czbdsw
Tcjbssw	Temperature dependence of czbssw
Tcjbdswg	Temperature dependence of czbdswg
Tcjbsswg	Temperature dependence of czbsswg
Nsubcw	Parameter for narrow channel effect
Nsubcwp	Parameter for narrow channel effect
Nsubcmax	Parameter for narrow channel effect

Name (Alias)	Description
Falph	parameter for 1/f noise
Ptl	Strength of punchthrough effect
Ptp	Strength of punchthrough effect
Pt2	Vds dependence of punchthrough effect
Ptlp	Channel-length dependence of punchthrough effect
Pt4	Vbs dependence of punchthrough effect
Pt4p	Vbs dependence of punchthrough effect
Gdl	Strength of high-field effect
Gdlp	Channel-length dependence of high-field effect
Gdld	Channel-length dependence of high-field effect
Muephl2	Length dependence of phonon mobility reduction
Mueplp2	Length dependence of phonon mobility reduction
Muephw2	Phonon related mobility reduction
Muepwp2	Phonon related mobility reduction
Vgsmin	minimal/maximal expected Vgs (NMOS/PMOS) [V]
Sc3vbs	Vbs value for clamping sc3 [V]
Byptol	BYP_TOL_FACTOR for bypass control
Muecb0lp	L dependence of MUECB0
Muecb1lp	L dependence of MUECB1

Name (Alias)	Description
Lsc4	Length dependence of sc4
Wsc4	Width dependence of sc4
Psc4	Cross-term dependence of sc4
Nsubcw2	Modification of substrate concentration for narrow width
Nsubcwp2	Modification of substrate concentration for narrow width

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName HiSIM [parm=value]*
```

Example:

> *model Nch HiSIM_2_51 Tox=2.15e-9*

Instance Parameters

Name (Alias)	Description
L	Length
W	Width
Ad	Drain area
As	Source area
Pd	Drain perimeter
Ps	Source perimeter
Nrd	Number of squares in drain

Name (Alias)	Description
Nrs	Number of squares in source
Off	Device is initially off
Corbnet	Activate body resistance (1) or not (0)
Rbpb	Substrate resistance network
Rbpd	Substrate resistance network
Rbps	Substrate resistance network
Rbdb	Substrate resistance network
Rbsb	Substrate resistance network
Corg	Activate gate resistance (1) or not (0)
Ngcon	Number of gate contacts
Xgw	Distance from gate contact to channel edge
Xgl	Offset of gate length due to variation in patterning
Nf	Number of fingers
Sa	Distance from STI edge to Gate edge [m]
Sb	Distance from STI edge to Gate edge [m]
Sd	Distance from Gate edge to Gate edge [m]
Nsubcdfm	Constant part of Nsub for DFM [1/cm^3]
M	Multiplication factor [-]
Mphdfm	NSUBCDFM dependence of phonon scattering for DFM

Instance Netlist Format

`modelName [:Name] d g s b`

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example

> *Nch7:M1 2 1 0 0 W=10u L=0.9u*

For detailed information, refer to HiSIM2 manual.

HiSIM 26x (HiSIM 260 and 261 Model and Instance)

HiSIM 26x (HiSIM 260 and 261 Model and Instance)

The following topic lists the HiSIM 260 and 261 model and instance parameters.

Model Parameters

Name (Alias)	Description
Gender	+1=N-type, -1=P-type
TnomC	Parameter measurement temperature
Secured	Secured model parameters
Info	Information level (for debug, etc.)
Noise	Noise model selector
Version	Model version
Corsrd	Handling of Rs and Rd
Corg	Activate gate resistance (1) or not (0)
Coiprv	Use ids_prv as initial guess of Ids (internal flag)
Copprv	Use ps{0/l}_prv as initial guess of Ps{0/l} (internal flag)
Coadov	Add overlap to intrinsic
Coisub	Calculate isub
Coiigs	Calculate igate
Cogidl	Calculate igidl

Name (Alias)	Description
Coovlp	Calculate overlap charge on the drain side
Coflick	Calculate 1/f noise
Coisti	Calculate STI
Conqs	Calculate in nqs mode or qs mode
Corbnet	
Cothrml	Calculate thermal noise
Coign	Calculate induced gate noise
Codfm	Calculation of model for DFM
Vmax	Saturation velocity [cm/s]
Bgtmp1	First order temp. coeff. for band gap [V/K]
Bgtmp2	Second order temp. coeff. for band gap [V/K^2]
Eg0	Bandgap
Tox	Oxide thickness [m]
Xld	Lateral diffusion of S/D under the gate [m]
Lover	Overlap length
Ddltmax	Smoothing coefficient for Vds
Ddltslp	Lgate dependence of smoothing coefficient
Ddltict	Lgate dependence of smoothing coefficient
Vfbover	Flat-band voltage in overlap region

Name (Alias)	Description
Nover	Impurity concentration in overlap region
Xwd	Lateral diffusion along the width dir. [m]
Xl	Gate length offset due to mask/etch effect [m]
Xw	Gate width offset due to mask/etch effect [m]
Saref	Reference distance from STI edge to Gate edge [m]
Sbref	Reference distance from STI edge to Gate edge [m]
Ll	Gate length parameter
Lld	Gate length parameter
Lln	Gate length parameter
Wl	Gate width parameter
Wl1	Gate width parameter
Wl1p	Gate width parameter
Wl2	Gate width parameter
Wl2p	Gate width parameter
Wld	Gate width parameter
Wln	Gate width parameter
Xqy	Distance from drain junction to maximum electric field point [m]
Xqy1	Vbs dependence of Qy [F m^{XQY2}]
Xqy2	Lgate dependence of Qy [-]

Name (Alias)	Description
Rs	Source contact resistance [ohm m]
Rd	Drain contact resistance [ohm m]
Rsh	Source/drain diffusion sheet resistance [ohm]
Rshg	Gate-elecrode sheet resistance
Vfbc	Constant part of Vfb [V]
Vbi	Built-in potential [V]
Nsubc	Constant part of Nsub [1/cm^3]
Parl2	Under diffusion [m]
Lp	Length of pocket potential [m]
Nsubp	maximum pocket concentration [1/cm^3]
Nsubpw	Pocket implant parameter
Nsubpwp	Pocket implant parameter
Scp1	Parameter for pocket [-]
Scp2	Parameter for pocket [1/V]
Scp3	Parameter for pocket [m/V]
Sc1	Parameter for SCE [-]
Sc2	Parameter for SCE [1/V]
Sc3	Parameter for SCE [m/V]
Pgd1	Parameter for gate-poly depletion [V]

Name (Alias)	Description
Pgd2	Parameter for gate-poly depletion [V]
Pgd4	Parameter for gate-poly depletion [-]
Ndep	Coeff. of Qbm for Eeff [-]
Ndepl	Coeff. of Qbm for Eeff [-]
Ndeplp	Coeff. of Qbm for Eeff [-]
Ninv	Coeff. of Qnm for Eeff [-]
Muecb0	Const. part of coulomb scattering [cm^2/Vs]
Muecb1	Coeff. for coulomb scattering [cm^2/Vs]
Mueph0	Power of Eeff for phonon scattering [-]
Mueph1	Phonon scattering
Muephw	Width dependence of phonon mobility reduction
Muepwp	Phonon scattering parameter
Muephl	Phonon scattering parameter
Mueplp	Phonon scattering parameter
Muephs	Mobility modification due to small size
Muepsp	Mobility modification due to small size
Vtmp	Temperature dependence of the saturation velocity
Wvth0	Threshold voltage shift
Muesr0	Power of Eeff for S.R. scattering [-]

Name (Alias)	Description
Muesr1	Coeff. for S.R. scattering [-]
Muesrl	Surface roughness parameter
Muesrw	Change of surface roughness related mobility
Mueswp	Change of surface roughness related mobility
Mueslp	Surface roughness parameter
Muetmp	Parameter for mobility [-]
Bb	Empirical mobility model coefficient [-]
Sub1	Parameter for Isub [1/V]
Sub2	Parameter for Isub [V]
Svgs	Coefficient for Vg of Psislsat
Svbs	Coefficient for Vbs of Psislsat
Svbsl	Lgate dependence of SVBS
Svds	Substrate current dependence on Vds
Slg	Substrate current dependence on Lgate
Sub1l	Lgate dependence SUB1
Sub2l	Lgate dependence SUB2
Svgsl	Lgate dependence of SVGS
Svgsw	Wgate dependence of SVGS
Svgslp	Lgate dependence of SVGS

Name (Alias)	Description
Svgswp	Wgate dependence of SVGS
Svbslp	Lgate dependence of SVBS
Slgl	Substrate current dependence on Lgate
Slglp	Substrate current dependence on Lgate
Sub1lp	Lgate dependence SUB1
Nsti	Parameter for STI [1/cm^3]
Wsti	Parameter for STI [m]
Wstil	Parameter for STI [?]
Wstilp	Parameter for STI [?]
Wstiw	Parameter for STI [?]
Wstiwp	Parameter for STI [?]
Scsti1	Parameter for STI [-]
Scsti2	Parameter for STI [1/V]
Vthsti	Parameter for STI
Vdsti	Parameter for STI [-]
Muesti1	STI Stress mobility parameter
Muesti2	STI Stress mobility parameter
Muesti3	STI Stress mobility parameter
Nsubpsti1	STI Stress pocket implant parameter

Name (Alias)	Description
Nsubpsti2	STI Stress pocket implant parameter
Nsubpsti3	STI Stress pocket implant parameter
Lpext	Pocket extension
Npext	Pocket extension
Scp22	Short-channel-effect modification for small Vds
Scp21	Short-channel-effect modification for small Vds
Bs1	Body-coefficient modification by impurity profile
Bs2	Body-coefficient modification by impurity profile
Cgso	G-S overlap capacitance per unit W [F/m]
Cgdo	G-D overlap capacitance per unit W [F/m]
Cgbo	G-B overlap capacitance per unit L [F/m]
Tpoly	Height of poly gate on the source side[m]
Js0	Saturation current density [A/m^2]
Js0sw	Side wall saturation current density [A/m]
Nj	Emission coefficient [-]
Njsw	Sidewall emission coefficient
Xti	Junction current temperature exponent coefficient [-]
Cj	Bottom junction capacitance per unit area at zero bias [F/m^2]
Cjsw	Source/drain sidewall junction capacitance grading coefficient per unit length at zero bias [F/m]

Name (Alias)	Description
Cjswg	Source/drain gate sidewall junction capacitance per unit length at zero bias [F/m]
Mj	Bottom junction capacitance grading coefficient
Mjsw	Source/drain sidewall junction capacitance grading coefficient
Mjswg	Source/drain gate sidewall junction capacitance grading coefficient
Pb	Bottom junction build-in potential [V]
Pbsw	Source/drain sidewall junction build-in potential [V]
Pbswg	Source/drain gate sidewall junction build-in potential [V]
Xti2	Temperature coefficient [-]
Cisb	Reverse bias saturation current [-]
Cvb	Bias dependence coefficient of cisb [-]
Ctemp	Temperature coefficient [-]
Cisbk	Reverse bias saturation current [A]
Cvbk	Bias dependence coefficient of cisb [-]
Divx	Reverse current coefficient [1/V]
Clm1	Parameter for CLM [-]
Clm2	Parameter for CLM [1/m]
Clm3	Parameter for CLM [-]
Clm5	Parameter for CLM [-]
Clm6	Parameter for CLM [um^{-clm5}]

Name (Alias)	Description
Vover	Parameter for overshoot [m^{voverp}]
Voverp	Parameter for overshoot [-]
Vovers	Parameter for overshoot [-]
Voversp	Parameter for overshoot [-]
Wfc	Parameter for narrow channel effect [m*F/(cm^2)]
Qme1	Parameter for quantum effect [mV]
Qme2	Parameter for quantum effect [V]
Qme3	Parameter for quantum effect [m]
Gidl1	Parameter for GIDL [?]
Gidl2	Parameter for GIDL [?]
Gidl3	Parameter for GIDL [?]
Gidl4	Parameter for GIDL [?]
Gidl5	Parameter for GIDL [?]
Gleak1	Parameter for gate current [A*V^(-3/2)/C]
Gleak2	Parameter for gate current [V^(-1/2)/m]
Gleak3	Parameter for gate current [-]
Gleak4	Parameter for gate current [1/m]
Gleak5	Parameter for gate current [V/m]
Gleak6	Parameter for gate current [V]

Name (Alias)	Description
Gleak7	Parameter for gate current [m^2]
Glksd1	Parameter for gate current [A*m/V^2]
Glksd2	Parameter for gate current [1/(V*m)]
Glksd3	Parameter for gate current [1/m]
Glkb1	Parameter for gate current [A/V^2]
Glkb2	Parameter for gate current [m/V]
Glkb3	Parameter for gate current [V]
Egig	Parameter for gate current [V]
Igtemp2	Parameter for gate current [V*k]
Igtemp3	Parameter for gate current [V*k^2]
Vzadd0	Vzadd at Vds=0 [V]
Pzadd0	Pzadd at Vds=0 [V]
Nftrp	Ratio of trap density to attenuation coefficient
Nfalp	Contribution of the mobility fluctuation
Cit	Capacitance caused by the interface trapped carriers
Kappa	Dielectric constant for high-k stacked gate
Vdiffj	Threshold voltage for S/D junction diode [V]
Dly1	Parameter for transit time [-]
Dly2	Parameter for transit time [-]

Name (Alias)	Description
Dly3	Parameter for transforming bulk charge [s/F]
Ovslp	Coefficient for overlap capacitance
Ovmag	Coefficient for overlap capacitance
Gbmin	Substrate resistance network
Rbpb	Substrate resistance network
Rbpd	Substrate resistance network
Rbps	Substrate resistance network
Rbdb	Substrate resistance network
Rbsb	Substrate resistance network
Ibpc1	Parameter for impact-ionization induced bulk potential change
Ibpc2	Parameter for impact-ionization induced bulk potential change
Mphdfm	NSUBCDFM dependence of phonon scattering for DFM
Lmin	Minimum length for the model
Lmax	Maximum length for the model
Wmin	Minimum width for the model
Wmax	Maximum width for the model
Lbinn	L modulation coefficient for binning
Wbinn	W modulation coefficient for binning
Lvmax	Length dependence of vmax

Name (Alias)	Description
Lbgtmp1	Length dependence of bgtmp1
Lbgtmp2	Length dependence of bgtmp2
Leg0	Length dependence of eg0
Llover	Length dependence of lover
Lvfbover	Length dependence of vfbover
Lnover	Length dependence of nover
Lwl2	Length dependence of wl2
Lvfbc	Length dependence of vfbc
Lnsubc	Length dependence of nsubc
Lnsubp	Length dependence of nsubp
Lscp1	Length dependence of scp1
Lscp2	Length dependence of scp2
Lscp3	Length dependence of scp3
Lsc1	Length dependence of sc1
Lsc2	Length dependence of sc2
Lsc3	Length dependence of sc3
Lpgd1	Length dependence of pgd1
Lndep	Length dependence of ndep
Lninv	Length dependence of ninv

Name (Alias)	Description
Lmuecb0	Length dependence of muecb0
Lmuecb1	Length dependence of muecb1
Lmueph1	Length dependence of mueph1
Lvtmp	Length dependence of vtmp
Lwvth0	Length dependence of wvth0
Lmuesr1	Length dependence of muesr1
Lmuetmp	Length dependence of muetmp
Lsub1	Length dependence of sub1
Lsub2	Length dependence of sub2
Lsvds	Length dependence of svds
Lsvbs	Length dependence of svbs
Lsvgs	Length dependence of svgs
Lnsti	Length dependence of nsti
Lwsti	Length dependence of wsti
Lscsti1	Length dependence of scsti1
Lscsti2	Length dependence of scsti2
Lvthsti	Length dependence of vthsti
Lmuesti1	Length dependence of muesti1
Lmuesti2	Length dependence of muesti2

Name (Alias)	Description
Lmuesti3	Length dependence of muesti3
Lnsubpsti1	Length dependence of nsubpsti1
Lnsubpsti2	Length dependence of nsubpsti2
Lnsubpsti3	Length dependence of nsubpsti3
Lcgso	Length dependence of cgso
Lcgdo	Length dependence of cgdo
Ljs0	Length dependence of js0
Ljs0sw	Length dependence of js0sw
Lnj	Length dependence of nj
Lcisbk	Length dependence of cisbk
Lclm1	Length dependence of clm1
Lclm2	Length dependence of clm2
Lclm3	Length dependence of clm3
Lwfc	Length dependence of wfc
Lgidl1	Length dependence of gidl1
Lgidl2	Length dependence of gidl2
Lgleak1	Length dependence of gleak1
Lgleak2	Length dependence of gleak2
Lgleak3	Length dependence of gleak3

Name (Alias)	Description
Lgleak6	Length dependence of gleak6
Lglksd1	Length dependence of glksd1
Lglksd2	Length dependence of glksd2
Lglkb1	Length dependence of glkb1
Lglkb2	Length dependence of glkb2
Lnftrp	Length dependence of nftrp
Lnfalp	Length dependence of nfalp
Lvdiffj	Length dependence of vdiffj
Libpc1	Length dependence of ibpc1
Libpc2	Length dependence of ibpc2
Wvmax	Width dependence of vmax
Wbgtmp1	Width dependence of bgtmp1
Wbgtmp2	Width dependence of bgtmp2
Weg0	Width dependence of eg0
Wlover	Width dependence of lover
Wvfbover	Width dependence of vfbover
Wnover	Width dependence of nover
Wwl2	Width dependence of wl2
Wvfbc	Width dependence of vfbc

Name (Alias)	Description
Wnsubc	Width dependence of nsubc
Wnsubp	Width dependence of nsubp
Wscp1	Width dependence of scp1
Wscp2	Width dependence of scp2
Wscp3	Width dependence of scp3
Wsc1	Width dependence of sc1
Wsc2	Width dependence of sc2
Wsc3	Width dependence of sc3
Wpgd1	Width dependence of pgd1
Wndep	Width dependence of ndep
Wninv	Width dependence of ninv
Wmuecb0	Width dependence of muecb0
Wmuecb1	Width dependence of muecb1
Wmueph1	Width dependence of mueph1
Wvtmp	Width dependence of vtmp
Wwvth0	Width dependence of wvth0
Wmuesr1	Width dependence of muesr1
Wmuetmp	Width dependence of muetmp
Wsub1	Width dependence of sub1

Name (Alias)	Description
Wsub2	Width dependence of sub2
Wsvds	Width dependence of svds
Wsvbs	Width dependence of svbs
Wsvgs	Width dependence of svgs
Wnsti	Width dependence of nsti
Wwsti	Width dependence of wsti
Wscsti1	Width dependence of scsti1
Wscsti2	Width dependence of scsti2
Wvthsti	Width dependence of vthsti
Wmuesti1	Width dependence of muesti1
Wmuesti2	Width dependence of muesti2
Wmuesti3	Width dependence of muesti3
Wnsubpsti1	Width dependence of nsubpsti1
Wnsubpsti2	Width dependence of nsubpsti2
Wnsubpsti3	Width dependence of nsubpsti3
Wcgso	Width dependence of cgso
Wcgdo	Width dependence of cgdo
Wjs0	Width dependence of js0
Wjs0sw	Width dependence of js0sw

Name (Alias)	Description
Wnj	Width dependence of nj
Wcisbk	Width dependence of cisbk
Wclm1	Width dependence of clm1
Wclm2	Width dependence of clm2
Wclm3	Width dependence of clm3
Wwfc	Width dependence of wfc
Wgidl1	Width dependence of gidl1
Wgidl2	Width dependence of gidl2
Wgleak1	Width dependence of gleak1
Wgleak2	Width dependence of gleak2
Wgleak3	Width dependence of gleak3
Wgleak6	Width dependence of gleak6
Wglksd1	Width dependence of glksd1
Wglksd2	Width dependence of glksd2
Wglkb1	Width dependence of glkb1
Wglkb2	Width dependence of glkb2
Wnftrp	Width dependence of nftrp
Wnfalp	Width dependence of nfalp
Wvdiffj	Width dependence of vdiffj

Name (Alias)	Description
Wibpc1	Width dependence of ibpc1
Wibpc2	Width dependence of ibpc2
Pvmax	Cross-term dependence of vmax
Pbgtmp1	Cross-term dependence of bgtmp1
Pbgtmp2	Cross-term dependence of bgtmp2
Peg0	Cross-term dependence of eg0
Plover	Cross-term dependence of lover
Pvfbover	Cross-term dependence of vfbover
Pnover	Cross-term dependence of nover
Pwl2	Cross-term dependence of wl2
Pvfbc	Cross-term dependence of vfbc
Pnsubc	Cross-term dependence of nsubc
Pnsubp	Cross-term dependence of nsubp
Pscp1	Cross-term dependence of scp1
Pscp2	Cross-term dependence of scp2
Pscp3	Cross-term dependence of scp3
Psc1	Cross-term dependence of sc1
Psc2	Cross-term dependence of sc2
Psc3	Cross-term dependence of sc3

Name (Alias)	Description
Ppgd1	Cross-term dependence of pgd1
Pndep	Cross-term dependence of ndep
Pninv	Cross-term dependence of ninv
Pmuecb0	Cross-term dependence of muecb0
Pmuecb1	Cross-term dependence of muecb1
Pmueph1	Cross-term dependence of mueph1
Pvtmp	Cross-term dependence of vtmp
Pwvth0	Cross-term dependence of wvth0
Pmuesr1	Cross-term dependence of muesr1
Pmuetmp	Cross-term dependence of muetmp
Psub1	Cross-term dependence of sub1
Psub2	Cross-term dependence of sub2
Psvds	Cross-term dependence of svds
Psvbs	Cross-term dependence of svbs
Psvgs	Cross-term dependence of svgs
Pnsti	Cross-term dependence of nsti
Pwsti	Cross-term dependence of wsti
Pscsti1	Cross-term dependence of scsti1
Pscsti2	Cross-term dependence of scsti2

Name (Alias)	Description
Pvthsti	Cross-term dependence of vthsti
Pmuesti1	Cross-term dependence of muesti1
Pmuesti2	Cross-term dependence of muesti2
Pmuesti3	Cross-term dependence of muesti3
Pnsubpsti1	Cross-term dependence of nsubpsti1
Pnsubpsti2	Cross-term dependence of nsubpsti2
Pnsubpsti3	Cross-term dependence of nsubpsti3
Pcgso	Cross-term dependence of cgso
Pcgdo	Cross-term dependence of cgdo
Pjs0	Cross-term dependence of js0
Pjs0sw	Cross-term dependence of js0sw
Pnj	Cross-term dependence of nj
Pcisbk	Cross-term dependence of cisbk
Pclm1	Cross-term dependence of clm1
Pclm2	Cross-term dependence of clm2
Pclm3	Cross-term dependence of clm3
Pwfc	Cross-term dependence of wfc
Pgidl1	Cross-term dependence of gidl1
Pgidl2	Cross-term dependence of gidl2

Name (Alias)	Description
Pgleak1	Cross-term dependence of gleak1
Pgleak2	Cross-term dependence of gleak2
Pgleak3	Cross-term dependence of gleak3
Pgleak6	Cross-term dependence of gleak6
Pglksd1	Cross-term dependence of glksd1
Pglksd2	Cross-term dependence of glksd2
Pglkb1	Cross-term dependence of glkb1
Pglkb2	Cross-term dependence of glkb2
Pnftrp	Cross-term dependence of nftrp
Pnfalp	Cross-term dependence of nfalp
Pvdiffj	Cross-term dependence of vdiffj
Pibpc1	Cross-term dependence of ibpc1
Pibpc2	Cross-term dependence of ibpc2
Corecip	Capacitance reciprocity takes first priority
Coqy	Calculate lateral-field-induced charge/capacitance
Coqovsm	Select smoothing method of Qover
Qyrat	Partitioning ratio of Qy between source and drain
Nsubpl	Gate-length dependence of NSUBP
Nsubpfac	Gate-length dependence of NSUBP

Name (Alias)	Description
Sc4	parameter for SCE []
Ndepw	Coefficient of Qbm for Eeff[-]
Ndepwp	Coefficient of Qbm for Eeff[-]
Ninvd	Modification of Vdse dependence on Eeff [-]
Muepwd	Phonon scattering parameter
Muepld	Phonon scattering parameter
Npextw	New model parameter NPEXTW
Npextwp	New model parameter NPEXTWP
Tcjbd	Temperature dependence of czbd
Tcjbs	Temperature dependence of czbs
Tcjbdsw	Temperature dependence of czbdsw
Tcjbssw	Temperature dependence of czbssw
Tcjbdswg	Temperature dependence of czbdswg
Tcjbsswg	Temperature dependence of czbsswg
Nsubcw	Parameter for narrow channel effect
Nsubcwp	Parameter for narrow channel effect
Nsubcmax	Parameter for narrow channel effect
Falph	parameter for 1/f noise
Ptl	Strength of punchthrough effect

Name (Alias)	Description
Ptp	Strength of punchthrough effect
Pt2	Vds dependence of punchthrough effect
Ptlp	Channel-length dependence of punchthrough effect
Pt4	Vbs dependence of punchthrough effect
Pt4p	Vbs dependence of punchthrough effect
Gdl	Strength of high-field effect
Gdlp	Channel-length dependence of high-field effect
Gdld	Channel-length dependence of high-field effect
Muephl2	Length dependence of phonon mobility reduction
Mueplp2	Length dependence of phonon mobility reduction
Muephw2	Phonon related mobility reduction
Muepwp2	Phonon related mobility reduction
Vgsmin	minimal/maximal expected Vgs (NMOS/PMOS) [V]
Sc3vbs	Vbs value for clamping sc3 [V]
Byptol	BYP_TOL_FACTOR for bypass control
Muecb0lp	L dependence of MUECB0
Muecb1lp	L dependence of MUECB1
Lsc4	Length dependence of sc4
Wsc4	Width dependence of sc4

Name (Alias)	Description
Psc4	Cross-term dependence of sc4
Nsubcw2	Modification of substrate concentration for narrow width
Nsubcwp2	Modification of substrate concentration for narrow width
Web	Description for the model parameter WPE web
Wec	Description for the model parameter WPE wec
Nsubcwpe	Description for the model parameter WPE nsubcwpe
Npextwpe	Description for the model parameter WPE npextwpe
Nsubpwpe	Description for the model parameter WPE nsubpwpe

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName HiSIM [parm=value]*
```

Example:

> *model Nch HiSIM_2_61 Tox=2.15e-9*

Instance Parameters

Name (Alias)	Description
L	Length
W	Width
Ad	Drain area
As	Source area

Name (Alias)	Description
Pd	Drain perimeter
Ps	Source perimeter
Nrd	Number of squares in drain
Nrs	Number of squares in source
Off	Device is initially off
Corbnet	Activate body resistance (1) or not (0)
Rbpb	Substrate resistance network
Rbpd	Substrate resistance network
Rbps	Substrate resistance network
Rbdb	Substrate resistance network
Rbsb	Substrate resistance network
Corg	Activate gate resistance (1) or not (0)
Ngcon	Number of gate contacts
Xgw	Distance from gate contact to channel edge
Xgl	Offset of gate length due to variation in patterning
Nf	Number of fingers
Sa	Distance from STI edge to Gate edge [m]
Sb	Distance from STI edge to Gate edge [m]
Sd	Distance from Gate edge to Gate edge [m]

Name (Alias)	Description
Nsubcdfm	Constant part of Nsub for DFM [1/cm^3]
M	Multiplication factor [-]
Mphdfm	NSUBCDFM dependence of phonon scattering for DFM
Sca	WPE sca
Scb	WPE scb
Scc	WPE Scc

Instance Netlist Format

`modelName [:Name] d g s b`
where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example

> *Nch7:M1 2 1 0 0 W=10u L=0.9u*

For detailed information, refer to HiSIM2 manual.

HiSIM 27x (HiSIM 270 Model and Instance)

HiSIM 27x (HiSIM 270 Model and Instance)

The following topic lists the HiSIM 270 model and instance parameters.

Model Parameters

Name (Alias)	Description
Info	information level (for debug
Noise	noise model selector
Version	model version
Corsrd	solve equations accounting Rs and Rd.
Corg	solve equations accounting Rg.
Coiprv	use ids_prv as initial guess of Ids (internal flag)
Copprv	use ps[0/l]_prv as initial guess of Ps[0/l] (internal flag)
Coadov	add overlap to intrisic
Coisub	calculate isub
Coiigs	calculate igate
Cogidl	calculate igidl
Coovlp	calculate overlap charge
Coflick	calculate 1/f noise
Coisti	calculate STI

Name (Alias)	Description
Conqs	calculate in nqs mode or qs mode
Corbnet	activate body resistance (1)
Cothrml	calculate thermal noise
Coign	calculate induced gate noise
Codfm	calculation of model for DFM
Vmax	saturation velocity [cm/s
Bgtmp1	first order temp. coeff. for band gap [V/K]
Bgtmp2	second order temp. coeff. for band gap [V/K^2]
Eg0	bandgap
Tox	oxide thickness [m]
Xld	lateral diffusion of S/D under the gate [m]
Lover	overlap length
Ddltmax	smoothing coefficient for Vds
Ddltslp	Lgate dependence of smoothing coefficient
Ddltict	Lgate dependence of smoothing coefficient
Vfbover	flat-band voltage in overlap region
Nover	impurity concentration in overlap region
Xwd	lateral diffusion along the width dir. [m]
Xl	gate length offset due to mask/etch effect [m]

Name (Alias)	Description
Xw	gate width offset due to mask/etch effect [m]
Saref	reference distance from STI edge to Gate edge [m]
Sbref	reference distance from STI edge to Gate edge [m]
Ll	gate length parameter
Lld	gate length parameter
Lln	gate length parameter
Wl	gate width parameter
Wl1	gate width parameter
Wl1p	gate width parameter
Wl2	gate width parameter
Wl2p	gate width parameter
Wld	gate width parameter
Wln	gate width parameter
Xqy	distance from drain junction to maximum electric field point [m]
Xqy1	Vbs dependence of Qy [F m^(XQY2)]
Xqy2	Lgate dependence of Qy
Rs	source contact resistance [ohm m]
Rd	drain contact resistance [ohm m]
Rsh	source/drain diffusion sheet resistance [ohm]

Name (Alias)	Description
Rshg	gate-elecrode sheet resistance
Vfbc	constant part of Vfb [V]
Vbi	built-in potential [V]
Nsubc	constant part of Nsub [1/cm^3]
Parl2	under diffusion [m]
Lp	length of pocket potential [m]
Nsubp	maximum pocket concentration [1/cm^3]
Nsubpw	pocket implant parameter
Nsubpwp	pocket implant parameter
Scp1	parameter for pocket
Scp2	parameter for pocket [1/V]
Scp3	parameter for pocket [m/V]
Sc1	parameter for SCE
Sc2	parameter for SCE [1/V]
Sc3	parameter for SCE [m/V]
Pgd1	parameter for gate-poly depletion [V]
Pgd2	parameter for gate-poly depletion [V]
Pgd4	parameter for gate-poly depletion
Ndep	coeff. of Qbm for Eeff

Name (Alias)	Description
Ndepl	coeff. of Qbm for Eeff
Ndeplp	coeff. of Qbm for Eeff
Ninv	coeff. of Qnm for Eeff
Muecb0	const. part of coulomb scattering [cm^2/Vs]
Muecb1	coeff. for coulomb scattering [cm^2/Vs]
Mueph0	power of Eeff for phonon scattering
Mueph1	phonon scattering
Muephw	width dependence of phonon mobility reduction
Muepwp	phonon scattering parameter
Muephl	phonon scattering parameter
Mueplp	phonon scattering parameter
Muephs	mobility modification due to small size
Muepsp	mobility modification due to small size
Vtmp	temperature dependence of the saturation velocity
Wvth0	threshold voltage shift
Muesr0	power of Eeff for S.R. scattering
Muesr1	coeff. for S.R. scattering
Muesrl	surface roughness parameter
Muesrw	change of surface roughness related mobility

Name (Alias)	Description
Mueswp	change of surface roughness related mobility
Mueslp	surface roughness parameter
Muetmp	parameter for mobility
Bb	empirical mobility model coefficient
Sub1	parameter for Isub [1/V]
Sub2	parameter for Isub [V]
Svgs	coefficient for Vg of Psislsat
Svbs	coefficient for Vbs of Psislsat
Svbsl	Lgate dependence of SVBS
Svds	substrate current dependence on Vds
Slg	substrate current dependence on Lgate
Sub1l	Lgate dependence SUB1
Sub2l	Lgate dependence SUB1
Svgsl	Lgate dependence of SVGS
Svgslp	Lgate dependence of SVGS
Svgswp	Wgate dependence of SVGS
Svgsw	Wgate dependence of SVGS
Svbslp	Lgate dependence of SVBS
Slgl	substrate current dependence on Lgate

Name (Alias)	Description
Slglp	substrate current dependence on Lgate
Sub1lp	Lgate dependence SUB1
Nsti	parameter for STI [1/cm^3]
Wsti	parameter for STI [m]
Wstil	parameter for STI
Wstilp	parameter for STI
Wstiw	parameter for STI
Wstiwp	parameter for STI
Scsti1	parameter for STI
Scsti2	parameter for STI [1/V]
Vthsti	parameter for STI
Vdsti	parameter for STI
Muesti1	STI Stress mobility parameter
Muesti2	STI Stress mobility parameter
Muesti3	STI Stress mobility parameter
Nsubpsti1	STI Stress pocket impla parameter
Nsubpsti2	STI Stress pocket impla parameter
Nsubpsti3	STI Stress pocket impla parameter
Lpext	Pocket extension

Name (Alias)	Description
Npext	Pocket extension
Scp22	short-channel-effect modification for small Vds
Scp21	short-channel-effect modification for small Vds
Bs1	body-coefficient modification by impurity profile
Bs2	body-coefficient modification by impurity profile
Cgso	G-S overlap capacitance per unit W [F/m]
Cgdo	G-D overlap capacitance per unit W [F/m]
Cgbo	G-B overlap capacitance per unit L [F/m]
Tpoly	hight of poly gate [m]
Js0	Saturation current density [A/m^2]
Js0sw	Side wall saturation current density [A/m]
Nj	Emission coefficient
Njsw	Sidewall emission coefficient
Xti	Junction current temperature exponent coefficient
Cj	Bottom junction capacitance per unit area at zero bias [F/m^2]
Cjsw	Source/drain sidewall junction capacitance grading coefficient per unit length at zero bias [F/m]
Cjswg	Source/drain gate sidewall junction capacitance per unit length at zero bias [F/m]
Mj	Bottom junction capacitance grading coefficient
Mjsw	Source/drain sidewall junction capacitance grading coefficient

Name (Alias)	Description
Mjswg	Source/drain gate sidewall junction capacitance grading coefficient
Pb	Bottom junction build-in potential [V]
Pbsw	Source/drain sidewall junction build-in potential [V]
Pbswg	Source/drain gate sidewall junction build-in potential [V]
Xti2	temperature coefficient
Cisb	reverse bias saturation current
Cvb	bias dependence coefficient of cisb
Ctemp	temperature coefficient
Cisbk	reverse bias saturation current [A]
Cvbk	bias dependence coefficient of cisb
Divx	reverse current coefficient [1/V]
Clm1	parameter for CLM
Clm2	parameter for CLM [1/m]
Clm3	parameter for CLM
Clm5	parameter for CLM
Clm6	parameter for CLM [um^(-clm5)
Vover	parameter for overshoot [m^(voverp)
Voverp	parameter for overshoot
Vovers	parameter for overshoot

Name (Alias)	Description
Voversp	parameter for overshoot
Wfc	parameter for narrow channel effect [m*F/(cm^2)
Qme1	parameter for quantum effect [mV]
Qme2	parameter for quantum effect [V]
Qme3	parameter for quantum effect [m]
Gidl1	parameter for GIDL
Gidl2	parameter for GIDL
Gidl3	parameter for GIDL
Gidl4	parameter for GIDL
Gidl5	parameter for GIDL
Gleak1	parameter for gate current [A*V^(-3/2)
Gleak2	parameter for gate current [V^(-1/2)
Gleak3	parameter for gate current
Gleak4	parameter for gate current [1/m]
Gleak5	parameter for gate current [V/m]
Gleak6	parameter for gate current [V]
Gleak7	parameter for gate current [m^2]
Glksd1	parameter for gate current [A*m/V^2]
Glksd2	parameter for gate current [1/(V*m)

Name (Alias)	Description
Glksd3	parameter for gate current [1/m]
Glkb1	parameter for gate current [A/V^2]
Glkb2	parameter for gate current [m/V]
Glkb3	parameter for gate current [V]
Egig	parameter for gate current [V]
Igtemp2	parameter for gate current [V*k]
Igtemp3	parameter for gate current [V*k^2]
Vzadd0	Vzadd at Vds=0 [V]
Pzadd0	Pzadd at Vds=0 [V]
Nftrp	ratio of trap density to attenuation coefficient
Nfalp	contribution of the mobility fluctuation
Cit	capacitance caused by the interface trapped carriers
Kappa	dielectric constant for high-k stacked gate
Vdiffj	threshold voltage for S/D junction diode [V]
Dly1	parameter for transit time
Dly2	parameter for transit time
Dly3	parameter for transforming bulk charge [s/F]
Ovslp	coefficient for overlap capacitance
Ovmag	coefficient for overlap capacitance

Name (Alias)	Description
Gbmin	substrate resistance network
Rbpb	substrate resistance network
Rbpd	substrate resistance network
Rbps	substrate resistance network
Rbdb	substrate resistance network
Rbsb	substrate resistance network
Ibpc1	parameter for Impact-Ionization Induced Bulk Potential Change
Ibpc2	parameter for Impact-Ionization Induced Bulk Potential Change
Mphdfm	NSUBCDFM dependence of phonon scattering for DFM
Lmin	Minimum length for the model
Lmax	Maximum length for the model
Wmin	Minimum width for the model
Wmax	Maximum width for the model
Lbinn	L modulation coefficient for binning
Wbinn	W modulation coefficient for binning
Lvmax	Length dependence of vmax
Lbgtmp1	Length dependence of bgtmp1
Lbgtmp2	Length dependence of bgtmp2
Leg0	Length dependence of eg0

Name (Alias)	Description
Llover	Length dependence of lover
Lvfbover	Length dependence of vfbover
Lnover	Length dependence of nover
Lwl2	Length dependence of wl2
Lvfbc	Length dependence of vfbc
Lnsubc	Length dependence of nsubc
Lnsubp	Length dependence of nsubp
Lscp1	Length dependence of scp1
Lscp2	Length dependence of scp2
Lscp3	Length dependence of scp3
Lsc1	Length dependence of sc1
Lsc2	Length dependence of sc2
Lsc3	Length dependence of sc3
Lpgd1	Length dependence of pgd1
Lndep	Length dependence of ndep
Lninv	Length dependence of ninv
Lmuecb0	Length dependence of muecb0
Lmuecb1	Length dependence of muecb1
Lmueph1	Length dependence of mueph1

Name (Alias)	Description
Lvtmp	Length dependence of vtmp
Lwvth0	Length dependence of wvth0
Lmuesr1	Length dependence of muesr1
Lmuetmp	Length dependence of muetmp
Lsub1	Length dependence of sub1
Lsub2	Length dependence of sub2
Lsvds	Length dependence of svds
Lsvbs	Length dependence of svbs
Lsvgs	Length dependence of svgs
Lnsti	Length dependence of nsti
Lwsti	Length dependence of wsti
Lscsti1	Length dependence of scsti1
Lscsti2	Length dependence of scsti2
Lvthsti	Length dependence of vthsti
Lmuesti1	Length dependence of muesti1
Lmuesti2	Length dependence of muesti2
Lmuesti3	Length dependence of muesti3
Lnsubpsti1	Length dependence of nsubpsti1
Lnsubpsti2	Length dependence of nsubpsti2

Name (Alias)	Description
Lnsubpsti3	Length dependence of nsubpsti3
Lcgso	Length dependence of cgso
Lcgdo	Length dependence of cgdo
Ljs0	Length dependence of js0
Ljs0sw	Length dependence of js0sw
Lnj	Length dependence of nj
Lcisbk	Length dependence of cisbk
Lclm1	Length dependence of clm1
Lclm2	Length dependence of clm2
Lclm3	Length dependence of clm3
Lwfc	Length dependence of wfc
Lgidl1	Length dependence of gidl1
Lgidl2	Length dependence of gidl2
Lgleak1	Length dependence of gleak1
Lgleak2	Length dependence of gleak2
Lgleak3	Length dependence of gleak3
Lgleak6	Length dependence of gleak6
Lglksd1	Length dependence of glksd1
Lglksd2	Length dependence of glksd2

Name (Alias)	Description
Lglkb1	Length dependence of glkb1
Lglkb2	Length dependence of glkb2
Lnftrp	Length dependence of nftrp
Lnfalp	Length dependence of nfalp
Lvdiffj	Length dependence of vdiffj
Libpc1	Length dependence of ibpc1
Libpc2	Length dependence of ibpc2
Wvmax	Width dependence of vmax
Wbgtmp1	Width dependence of bgtmp1
Wbgtmp2	Width dependence of bgtmp2
Weg0	Width dependence of eg0
Wlover	Width dependence of lover
Wvfbover	Width dependence of vfbover
Wnover	Width dependence of nover
Wwl2	Width dependence of wl2
Wvfbc	Width dependence of vfbc
Wnsubc	Width dependence of nsubc
Wnsubp	Width dependence of nsubp
Wscp1	Width dependence of scp1

Name (Alias)	Description
Wscp2	Width dependence of scp2
Wscp3	Width dependence of scp3
Wsc1	Width dependence of sc1
Wsc2	Width dependence of sc2
Wsc3	Width dependence of sc3
Wpgd1	Width dependence of pgd1
Wndep	Width dependence of ndep
Wninv	Width dependence of ninv
Wmuecb0	Width dependence of muecb0
Wmuecb1	Width dependence of muecb1
Wmueph1	Width dependence of mueph1
Wvtmp	Width dependence of vtmp
Wwvth0	Width dependence of wvth0
Wmuesr1	Width dependence of muesr1
Wmuetmp	Width dependence of muetmp
Wsub1	Width dependence of sub1
Wsub2	Width dependence of sub2
Wsvds	Width dependence of svds
Wsvbs	Width dependence of svbs

Name (Alias)	Description
Wsvgs	Width dependence of svgs
Wnsti	Width dependence of nsti
Wwsti	Width dependence of wsti
Wscsti1	Width dependence of scsti1
Wscsti2	Width dependence of scsti2
Wvthsti	Width dependence of vthsti
Wmuesti1	Width dependence of muesti1
Wmuesti2	Width dependence of muesti2
Wmuesti3	Width dependence of muesti3
Wnsubpsti1	Width dependence of nsubpsti1
Wnsubpsti2	Width dependence of nsubpsti2
Wnsubpsti3	Width dependence of nsubpsti3
Wcgso	Width dependence of cgso
Wcgdo	Width dependence of cgdo
Wjs0	Width dependence of js0
Wjs0sw	Width dependence of js0sw
Wnj	Width dependence of nj
Wcisbk	Width dependence of cisbk
Wclm1	Width dependence of clm1

Name (Alias)	Description
Wclm2	Width dependence of clm2
Wclm3	Width dependence of clm3
Wwfc	Width dependence of wfc
Wgidl1	Width dependence of gidl1
Wgidl2	Width dependence of gidl2
Wgleak1	Width dependence of gleak1
Wgleak2	Width dependence of gleak2
Wgleak3	Width dependence of gleak3
Wgleak6	Width dependence of gleak6
Wglksd1	Width dependence of glksd1
Wglksd2	Width dependence of glksd2
Wglkb1	Width dependence of glkb1
Wglkb2	Width dependence of glkb2
Wnftrp	Width dependence of nftrp
Wnfalp	Width dependence of nfalp
Wvdiffj	Width dependence of vdiffj
Wibpc1	Width dependence of ibpc1
Wibpc2	Width dependence of ibpc2
Pvmax	Cross-term dependence of vmax

Name (Alias)	Description
Pbgtmp1	Cross-term dependence of bgtmp1
Pbgtmp2	Cross-term dependence of bgtmp2
Peg0	Cross-term dependence of eg0
Plover	Cross-term dependence of lover
Pvfbover	Cross-term dependence of vfbover
Pnover	Cross-term dependence of nover
Pwl2	Cross-term dependence of wl2
Pvfbc	Cross-term dependence of vfbc
Pnsubc	Cross-term dependence of nsubc
Pnsubp	Cross-term dependence of nsubp
Pscp1	Cross-term dependence of scp1
Pscp2	Cross-term dependence of scp2
Pscp3	Cross-term dependence of scp3
Psc1	Cross-term dependence of sc1
Psc2	Cross-term dependence of sc2
Psc3	Cross-term dependence of sc3
Ppgd1	Cross-term dependence of pgd1
Pndep	Cross-term dependence of ndep
Pninv	Cross-term dependence of ninv

Name (Alias)	Description
Pmuecb0	Cross-term dependence of muecb0
Pmuecb1	Cross-term dependence of muecb1
Pmueph1	Cross-term dependence of mueph1
Pvtmp	Cross-term dependence of vtmp
Pwvth0	Cross-term dependence of wvth0
Pmuesr1	Cross-term dependence of muesr1
Pmuetmp	Cross-term dependence of muetmp
Psub1	Cross-term dependence of sub1
Psub2	Cross-term dependence of sub2
Psvds	Cross-term dependence of svds
Psvbs	Cross-term dependence of svbs
Psvgs	Cross-term dependence of svgs
Pnsti	Cross-term dependence of nsti
Pwsti	Cross-term dependence of wsti
Pscsti1	Cross-term dependence of scsti1
Pscsti2	Cross-term dependence of scsti2
Pvthsti	Cross-term dependence of vthsti
Pmuesti1	Cross-term dependence of muesti1
Pmuesti2	Cross-term dependence of muesti2

Name (Alias)	Description
Pmuesti3	Cross-term dependence of muesti3
Pnsubpsti1	Cross-term dependence of nsubpsti1
Pnsubpsti2	Cross-term dependence of nsubpsti2
Pnsubpsti3	Cross-term dependence of nsubpsti3
Pcgso	Cross-term dependence of cgso
Pcgdo	Cross-term dependence of cgdo
Pjs0	Cross-term dependence of js0
Pjs0sw	Cross-term dependence of js0sw
Pnj	Cross-term dependence of nj
Pcisbk	Cross-term dependence of cisbk
Pclm1	Cross-term dependence of clm1
Pclm2	Cross-term dependence of clm2
Pclm3	Cross-term dependence of clm3
Pwfc	Cross-term dependence of wfc
Pgidl1	Cross-term dependence of gidl1
Pgidl2	Cross-term dependence of gidl2
Pgleak1	Cross-term dependence of gleak1
Pgleak2	Cross-term dependence of gleak2
Pgleak3	Cross-term dependence of gleak3

Name (Alias)	Description
Pgleak6	Cross-term dependence of gleak6
Pglksd1	Cross-term dependence of glksd1
Pglksd2	Cross-term dependence of glksd2
Pglkb1	Cross-term dependence of glkb1
Pglkb2	Cross-term dependence of glkb2
Pnftrp	Cross-term dependence of nftrp
Pnfalp	Cross-term dependence of nfalp
Pvdiffj	Cross-term dependence of vdiffj
Pibpc1	Cross-term dependence of ibpc1
Pibpc2	Cross-term dependence of ibpc2
Corecip	capacitance reciprocity takes first priority
Coqy	calculate lateral-field-induced charge/capacitance
Coqovsm	select smoothing method of Qover
Qyrat	partitioning ratio of Qy between source and drain
Nsubpl	gate-length dependence of NSUBP
Nsubpfac	gate-length dependence of NSUBP
Sc4	parameter for SCE
Ndepw	coeff. of Qbm for Eeff
Ndepwp	coeff. of Qbm for Eeff

Name (Alias)	Description
Ninvd	modification of Vdse dependence on Eeff [1/V]
Muepwd	phonon scattering parameter
Muepld	phonon scattering parameter
Npextw	new model parameter NPEXTW
Npextwp	new model parameter NPEXTWP
Tcjbd	Temperature dependence of czbd
Tcjbs	Temperature dependence of czbs
Tcjbdsw	Temperature dependence of czbdsw
Tcjbssw	Temperature dependence of czbssw
Tcjbdswg	Temperature dependence of czbdswg
Tcjbsswg	Temperature dependence of czbsswg
Nsubcw	Parameter for narrow channel effect
Nsubcwp	Parameter for narrow channel effect
Nsubcmax	Parameter for narrow channel effect
Falph	parameter for 1/f noise
Ptl	strength of punchthrough effect
Ptp	strength of punchthrough effect
Pt2	Vds dependence of punchthrough effect
Ptlp	channel-length dependence of punchthrough effect

Name (Alias)	Description
Pt4	Vbs dependence of punchthrough effect
Pt4p	Vbs dependence of punchthrough effect
Gdl	strength of high-field effect
Gdlp	channel-length dependence of high-field effect
Gdld	channel-length dependence of high-field effect
Muephl2	length dependence of phonon mobility reduction
Mueplp2	length dependence of phonon mobility reduction
Muephw2	phonon related mobility reduction
Muepwp2	phonon related mobility reduction
Vgsmin	minimal/maximal expected Vgs (NMOS/PMOS)
Sc3vbs	Vbs value for clamping sc3 [V]
Byptol	BYP_TOL_FACTOR for bypass control
Muecb0lp	L dependence of MUECB0
Muecb1lp	L dependence of MUECB1
Lsc4	Length dependence of sc4
Wsc4	Width dependence of sc4
Psc4	Cross-term dependence of sc4
Nsubcw2	modification of substrate concentration for narrow width
Nsubcwp2	modification of substrate concentration for narrow width

Name (Alias)	Description
Web	Description for the model parameter WPE web
Wec	Description for the model parameter WPE wec
Nsubcwpe	Description for the model parameter WPE nsubcwpe
Npextwpe	Description for the model parameter WPE npextwpe
Nsubpwpe	Description for the model parameter WPE nsubpwpe
Coerrrep	selector for error report
Vfbcl	gate-length dependence of VFBC [um]
Vfbclp	gate-length dependence of VFBC
Nsubpdlt	Delta for nsubp smoothing
Nsubcsti1	STI Stress Parameter for Nsubc
Nsubcsti2	STI Stress Parameter for Nsubc
Nsubcsti3	STI Stress Parameter for Nsubc
Gidl6	parameter for GIDL
Gidl7	parameter for GIDL
Lnsubcsti1	Length dependence of nsubcsti1
Lnsubcsti2	Length dependence of nsubcsti2
Lnsubcsti3	Length dependence of nsubcsti2
Wnsubcsti1	Width dependence of nsubcsti1
Wnsubcsti2	Width dependence of nsubcsti2

Name (Alias)	Description
Wnsubcsti3	Width dependence of nsubcsti3
Pnsubcsti1	Cross-term dependence of nsubcsti1
Pnsubcsti2	Cross-term dependence of nsubcsti2
Pnsubcsti3	Cross-term dependence of nsubcsti3

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName HiSIM [parm=value]*
```

Example:

> *model Nch HiSIM_2_70 Tox=2.15e-9*

Instance Parameters

Name (Alias)	Description
L	Length
W	Width
Ad	Drain area
As	Source area
Pd	Drain perimeter
Ps	Source perimeter
Nrd	Number of squares in drain
Nrs	Number of squares in source

Name (Alias)	Description
Temp	Lattice temperature [K]
Dtemp	
Off	Device is initially off
Corbnet	activate body resistance (1)
Rbpb	substrate resistance network
Rbpd	substrate resistance network
Rbps	substrate resistance network
Rbdb	substrate resistance network
Rbsb	substrate resistance network
Corg	activate gate resistance (1)
Ngcon	number of gate contacts
Xgw	distance from gate contact to channel edge
Xgl	offset of gate length due to variation in patterning
Nf	number of fingers
Sa	distance from STI edge to Gate edge [m]
Sb	distance from STI edge to Gate edge [m]
Sd	distance from Gate edge to Gate edge [m]
Nsubcdfm	constant part of Nsub for DFM [1/cm^3]
M	Multiplication factor

Name (Alias)	Description
Mphdfm	NSUBCDFM dependence of phonon scattering for DFM
Sca	WPE sca
Scb	WPE scb
Scc	WPE scc

Instance Netlist Format

`modelName [:Name] d g s b`
where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example

> *Nch7:M1 2 1 0 0 W=10u L=0.9u*

For detailed information, refer to HiSIM2 manual.

HiSIM_SOI

HiSIM_SOI

The HiSIM_SOI model was developed by the University of Hiroshima. For detailed information, refer to the HiSIM_SOI manual provided by the Hiroshima University [Link].

NOTE Only version 1.3.0 is supported.

Instance Parameters

NOTE The square brackets indicate range includes endpoint value while parentheses indicate range is up to but not including value.

Name	Description [Range]	Units	Default
L	Gate length (Lgate) (0 : inf]	m	5.00E-06
W	Gate width (Wgate) (0 : inf]	m	5.00E-06
AD	Area of drain junction [0 : inf]	m^2	0
AS	Area of source junction [0 : inf]	m^2	0
PD	Perimeter of drain junction [0 : inf]	m	0
PS	Perimeter of source junction [0 : inf]	m	0
NGCON	Number of gate contacts (0 : inf]	-	1
XGW	Distance from gate contact to channel edge	m	0
XGL	Offset of gate length [0 : L]	m	0
NF	Number of gate fingers (0 : inf]	-	1
SA	Length of diffusion between gate and STI [0 : inf]	m	0
SB	Length of diffusion between gate and STI [0 : inf]	m	0
SD	Length of diffusion between gate and gate [0 : inf]	m	0
PDBCP	Parasitic perimeter length for body contact at drain	m	-
PSBCP	Parasitic perimeter length for body contact at source	m	-

Name	Description [Range]	Units	Default
LOD	Diffusion length between gate and STI edge	m	1.00E-05
TEMP	Device temperature	C	-
DTEMP	Device temperature change	C	0
NBT	Number of body contact		1
LBT	Length of gate over body-contact well	m	0
WBTP	Distance of gate protrusion over body-contact well	m	0
WBTN	Distance of gate protrusion over body-contact well	m	0
ABTN	Area of N+ poly area of body contact	m^2	-
ABTP	Area of P+ poly area of body contact	m^2	-
LDRIFT	Parameter for drift region length (drain) [0 : inf)	m	1.00E-06
LDRIFTS	Parameter for drift region length (source) [0 : inf)	m	1.00E-06

Model Parameters

NOTE The square brackets indicate range includes endpoint value while parentheses indicate range is up to but not including value.

Name	Description [Range]	Units	Default
COPPRV	Previous phi_s flag		0
COADOV	Lateral field induced and overlap capacitances are added to intrinsic		1
COISUB	Substrate current flag		0
COFBE	Floating-Body Effect flag		0
COIIGS	Gate current flag		0
COGIDL	GIDL current flag		0
COOVLP	Overlap capacitance model selector		0
COIGN	Induced gate and cross correlation noise flag		0

Name	Description [Range]	Units	Default
COFLICK	1/f noise flag		0
COTHRML	Thermal noise flag		0
COISTI	STI leakage current flag		0
CONQS	Non-quasi-static model flag		0
CORG	Gate-contact resistance flag		0
COIEVB	Valence-band-electron-tunneling-current model flag		0
COHIST	History Effect flag		0
COSELFHEAT	Self-Heating flag		0
COVBSBIZ	Symmetry treatment flag		0
COLGLEFF	Lgate to Leff flag		0
COQOVSM	Qover capacitance model selector (0 : 2]		1
COQBDSM	Gate/body contact well MOS-capacitance model selector (0 : 2]		1
COBCNODE	Body contact node flag		0
INFO	print information selector		0
TYPE	1 for nMOS and -1 for pMOS (non-zero)	-	1
VERSION	model version selector	-	1.3
VMAX	saturation velocity	cm*s^-1	7.00E+06
BGTMP1	temperature dependence of bandgap	eV*K^-1	9.03E-05
BGTMP2	temperature dependence of bandgap	eV*K^-2	1.00E-07
EG0	bandgap	eV	1.1785
XLD	gate overlap length	m	0
VFBOVER	flat-band voltage in overlap region	V	0
NOVER	impurity concentration in overlap region	cm^-3	1.00E+19
XWD	gate overlap width	m	0

Name	Description [Range]	Units	Default
XWDC	XWD for cap	m	XWD
SAREF	Ref-dist between OD edge to poly of one side	m	1.00E-06
SBREF	Ref-dist between OD edge to poly of the other side	m	1.00E-06
XQY	distance from junction to max field point [0 : inf)	m	0
XQY1	Vbs-dependence of Qy	F*um^XQY2-1	0
XQY2	Lgate-dependence of Qy	-	2
RSHG	gate sheet resistance [0 : 100]	Ohm/square	0
VFBC	flat-band voltage	V	-1
VBI	built-in potential	V	1.1
NSUBPL	modification of pocket-impurity concentration	m^-1	0.001
NSUBPFAC	modification of pocket-impurity concentration	-	1
PARL1	SOI SCE parameter	cm	1.00E-08
PARL2	depletion width of channel/contact junction	m	1.00E-08
LP	pocket penetration length	m	0
NSUBP	max pocket concentration (0 : inf)	cm^-3	1.00E+17
NSUBP0	modification of pocket concentration for narrow W	um^NSUBWP	0
NSUBWP	modification of pocket concentration for narrow W	-	1
WL1	small-size effect parameter for STI leakage	um^2WL1P+1	0
WL1P	small-size effect parameter for STI leakage	-	1
WL2	threshold voltage shift due to small-size effect	Vum^WL2P	0
WL2P	threshold voltage shift due to small-size effect	-	1
SCP1	magnitude of short-channel effect due to pocket	-	0
SCP2	Vds-dependence of SCE due to pocket	V^-1	0
SCP3	Vds-dependence of SCE due to pocket	m*V^-1	0

Name	Description [Range]	Units	Default
SC1	magnitude of short-channel effect	-	0
SC2	Vds-dependence of short-channel effect	V^-1	0
SC3	Vbs dependence of short-channel effect	m*V^-1	0
SCR1	parameter for SCE via BOX	-	0
SCR2	parameter for SCE via BOX	-	0
SCR3	parameter for SCE via BOX	-	0.23
PGD1	strength of poly-depletion effect	V	0
PGD2	threshold voltage of poly-depletion effect	V	1
PGD4	Lgate-dependence of poly-depletion effect	-	0
NDEP	depletion charge contribution to Eeff	-	1
NINV	inversion charge contribution to Eeff	-	0.5
NINVD	inversion charge parameter	V^-1	0
MUECB0	Coulomb scattering	cm^2V^-1s^-1	300
MUECB1	Coulomb scattering	cm^2V^-1s^-1	30
MUEPH0	phonon scattering	-	3.00E-01
MUEPHW	phonon-related mobility reduction	um^MUEPHP	0
MUEPWP	phonon-related mobility reduction	-	1
MUEPHL	L-dependence of phonon mobility reduction	-	0
MUEPLP	L-dependence of phonon mobility reduction	-	1
MUEPHS	mobility change due to small size	um^MUEPSP	0
MUEPSP	mobility change due to small size	-	1
VTMP	temperature-dependence of saturation velocity	cm*s^-1	0
WVTH0	threshold voltage shift	Vum	0
MUESR1	surface-roughness scattering	cm^2V^-1s^-1	2.00E+15

Name	Description [Range]	Units	Default
MUESR0	surface-roughness scattering	-	2
MUESRL	L-dependence of surface roughness on mobility	um^MUESLP	0
MUESRW	surface roughness-related mobility change	um^MUESWP	0
MUESWP	surface roughness-related mobility change	-	1
MUESLP	L-dependence of surface roughness on mobility	-	1
MUETMP	temperature-dependence of phonon scattering	um^MUEPLP	1.5
BB	high-field-mobility degradation	-	((TYPE>0)? 2.0:1.0)
DDLTMAX	smoothing coefficient for Vds	-	10
DDLTSLP	Lgate-dependence of smoothing coefficient	um^-1	10
DDLTICT	Lgate-dependence of smoothing coefficient	-	0
SUB1	substrate current coefficient of magnitude	V^-1	0.01
SUB2	substrate current coefficient of exponential term	V	20
SUB1L	Lgate-dependence of SUB1	m	2.50E-03
SUB1LP	Lgate-dependence SUB1	-	1
SUB2L	Lgate-dependence of SUB2	m	2.00E-06
SVDS	Substrate current dependence on Vds	-	3
SLG	substrate current dependence on Lgate	m	3.00E-08
SVBS	substrate current dependence on Vbs	-	0.5
SVBSL	Lgate-dependence of SVBS	m^SVBSLP	0
SVBSLP	Lgate-dependence of SVBS	-	1
SVGS	substrate current dependence on Vgs	-	0.8
SVGSL	Lgate-dependence of SVGS	m^SLGLP	0
SVGSLP	Lgate-dependence of SVGS	-	1
SVGSW	Wgate-dependence of SVGS	m^SVGSWP	0

Name	Description [Range]	Units	Default
SVGSWP	Wgate-dependence of SVGS	-	1
VFBSUB	flatband voltage for Isub calculation	V	-1
VFBSUBL	Lgate-dependence of VFBSUB	um^VFBSUBLP	0
VFBSUBLP	Lgate-dependence of VFBSUB	-	1
SUBDLT	smoothing parameter (hisimsoi_fb only)	-	2.00E-03
HIST1	history-effect parameter	V	1.00E-08
HIST2	history-effect parameter	A	1.00E-20
QHE1	FBE parameter	-	1.5
QHE2	FBE parameter	V	0.35
EVB1	electron tunneling from valence band	V^-2s^-1	0
EVB2	electron tunneling from valence band	V*m^-1	0
EVB3	electron tunneling from valence band	-	0
FVBS	Vbs dependence of Fowler-Nordheim current	-	0
IBPC1	impact-ionization-induced bulk potential change	Ohm	0
IBPC2	impact-ionization-induced bulk potential change	V^-1	0
NSTI	substrate impurity concentration at STI edge	cm^-3	5.00E+17
WSTI	width of high-field region at STI edge	m	0
WSTIL	channel-length dependence of WSTI	um^WSTILP	0
WSTILP	channel-length dependence of WSTI	-	1
WSTIW	channel-width dependence of WSTI	um^WSTIWP	0
WSTIWP	channel-width dependence of WSTI	-	1
SCSTI1	the same effect as SC1 but at STI edge	-	0
SCSTI2	the same effect as SC2 but at STI edge	V^-1	0
VTHSTI	threshold voltage shift due to STI	V	0

Name	Description [Range]	Units	Default
VDSTI	Vds dependence of STI subthreshold	-	0
MUESTI1	mobility change due to diffusion length	m	0
MUESTI2	mobility change due to diffusion length	-	0
MUESTI3	mobility change due to diffusion length	-	1
NSUBPSTI1	pocket concentration modifier	m	0
NSUBPSTI2	pocket concentration modifier	-	0
NSUBPSTI3	pocket concentration modifier	-	1
NSUBCSTI1	channel concentration modifier	m	0
NSUBCSTI2	channel concentration modifier	-	0
NSUBCSTI3	channel concentration modifier	-	1
TPOLY	height of poly-Si gate for fringing capacitance	m	0
CGBO	gate-to-B overlap capacitance	F*m^-1	-
CGDO	gate-to-drain overlap capacitance	F*m^-1	-
CGSO	gate-to-source overlap capacitance	F*m^-1	-
OVSLP	coefficient for overlap capacitance	mV^-1	2.10E-07
OVMAG	coefficient for overlap capacitance	V	6.00E-01
JS0	saturation current density	A*m^-2	1.00E-04
NJ	emission coefficient	-	1
XTI	temp coefficient for forward current densities	-	2
XTI2	temp coefficient for reverse current densities	-	0
VDIFFJ	diode threshold voltage at junction	V	1.60E-03
DIVX	reverse current coefficient	V^-1	0
CJ	bottom junc cap/unit area at zero bias	F*m^-2	5.00E-04
CJSW	sidewall junc cap grading coefficient	F*m^-1	5.00E-10

Name	Description [Range]	Units	Default
CJSWG	sidewall junc cap per unit length at zero bias	F*m^-1	5.00E-10
MJ	bottom junc cap grading coefficient	-	0.33
MJSW	sidewall junc cap grading coefficient	-	0.33
MJSWG	gate sidewall junc cap grading coefficient	-	0.33
PB	bottom junc built-in potential	V	1
PBSW	sidewall junc built-in potential	V	1
PBSWG	gate sidewall junc built-in potential	V	1
LOVER	overlap length	m	3.00E-08
CLM1	hardness coefficient of channel/contact junction	-	7.00E-01
CLM2	coefficient for QB contribution	-	2
CLM3	coefficient for QI contribution	-	1
CLM5	CLM parameter	-	1
CLM6	CLM parameter	um^-CLM5	0
VOVER	velocity overshoot effect parameter	cm^VOVERP	1.00E-02
VOVERP	Leff-dependence of velocity overshoot	-	1.00E-01
VOVERS	modification of max velocity due to small size	-	0
VOVERSP	modification of max velocity due to small size	-	1
WFC	Threshold voltage change due to cap change	F*cm^-2*m^-1	0
NSUBCW	substrate concentration modifier	um^NSUBCWP	0
NSUBCWP	substrate concentration modifier	-	1
NSUBCMAX	upper limit of substrate concentration	cm^-3	5.00E+18
QME1	Vgs-dependence of quantum mechanical effect	mV	0
QME2	Vgs-dependence of quantum mechanical effect	V	0
QME3	minimum Tox modification	m	0

Name	Description [Range]	Units	Default
GIDL1	magnitude of GIDL	A*V^-3/2C^-1m	5.00E-06
GIDL2	field-dependence of GIDL	V^-2m^-1F^-3/2	1.00E+06
GIDL3	Vds-dependence of GIDL	-	3.00E-01
GIDL4	threshold for Vds dependence	V	0
GIDL5	high-field correction	-	2.00E-01
GLEAK1	gate-to-channel current coefficient	V^-3/2*s^-1	1.00E+04
GLEAK2	gate-to-channel current coefficient	V^-1/2*m^-1	2.00E+07
GLEAK3	gate-to-channel current coefficient	-	3.00E-01
GLEAK4	gate-to-channel current coefficient	m^-1	4.00E+00
GLEAK5	G-t-C short channel correction	V*m^-1	7.50E+03
GLEAK6	G-t-C Vds-dependence correction	V	2.50E-01
GLEAK7	G-t-C L and W dependence correction	m^2	1.00E-06
GLKSD1	G-t-S/D current coefficient	A*m*V^-2	1.00E-15
GLKSD2	G-t-S/D current coefficient	V^-1*m^-1	5.00E+06
GLKSD3	G-t-S/D current coefficient	m^-1	-5.00E+06
GLKB1	G-t-S/D current coefficient	A*V^-2	5.00E-16
GLKB2	G-t-S/D current coefficient	m*V^-1	1.00E+00
GLKB3	G-t-S/D current coefficient	V	0.00E+00
VZADD0	symmetry conservation coefficient	V	1.00E-02
PZADD0	symmetry conservation coefficient	V	5.00E-03
NFTRP	ratio of trap density to attenuation coefficient	V^-1	1.00E+10
NFALP	contribution of mobility fluctuation	cm*s	1.00E-19
CIT	cap caused by the interface trapped carriers	F*cm^-2	0

Name	Description [Range]	Units	Default
FALPH	power of f describing deviation of 1/f	sm^3	1
TNOM	temperature selected as a nominal value [22 : 32]	C	27
DLY1	coefficient for delay due to diffusion of carriers	s	1.00E-10
DLY2	coefficient for delay due to conduction of carriers	-	7.00E-01
DLY3	coefficient for RC delay of bulk carriers	Ohm	8.00E-07
TFOX	front oxide thickness (0 : inf)	m	3.50E-09
TSOI	silicon film thickness (0 : inf)	m	5.00E-08
XJ	impurity doping depth (0 : inf)	m	5.00E-08
TBOX	buried oxide thickness (0 : inf)	m	1.10E-07
NSUBS	SOI layer impurity concentration (0 : inf)	cm^-3	3.00E+17
NSUBB	substrate impurity concentration (0 : inf)	cm^-3	4.00E+14
RTH0	Thermal resistance	Kcm/W	0.1
CTH0	thermal capacitance	Ws/(Kcm)	1.00E-07
SC4	SCE parameter	-	0
PTL	punchthrough parameter	V^PTP-1m^PTLP	0
PTP	punchthrough parameter	-	3.5
PT2	punchthrough parameter	V^-1	0
PTLP	punchthrough parameter	-	1
GDL	strength of high-field effect	m^GDLP	0
GDLP	modification of channel conductance	-	0
GDLD	modification of channel conductance	m	0
PT4	punchthrough parameter	-	0
PT4P	punchthrough parameter	-	1
VGSMIN	surface potential limiter	V	-5.0*TYPE

Name	Description [Range]	Units	Default
RMIN	Minimum registance	ohm	1.00E-03
MUEPH1	phonon scattering	cm^2V^-1s^-1	2.50E+04
NRS	Number of squares in source [0 : inf]		1
NRD	Number of squares in drain [0 : inf]		1
LDRIFT	Parameter for drift region length (drain) [0 : inf)	m	1.00E-06
LDRIFTS	Parameter for drift region length (source) [0 : inf)	m	1.00E-06
CORS	source side resistance OFF(0)/ON(1) (0 : 1]		0
CORD	drain side resistance OFF(0)/ON(1) (0 : 1]		0
RSH	Drain diffusion sheet resistance [0 : inf)	ohm	0
NOVERS	impurity concentration in overlap region	cm^-3	1.00E+19
RDRMUED	Mobility in drift region (drain) (0 : inf)		1.00E+03
RDRMUES	Mobility in drift region (source) (0 : inf)		1.00E+03
RDRVMAXD	Saturation velocity in drift region (drain) (0 : inf)		3.00E+07
RDRVMAXS	Saturation velocity in drift region (source) (0 : inf)		3.00E+07
RDRMUETMP	Temperature dependence of resistance		0
RDRVTMP	Temperature dependence of resistance		0
RDRDJUNC	Junction depth at channel/drift region (0 : inf)		1.00E-06
RDRBBD	Degradation of the mobility in drift region (drain) [0.1 : inf)		1
RDRBBS	degradation of the mobility in drift region (source) [0.1 : inf)		1
RDRBBTMP	Temperature coefficient of RDRBB		0
RDRVMAXW	Wgate dependence of the saturation velocity in drift region		0
RDRVMAXWP	Wgate dependence of the saturation velocity in drift region		1

Name	Description [Range]	Units	Default
RDRVMAXL	Lgate dependence of the saturation velocity in drift region		0
RDRVMAXLP	Lgate dependence of the saturation velocity in drift region		1
RDRMUEL	Lgate dependence of the mobility in drift region		0
RDRMUELP	Lgate dependence of the mobility in drift region		1
VFBBTP	flatband voltage for overlaped MOSFET part	V	(VFBC+1.12)
CBTBN	N+ poly capacitance	F/m^2	-
CBTBP	P+ poly capacitance	F/m^2	-
XWDBT	BT overlap width	m	0

DC Operating Point Parameters

Name	Description	Units
Rdd	Drift Resistance on Drain side	Ohm
Rsd	Drift Resistance on Source side	Ohm
idse	Drain-Source current	A
Isuba	Substrate current	A
igidle	Gate-Induced Drain Leakage current	A
igisle	Gate-Induced Source Leakage current	A
igde	Gate-Drain current	A
igse	Gate-Source current	A
igbe	Gate-Substrate current	A
ggm	Transconductance	S
ggds	Channel conductance	S
ggmbs	Body effect(Back gate) transconductance	S
ggmt	Temperature transconductance	S

Name	Description	Units
deltemp	Temperature	S
vone	Threshold voltage	V
vdsate	Saturation voltage	V
qge	Gate charge	C
qde	Drain charge	C
qse	Bulk charge	C
cggbd	g-g MOSFET capacitance	F
cgdbd	g-d MOSFET capacitance	F
cgsbd	g-s MOSFET capacitance	F
cbgbd	b-g MOSFET capacitance	F
cbsbd	b-s MOSFET capacitance	F
cbdbd	b-d MOSFET capacitance	F
cdgbd	d-g MOSFET capacitance	F
cddbd	d-d MOSFET capacitance	F
cdsbd	d-s MOSFET capacitance	F
ibdb	b-d Diode current	A
ibsb	b-s Diode current	A
Gbd	b-d Diode conductance	S
Gbs	b-s Diode conductance	S
capbdb	b-d Diode capacitance	F
capbsb	b-s Diode capacitance	F

Usage

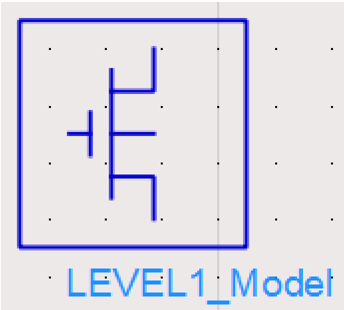
The HiSIM_SOI is only available from a netlist. Use the netlistInclude component to refer to a text file where the modelcard and instance are defined.

> *<modelname>: <instanceName> <d> <g> <s> <e> <bc> <n6> <instanceParameters>*
>
> *model <modelName> HiSIM_SOI_1_3_0 <modelParameters>*

LEVEL1 Model (MOSFET Level-1 Model)

LEVEL1_Model (MOSFET Level-1 Model)

Symbol



The simulator provides three MOSFET device models that differ in formulation of I-V characteristics. MOSFET Level1_Model is Shichman-Hodges model derived from [1].

Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Idsmod	IDS model: 1=LEVEL1 2=LEVEL2 3=LEVEL3 4=BSIM1 5=BSIM2 6=NMOD 8=BSIM3	None	1
Capmod	capacitance model selector: 0=NO CAP 1=CMEYER/WARD 2=SMOOTH 3=QMEYER	None	1
Vto †	zero-bias threshold voltage	V	0.0
Kp †	transconductance coefficient	A/V^2	2.0e-5
Gamma	bulk threshold	V$^{(1/2)}$	0.0
Phi †	surface potential	V	0.6
Lambda	channel-length modulation	1/V	0.0
Rd	Drain Resistance	Ohm	fixed at 0.0

Rs	Source Resistance	Ohm	fixed at 0.0
Cbd †	Bulk-Drain Zero-bias Junction Capacitance	F	0.0
Cbs †	Bulk-Source Zero-bias zero-bias Junction Capacitance	F	0.0
Is †	Gate Saturation Current	A	1.0e-14
Pb †	bulk junction potential	V	0.8
Cgso	gate-source overlap capacitance per meter of channel width	F/m	0.0
Cgdo	gate-drain overlap capacitance per meter of channel width	F/m	0.0
Cgbo	gate-bulk overlap capacitance per meter of channel length	F/m	0.0
Rsh	drain and source diffusion sheet resistance	Ohm/ sq	0.0
Cj †	zero-bias bulk junction bottom capacitance per square meter of junction area	F/m^2	0.0
Mj	bulk junction bottom grading coefficient	None	0.5
Cjsw †	zero-bias bulk junction periphery capacitance per meter of junction perimeter	F/m	0.0
Mjsw	bulk junction periphery grading coefficient	None	1/3
Js †	bulk junction saturation current per square meter of junction area	A/m^2	0.0
Tox	oxide thickness	m	1.0e-7
Nsub	substrate (bulk) doping density	cm^{-3}	0.0
Nss	surface state density	cm^{-2}	0.0
Tpg	Type of Gate Material: 1=opposite to bulk, 1=same as bulk, 0=aluminum	None	1
Ld	lateral diffusion length	m	0.0
Uo †	surface mobility	cm^2 / (Vs)	600.0
Nlev	noise model level	None	-1
Gdsnoi	drain noise parameters for Nlev=3	None	1
Kf	flicker-noise coefficient	None	0.0
Af	flicker-noise exponent	None	1.0
Fc	bulk junction forward-bias depletion capacitance coefficient	None	0.5
Rg	gate resistance	Ohm	fixed at 0.0
Rds	drain-source shunt resistance	Ohm	fixed at infinity ††

Tnom	Nominal ambient temperature	°C	25
Trise	temperature rise above ambient	°C	0
N	bulk P-N emission coefficient	None	1.0
Tt	bulk P-N transit time		0.0
Ffe (Ef)	flicker noise frequency exponent	None	1.0
Imax	explosion current	A	10.0
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 10)	A	defaults to Imax
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvg	gate oxide breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
Acm	area calculation method	None	0
Hdif	length of heavily doped diffusion (Acm=2, 3 only)	m	0.0
Ldif	length of lightly doped diffusion adjacent to gate (Acm=1, 2 only)	m	0.0
Wmlt	width diffusion layer shrink reduction factor	None	1.0
Lmlt	Gate length shrink factor	None	1.0
Xw	accounts for masking and etching effects	m	0.0
Rdc	additional drain resistance due to contact resistance	Ohm	0.0
Rsc	additional source resistance due to contact resistance	Ohm	0.0
Wmin	Binning minimum width (parsed but not used, use BinModel)	m	0.0
Wmax	Binning maximum width (parsed but not used, use BinModel)	m	1.0
Lmin	Binning minimum length (parsed but not used, use BinModel)	m	0.0
Lmax	Binning maximum length (parsed but not used, use BinModel)	m	1.0
AllParams	Data Access Component (DAC) Based Parameters	None	None
† Parameter value varies with temperature based on model Tnom and device Temp. †† Value of 0.0 is interpreted as infinity.			

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

*model modelname MOSFET Idsmod=1 [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *MOSFET*. Idsmod=1 is a required parameter that is used to tell the simulator to use the Spice level 1 equations. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

```
model  Nch1 MOSFET Idsmod=1 \
  Kp=4e-5 Vto=0.7 NMOS=yes
```

- Vto, Kp, Gamma, Phi, and Lambda determine the DC characteristics of a MOSFET device. ADS will calculate these parameters (except Lambda) if instead of specifying them, you specify the process parameters Tox, Uo, Nsub, and Nss.
- Vto is positive (negative) for enhancement mode and negative (positive) for depletion mode N-channel (P-channel) devices.
- P-N junctions between the bulk and the drain and the bulk and the source are modeled by parasitic diodes. Each bottom junction is modeled by a diode and each periphery junction is modeled by a depletion capacitance.
- Diode parameters for the bottom junctions can be specified as absolute values (Is, Cbd and Cbs) or as per unit junction area values (Js and Cj).
  If Cbd = 0.0 and Cbs = 0.0, then Cbd and Cbs will be calculated:

  $Cbd = Cj\ Ad,\ Cbs = Cj\ As$

  If Js > 0.0 and Ad > 0.0 and As > 0.0, then Is for drain and source will be calculated:

  $Is(drain) = Js\ Ad,\ Is(source) = Js\ As$
- Drain and source ohmic resistances can be specified as absolute values (Rd, Rs) or as per unit square value (Rsh).
  If Nrd 0.0 or Nrs 0.0, Rd and Rs will be calculated:
  Rd = Rsh Nrd, Rs = Rsh Nrs
- Charge storage in the MOSFET consists of capacitances associated with parasitics and intrinsic device. Parasitic capacitances consist of three constant overlap capacitances (Cgdo, Cgso, Cgbo) and the depletion layer capacitances for both substrate junctions (divided into bottom and periphery), that vary as Mj and Mjsw power of junction voltage, respectively, and are determined by the parameters Cbd, Cbs, Cj, Cjsw, Mj, Mjsw, Pb and Fc.
  The intrinsic capacitances consist of the nonlinear thin-oxide capacitance, which is distributed among the gate, drain, source, and bulk regions.

- Charge storage is modeled by fixed and nonlinear gate and junction capacitances. MOS gate capacitances, as a nonlinear function of terminal voltages, are modeled by Meyer's piece-wise linear model for levels 1, 2, and 3. The Ward charge conservation model is also available for levels 2 and 3, by specifying the XQC parameter to a value smaller than or equal to 0.5. For Level 1, the model parameter TOX must be specified to invoke the Meyer model when Capmod is equal to 1 (default value). If Capmod = 0, no gate capacitances will be calculated. If Capmod = 2, a smooth version of the Meyer model is used. If Capmod =3, the charge conserving first-order MOS charge model [2] that was used in Libra is used.
- To include the thin-oxide charge storage effect, model parameter Tox must be > 0.0.
- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.

Temperature Scaling

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device item Temp parameter. (Temperatures in the following equations are in Kelvin.)
The depletion capacitances Cbd, Cbs, Cj, and Cjsw vary as:

$$Cbd^{NEW} = Cbd\left[\frac{1 + Mj[4\times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mj[4\times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

$$Cbs^{NEW} = Cbs\left[\frac{1 + Mj[4\times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mj[4\times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

$$Cj^{NEW} = Cj\left[\frac{1 + Mj[4\times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mj[4\times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

$$Cjsw^{NEW} = Cjsw\left[\frac{1 + Mjsw[4\times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mjsw[4\times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

where γ is a function of the junction potential and the energy gap variation with temperature.

The surface potential Phi and the bulk junction potential Pb vary as:

$$Phi^{NEW} = \frac{Temp}{Tnom}\times Phi + \frac{2k\times Temp}{q} 1n\left(\frac{n_i^{Tnom}}{n_i^{Temp}}\right)$$

$$Pb^{NEW} = \frac{Temp}{Tnom}\times Pb + \frac{2k\times Temp}{q} 1n\left(\frac{n_i^{Tnom}}{n_i^{Temp}}\right)$$

The transconductance Kp and mobility Uo vary as:

$$Kp^{NEW} = Kp\left(\frac{Temp}{Tnom}\right)^{3/2}$$

$$Uo^{NEW} = Uo\left(\frac{Temp}{Tnom}\right)^{3/2}$$

The source and drain to substrate leakage currents Is and Js vary as:

$$Is^{NEW} = Is\times exp\left(\frac{q\times E_G^{Tnom}}{k\times Tnom} - \frac{q\times E_G^{Temp}}{k\times Temp}\right)$$

$$Js^{NEW} = Js\times exp\left(\frac{q\times E_G^{Tnom}}{k\times Tnom} - \frac{q\times E_G^{Temp}}{k\times Temp}\right)$$

where E_G is the silicon bandgap energy as a function of temperature.
The MOSFET threshold voltage variation with temperature is given by:

$$Vto^{NEW} = Vto + \gamma\left(\sqrt{Phi^{NEW}} - \sqrt{Phi}\right) + \frac{Phi^{NEW} - Phi}{2} - \frac{E_G^{Temp} - E_G^{Tnom}}{2}$$

Noise Model

Thermal noise generated by resistor Rg, Rs, Rd, and Rds is characterized by the following spectral density:

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

Channel and flicker noise (Kf, Af, Ffe) generated by DC transconductance g_m and current flow from drain to source is characterized by spectral density:

$$\frac{<i_{ds}^2>}{\Delta f} = \frac{8kTg_m}{3} + \mathrm{k}_f \frac{I_{DS}^{a_f}}{f^{f_{fe}}}$$

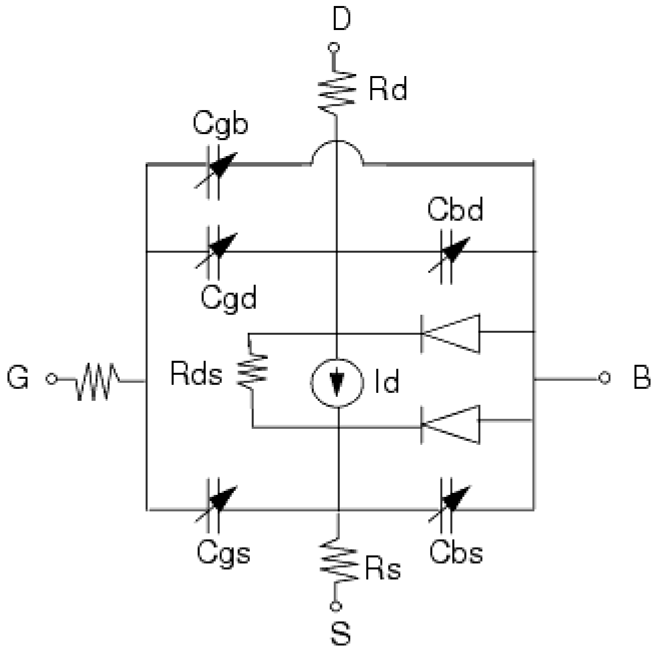
In the preceding expressions, *k* is Boltzmann's constant, T is operating temperature in Kelvin, *q* is electron charge, *kf* , *a* f, and *f* fe are model parameters, *f* is simulation frequency, and Δ *f* is noise bandwidth.

Additional Information

References

- H. Shichman and D. A. Hodges. "Modeling and simulation of insulated-gate field-effect transistor switching circuits," *IEEE Journal of Solid-State Circuits,* SC-3, 285, Sept. 1968.
- Karen A. Sakallah, Yao-tsung Yen, and Steve S. Greenberg. "The Meyer Model Revisited: Explaining and Correcting the Charge Non-Conservation Problem," *ICCAD* , 1987.
- P. Antognetti and G. Massobrio. *Semiconductor device modeling with SPICE* , New York: McGraw-Hill, Second Edition 1993.

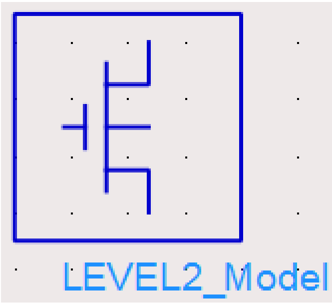
Equivalent Circuit


D
Rd
Cgb
Cbd
Cgd
G
Rds
Id
B
Cgs
Rs
Cbs
S

LEVEL2 Model (MOSFET Level-2 Model)

LEVEL2_Model (MOSFET Level-2 Model)

Symbol



The simulator provides three MOSFET device models that differ in formulation of I-V characteristics. LEVEL2_Model is a geometry-based, analytical model derived from [1]. LEVEL2_Model includes second order effects such as threshold voltage shift, mobility reduction, velocity saturation, channel length modulation, and subthreshold conduction.

Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Idsmod	IDS model: 1=LEVEL1 2=LEVEL2 3=LEVEL3 4=BSIM1 5=BSIM2 6=NMOD 8=BSIM3	None	2
Capmod	capacitance model selector: 0=NO CAP 1=CMEYER/WARD 2=SMOOTH 3=QMEYER	None	1
Vto †	zero-bias threshold voltage	V	0.0
Kp †	Transconductance	A/V^2	2.0e-5
Gamma	bulk threshold	$V^{(1/2)}$	0.0
Phi †	surface potential	V	0.6

Lambda	channel-length modulation	1/V	0.0
Rd	drain resistance	Ohm	fixed at 0.0
Rs	source resistance	Ohm	fixed at 0.0
Cbd †	bulk-drain zero-bias junction capacitance	F	0.0
Cbs †	bulk-source zero-bias junction capacitance	F	0.0
Is	Gate Saturation Current	A	1.0e-14
Pb †	bulk junction potential	V	0.8
Cgso	gate-source overlap capacitance per meter of channel width	F/m	0.0
Cgdo	gate-drain overlap capacitance per meter of channel width	F/m	0.0
Cgbo	gate-bulk overlap capacitance per meter of channel length	F/m	0.0
Rsh	drain and source diffusion sheet resistance	Ohm/ sq	0.0
Cj †	zero-bias bulk junction bottom capacitance per square meter of junction area	F/m^2	0.0 ††
Mj	bulk junction bottom grading coefficient	None	0.5
Cjsw †	zero-bias bulk junction periphery capacitance per meter of junction perimeter	F/m	0.0
Mjsw	bulk junction periphery grading coefficient	None	1/3
Js †	Gate Saturation Current per square meter of junction area	A/m^2	0.0
Tox	oxide thickness	m	1.0e-7
Nsub	substrate (bulk) doping density	cm^{-3}	0.0
Nss	surface state density	cm^{-2}	0.0
Nfs	fast surface state density	cm^{-2}	0.0
Tpg	Type of Gate Material: 1=opposite to bulk, 1=same as bulk, 0=aluminum	None	1
Xj	metallurgical junction depth	m	0.0
Ld	lateral diffusion length	m	0.0
Uo †	surface mobility	cm^2 / (V×s)	600.0
Ucrit	critical field for mobility degradation	V/cm	1.0e4
Uexp	critical field exponent in mobility degradation	None	0.0
Vmax	Maximum Drift Velocity of Carriers	m/s	0.0
Neff	total channel charge coefficient	None	1.0

Xqc (Xpart)	fraction of channel charge attributed to drain	None	1.0
Nlev	noise model level	None	-1
Gdsnoi	drain noise parameters for Nlev=3	None	1
Kf	flicker noise coefficient	None	0.0
Af	flicker noise exponent	None	1.0
Fc	bulk junction forward-bias depletion capacitance coefficient	None	0.5
Delta	width effect on threshold voltage	None	0.0
Rg	gate ohmic resistance	Ohm	fixed at 0.0
Rds	drain-source shunt resistance	Ohm	fixed at infinity ††
Tnom	nominal ambient temperature at which these model parameters were derived	°C	25
Trise	temperature rise above ambient	°C	0
N	bulk P-N emission coefficient	None	1.0
Tt	bulk P-N transit time		0.0
Ffe (Ef)	flicker noise frequency exponent	None	1.0
Imax	explosion current	A	10.0
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 10)	A	defaults to Imax
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvg	gate oxide breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
Acm	area calculation method	None	0
Hdif	length of heavily doped diffusion (Acm=2, 3 only)	m	0.0
Ldif	length of lightly doped diffusion adjacent to gate (Acm=1, 2 only)	m	0.0
Wmlt	width diffusion layer shrink reduction factor	None	1.0
Lmlt	Gate length shrink factor	None	1.0
Xw	accounts for masking and etching effects	m	0.0
Rdc	additional drain resistance due to contact resistance	Ohm	0.0
Rsc	additional source resistance due to contact resistance	Ohm	0.0

AllParams	Data Access Component (DAC) Based Parameters	None	None
† Parameter value varies with temperature based on Tnom of the model and Temp of the device. †† A value of 0.0 is interpreted as infinity.			

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *model modelname MOSFET Idsmod=2 [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *MOSFET*. Idsmod=2 is a required parameter that is used to tell the simulator to use the Spice level 2 equations. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

```
model Nch2 MOSFET Idsmod=2 \
Kp=4e-5 Vto=0.7 NMOS=yes
```

- Parameters Vto, Kp, Gamma, Phi, and Lambda determine the DC characteristics of a MOSFET device. The program will calculate these parameters (except Lambda) if, instead of specifying them, you specify the process parameters Tox, Uo, Nsub, and Nss.
- Vto is positive (negative) for enhancement mode and negative (positive) for depletion mode N-channel (P-channel) devices.
- The P-N junctions between the bulk and the drain and the bulk and the source are modeled by parasitic diodes. Each bottom junction is modeled by a diode and each periphery junction is modeled by a depletion capacitance.
- The diode parameters for the bottom junctions can be specified as absolute values (Is, Cbd and Cbs) or as per unit junction area values (Js and Cj).
  If Cbd = 0.0 and Cbs = 0.0, then Cbd and Cbs will be calculated:

  $$Cbd = Cj \times Ad, \; Cbs = Cj \times As$$

  If Js > 0.0 and Ad > 0.0 and As > 0.0, then Is for drain and source will be calculated:

Is(drain) = Js × Ad, Is(source) = Js × As

- Drain and source ohmic resistances can be specified as absolute values (Rd, Rs) or as per unit square value (Rsh).
If Nrd ≠ 0.0 or Nrs ≠ 0.0, Rd and Rs will be calculated:
Rd = Rsh × Nrd, Rs = Rsh × Nrs
- Charge storage is modeled by fixed and nonlinear gate and junction capacitances. MOS gate capacitances, as a nonlinear function of terminal voltages, are modeled by Meyer's piece-wise linear model for levels 1, 2, and 3. The Ward charge conservation model is also available for levels 2 and 3, by specifying the XQC parameter to a value smaller than or equal to 0.5. For Level 1, the model parameter TOX must be specified to invoke the Meyer model when Capmod is equal to 1 (default value). If Capmod = 0, no gate capacitances will be calculated. If Capmod = 2, a smooth version of the Meyer model is used. If Capmod =3, the charge conserving first-order MOS charge model [2] that was used in Libra is used.
- The simulator uses Ward and Dutton [2] charge-controlled capacitance model if Xqc ≤ 0.5. If Xqc > 0.5, the charge-conserving first-order MOS charge model is used.
- Imax and Imelt Parameters
Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.

Temperature Scaling

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device item Temp parameter. (Temperatures in the following equations are in Kelvin.)
The depletion capacitances Cbd, Cbs, Cj, and Cjsw vary as:

$$Cbd^{NEW} = Cbd\left[\frac{1 + Mj[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mj[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

$$Cbs^{NEW} = Cbs\left[\frac{1 + Mj[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mj[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

$$Cj^{NEW} = Cj\left[\frac{1 + Mj[4\times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mj[4\times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

$$Cjsw^{NEW} = Cjsw\left[\frac{1 + Mjsw[4\times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mjsw[4\times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

where γ is a function of the junction potential and the energy gap variation with temperature.

The surface potential Phi and the bulk junction potential Pb vary as:

$$Phi^{NEW} = \frac{Temp}{Tnom}\times Phi + \frac{2k\times Temp}{q}1n\left(\frac{n_i^{Tnom}}{n_i^{Temp}}\right)$$

$$Pb^{NEW} = \frac{Temp}{Tnom}\times Pb + \frac{2k\times Temp}{q}1n\left(\frac{n_i^{Tnom}}{n_i^{Temp}}\right)$$

The transconductance Kp and mobility Uo vary as:

$$Kp^{NEW} = Kp\left(\frac{Temp}{Tnom}\right)^{3/2}$$

$$Uo^{NEW} = Uo\left(\frac{Temp}{Tnom}\right)^{3/2}$$

The source and drain to substrate leakage currents Is and Js vary as:

$$Is^{NEW} = Is\times exp\left(\frac{q\times E_G^{Tnom}}{k\times Tnom} - \frac{q\times E_G^{Temp}}{k\times Temp}\right)$$

$$Js^{NEW} = Js\times exp\left(\frac{q\times E_G^{Tnom}}{k\times Tnom} - \frac{q\times E_G^{Temp}}{k\times Temp}\right)$$

where E_G is the silicon bandgap energy as a function of temperature.
The MOSFET threshold voltage variation with temperature is given by:

$$Vto^{NEW} = Vto + \gamma\left(\sqrt{Phi^{NEW}} - \sqrt{Phi}\right) + \frac{Phi^{NEW} - Phi}{2} - \frac{E_G^{Temp} - E_G^{Tnom}}{2}$$

Noise Model

Thermal noise generated by resistor Rg, Rs, Rd, and Rds is characterized by the following spectral density:

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

Channel noise and flicker noise (Kf, Af, Ffe) generated by the DC transconductance g_m and current flow from drain to source is characterized by the following spectral density:

$$\frac{<i_{ds}^2>}{\Delta f} = \frac{8kTg_m}{3} + \mathrm{k}_f \frac{I_{DS}^{a_f}}{f^{f_{fe}}}$$

In the preceding expressions, *k* is Boltzmann's constant, *T* is the operating temperature in Kelvin, *q* is the electron charge, *kf* , *af* , and *ffe* are model parameters, `f` is the simulation frequency, and Δ *f* is the noise bandwidth.

Additional Information

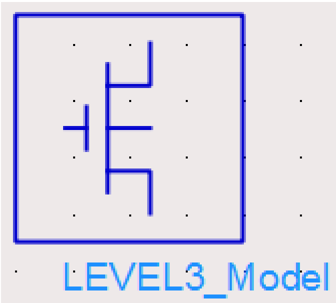
References

- 1Vladimirescu and S. Liu. The Simulation of MOS Integrated Circuits Using SPICE2, Memorandum No. M80/7, February 1980.
- D. E. Ward, and R. W. Dutton. "A Charge-Oriented Model for MOS Transistors Capacitances," *IEEE Journal on Solid-State Circuits* , SC-13, 1978.
- P. Antognetti and G. Massobrio . *Semiconductor device modeling with SPICE* , New York: McGraw-Hill, Second Edition 1993.

LEVEL3 Model (MOSFET Level-3 Model)

LEVEL3_Model (MOSFET Level-3 Model)

Symbol



The simulator provides three MOSFET device models that differ in formulation of I-V characteristics. LEVEL3_Model is a semi-empirical model derived from [1]. LEVEL3_Model includes second order effects such as threshold voltage shift, mobility reduction, velocity saturation, channel length modulation, and subthreshold conduction.

Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Idsmod	IDS model: 1=LEVEL1 2=LEVEL2 3=LEVEL3 4=BSIM1 5=BSIM2 6=NMOD 8=BSIM3	None	3
Capmod	capacitance model selector: 0=NO CAP 1=CMEYER/WARD 2=SMOOTH 3=QMEYER	None	1
Vto †	zero-bias threshold voltage	V	0.0
Kp †	transconductance	A/V^2	2.0e-5
Gamma	bulk threshold	$V^{(1/2)}$	0.0
Phi †	surface potential	V	0.6

Rd	drain resistance	Ohm	fixed at 0
Rs	source resistance	Ohm	fixed at 0
Cbd †	bulk-drain zero-bias junction capacitance	F	0.0
Cbs †	bulk-source zero-bias junction capacitance	F	0.0
Is †	Gate Saturation Current	A	1.0e-14
Pb †	bulk junction potential	V	0.8
Cgso	gate-source overlap capacitance per meter of channel width	F/m	0.0
Cgdo	gate-drain overlap capacitance per meter of channel width	F/m	0.0
Cgbo	gate-bulk overlap capacitance per meter of channel length	F/m	0.0
Rsh	drain and source diffusion sheet resistance	Ohm/sq	0.0
Cj †	zero-bias bulk junction bottom capacitance per square meter of junction area	F/m ^{2}	0.0
Mj	bulk junction bottom grading coefficient	None	0.5
Cjsw †	Zero-bias Bulk Junction Sidewall Capacitance per meter of junction perimeter	F/m	0.0
Mjsw	Junction Sidewall grading coefficient	None	1/3
Js †	bulk junction saturation current per square meter of junction area	A/m ^{2}	0.0
Tox	oxide thickness	m	1.0e-7
Nsub	substrate (bulk) doping density	cm $^{-3}$	0.0
Nss	surface state density	cm $^{-2}$	0.0
Nfs	fast surface state density	cm $^{-2}$	0.0
Tpg	gate material type: 1=opposite substrate, 1=same as substrate, 0=aluminum	None	1
Xj	metallurgical junction depth	m	0.0
Ld	lateral diffusion length	m	0.0
Uo †	surface mobility	cm ^{2} / (V×s)	600.0
Vmax	Maximum Drift Velocity of Carriers	m/s	0.0
Xqc (Xpart)	coefficient of channel charge share	None	1.0
Nlev	noise model level	None	-1
Gdsnoi	drain noise parameters for Nlev=3	None	1
Kf	flicker noise coefficient	None	0.0

Af	flicker noise exponent	None	1.0
Fc	bulk junction forward-bias depletion capacitance coefficient	None	0.5
Delta	width effect on threshold voltage	None	0.0
Theta	mobility modulation	1/V	0.0
Eta	static feedback	None	0.0
Kappa	saturation field factor	None	0.2
Rg	gate resistance	Ohm	fixed at 0
Rds	drain-source shunt resistance	Ohm	fixed at infinity ††
Tnom	nominal ambient temperature at which these model parameters were derived	°C	25
Trise	temperature rise above ambient	°C	0
N	bulk P-N emission coefficient	None	1.0
Tt	bulk P-N transit time		0.0
Ffe (Ef)	flicker noise frequency exponent	None	1.0
Imax	explosion current	A	10.0
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 8)	A	defaults to Imax
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvg	gate oxide breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
Acm	area calculation method	None	0
Hdif	length of heavily doped diffusion (Acm=2, 3 only)	m	0.0
Ldif	length of lightly doped diffusion adjacent to gate (Acm=1, 2 only)	m	0.0
Wmlt	width diffusion layer shrink reduction factor	None	1.0
Lmlt	Gate length shrink factor	None	1.0
Xw	accounts for masking and etching effects	m	0.0
Rdc	additional drain resistance due to contact resistance	Ohm	0.0
Rsc	additional source resistance due to contact resistance	Ohm	0.0
MinR	minimum resistance value to be taken into consideration	Ohm	

AllParams	Data Access Component (DAC) Based Parameters	None	None
† Parameter value varies with temperature based on Tnom of model and Temp of device. †† Value of 0.0 is interpreted as infinity.			

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

> *model modelname MOSFET Idsmod=3 [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *MOSFET* . Idsmod=3 is a required parameter that is used to tell the simulator to use the Spice level 3 equations. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example:

```
model Nch3 MOSFET Idsmod=3 \
Kp=4e-5 Vto=0.7 NMOS=yes
```

- Parameters Vto, Kp, Gamma, Phi, and Lambda determine the DC characteristics of a MOSFET device. ADS will calculate these parameters (except Lambda) if, instead of specifying them, you specify the process parameters Tox, Uo, Nsub, and Nss.
- Vto is positive (negative) for enhancement mode and negative (positive) for depletion mode N-channel (P-channel) devices.
- P-N junctions between the bulk and the drain and the bulk and the source are modeled by parasitic diodes. Each bottom junction is modeled by a diode and each periphery junction is modeled by a depletion capacitance.
- Diode parameters for the bottom junctions can be specified as absolute values (Is, Cbd and Cbs) or as per unit junction area values (Js and Cj).
  If Cbd=0.0 and Cbs=0.0, Cbd and Cbs will be calculated:

  $$Cbd = Cj \times Ad \quad Cbs = Cj \times As$$

  If Js>0.0 and Ad>0.0 and As>0.0, Is for drain and source will be calculated:

> *Is(drain) = Js × Ad Is(source) = Js × As*

Drain and source ohmic resistances can be specified as absolute values (Rd, Rs) or as per unit square value (Rsh).
If Nrd≠0.0 or Nrs≠0.0, Rd and Rs will be calculated:

> *Rd = Rsh × Nrd Rs = Rsh × Nrs*

- Charge storage in the MOSFET consists of capacitances associated with parasitics and intrinsic device. The parasitic capacitances consist of three constant overlap capacitances (Cgdo, Cgso, Cgbo) and the depletion layer capacitances for both substrate junctions (divided into bottom and periphery) that vary as Mj and Mjsw power of junction voltage, respectively, and are determined by the parameters Cbd, Cbs, Cj, Cjsw, Mj, Mjsw, Pb and Fc.
  The intrinsic capacitances consist of the nonlinear thin-oxide capacitance, which is distributed among the gate, drain, source, and bulk regions.
- Charge storage is modeled by fixed and nonlinear gate and junction capacitances. MOS gate capacitances, as a nonlinear function of terminal voltages, are modeled by Meyer's piece-wise linear model for levels 1, 2, and 3. The Ward charge conservation model is also available for levels 2 and 3, by specifying the XQC parameter to a value smaller than or equal to 0.5. For Level 1, the model parameter TOX must be specified to invoke the Meyer model when Capmod is equal to 1 (default value). If Capmod = 0, no gate capacitances will be calculated. If Capmod = 2, a smooth version of the Meyer model is used. If Capmod =3, the charge conserving first-order MOS charge model [2] that was used in Libra is used.
- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.

Temperature Scaling

The model specifies Tnom, the nominal temperature at which the model parameters were calculated or extracted. To simulate the device at temperatures other than Tnom, several model parameters must be scaled with temperature. The temperature at which the device is simulated is specified by the device item Temp parameter. (Temperatures in the following equations are in Kelvin.)

The depletion capacitances Cbd, Cbs, Cj, and Cjsw vary as:

$$Cbd^{NEW} = Cbd\left[\frac{1 + Mj[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mj[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

$$Cbs^{NEW} = Cbs\left[\frac{1 + Mj[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mj[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

$$Cj^{NEW} = Cj\left[\frac{1 + Mj[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mj[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

$$Cjsw^{NEW} = Cjsw\left[\frac{1 + Mjsw[4 \times 10^{-4}(Temp - T_{REF}) - \gamma^{Temp}]}{1 + Mjsw[4 \times 10^{-4}(Tnom - T_{REF}) - \gamma^{Temp}]}\right]$$

where γ is a function of the junction potential and the energy gap variation with temperature. The surface potential Phi and the bulk junction potential Pb vary as:

$$Phi^{NEW} = \frac{Temp}{Tnom} \times Phi + \frac{2k \times Temp}{q} 1n\left(\frac{n_i^{Tnom}}{n_i^{Temp}}\right)$$

$$Pb^{NEW} = \frac{Temp}{Tnom} \times Pb + \frac{2k \times Temp}{q} 1n\left(\frac{n_i^{Tnom}}{n_i^{Temp}}\right)$$

The transconductance Kp and mobility Uo vary as:

$$Kp^{NEW} = Kp\left(\frac{Temp}{Tnom}\right)^{3/2}$$

$$Uo^{NEW} = Uo\left(\frac{Temp}{Tnom}\right)^{3/2}$$

The source and drain to substrate leakage currents Is and Js vary as:

$$Is^{NEW} = Is \times exp\left(\frac{q \times E_G^{Tnom}}{k \times Tnom} - \frac{q \times E_G^{Temp}}{k \times Temp}\right)$$

$$Js^{NEW} = Js \times exp\left(\frac{q \times E_G^{Tnom}}{k \times Tnom} - \frac{q \times E_G^{Temp}}{k \times Temp}\right)$$

where E_G is the silicon bandgap energy as a function of temperature.
The MOSFET threshold voltage variation with temperature is given by:

$$Vto^{NEW} = Vto + \gamma\left(\sqrt{Phi^{NEW}} - \sqrt{Phi}\right) + \frac{Phi^{NEW} - Phi}{2} - \frac{E_G^{Temp} - E_G^{Tnom}}{2}$$

Noise Model

Thermal noise generated by resistor Rg, Rs, Rd, and Rds is characterized by the following spectral density:

$$\frac{<i^2>}{\Delta f} = \frac{4kT}{R}$$

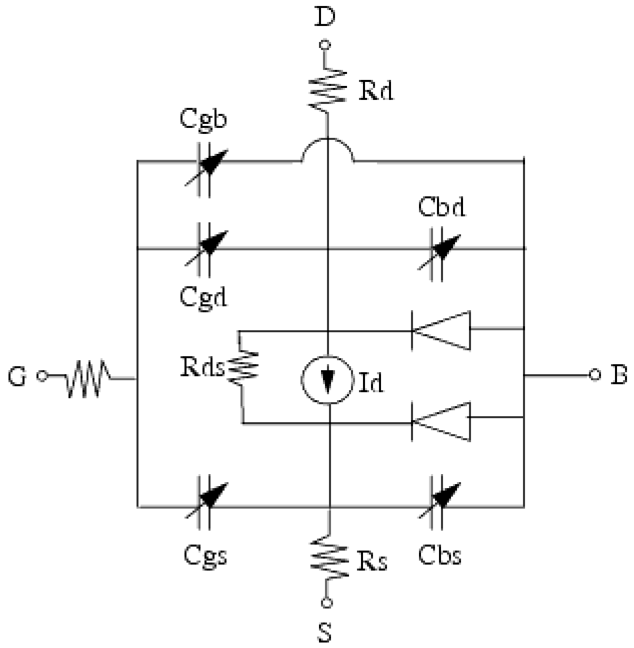
Channel noise and flicker noise (Kf, Af, Ffe) generated by DC transconductance g_m and current flow from drain to source is characterized by the spectral density:

$$\frac{<i_{ds}^2>}{\Delta f} = \frac{8kTg_m}{3} + k_f \frac{I_{DS}^{a_f}}{f^{f_{fe}}}$$

In the preceding expressions, *k* is Boltzmann's constant, *T* is the operating temperature in Kelvin, *q* is the electron charge, *kf* , *af* , and *ffe* are model parameters, *f* is the simulation frequency, and Δ `f` is the noise bandwidth.

Additional Information

Equivalent Circuit



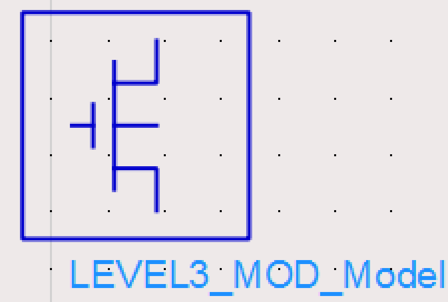
References

- Vladimirescu, and S. Liu. The Simulation of MOS Integrated Circuits Using SPICE2, Memorandum No. M80/7, February 1980.
- Karen A. Sakallah, Yao-tsung Yen, and Steve S. Greenberg. "The Meyer Model Revisited: Explaining and Correcting the Charge Non-Conservation Problem," *ICCAD* , 1987.
- P. Antognetti and G. Massobrio *. Semiconductor device modeling with SPICE* , New York: McGraw-Hill, Second Edition 1993.

LEVEL3 MOD Model (Level-3 NMOD MOSFET Model)

LEVEL3_MOD_Model (Level-3 NMOD MOSFET Model)

Symbol



LEVEL3_MOD_Model is an enhanced version of the SPICE level 3 model. It exhibits smooth and continuous transitions in the weak to strong inversion region, and in the region between linear and saturation modes of device operation.

Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Idsmod	IDS model type: 1=LEVEL1 2=LEVEL2 3=LEVEL3 4=BSIM1 5=BSIM2 6=NMOD 8=BSIM3	None	6
Capmod	capacitance model selector: 0=NO CAP 1=CMEYER/WARD 2=SMOOTH 3=QMEYER	None	1
Vto †	zero-bias threshold voltage	V	0.0
Kp †	transconductance	A/V^2	2.0e-5
Gamma	bulk threshold	$V^{(1/2)}$	0.0
Gamma2	bulk threshold parameter deep in substrate	$V^{(1/2)}$	0.0
Zeta	mobility modulation with substrate bias	None	0.0
Phi †	surface potential	V	0.6

Rd	drain resistance	Ohm	fixed at 0.0
Rs	source resistance	Ohm	fixed at 0.0
Cbd †	zero-bias bulk-drain junction capacitance	F	0.0
Cbs †	zero-bias bulk-source junction capacitance	F	0.0
Is †	bulk junction saturation current	A	1.0e-14
Pb †	bulk junction potential	V	0.8
Cgso	gate-source overlap cap. per meter of channel width	F/m	0.0
Cgdo	gate-drain overlap cap. per meter of channel width	F/m	0.0
Cgbo	gate-bulk overlap cap. per meter of channel length	F/m	0.0
Rsh	drain and source diffusion sheet resistance	Ohm/ sq.	0.0
Cj †	zero-bias bulk junction bottom capacitance per square meter of junction area	F/m^2	0.0
Mj	bulk junction bottom grading coefficient	None	0.5
Cjsw †	zero-bias bulk junction periphery capacitance perimeter of junction perimeter	F/m	0.0
Mjsw	bulk junction periphery grading coefficient	None	1/3
Js †	bulk junction saturation current per square meter of junction area	A/m^2	0.0
Tox	oxide thickness	m	1.0e-7
Nsub	substrate (bulk) doping density	cm^{-3}	0.0
Nss	surface state density	cm^{-2}	0.0
Nfs	fast surface state density	cm^{-2}	0.0
Tpg	Type of Gate Material: 1=opposite substrate, 1=same as substrate, 0=aluminum	None	1
Xj	metallurgical junction depth	m	0.0
Ld	lateral diffusion length	m	0.0
Uo †	surface mobility	cm^2 / (V×S)	600.0
Ucrit	critical field for mobility degradation	V/cm	1.0e4
Uexp	field exponent in mobility degradation	None	0.0
Vmax	carriers maximum drift velocity	m/s	0.0

Xqc (Xpart)	coefficient of channel charge share	None	1.0
Nlev	Noise model level	None	-1
Gdsnoi	Drain noise parameter for Nlev=3	None	1
Kf	flicker noise coefficient	None	0.0
Af	flicker noise exponent	None	1.0
Fc	bulk junction forward-bias depletion cap. coefficient	None	0.5
Delta	width effect on threshold voltage	None	0.0
Theta	mobility modulation	1/V	0.0
Eta	static feedback	None	0.0
Kappa	saturation field factor	None	0.2
Kappag	field correction factor gate drive dependence	None	0.0
Xmu	subthreshold fitting model parameter for NMOD	None	1.0
Rg	gate resistance	Ohm	fixed at 0.0
Rds	drain-source shunt resistance	Ohm	fixed at infinity ††
Tnom	nominal ambient temperature at which these model parameters were derived	°C	25
Trise	temperature rise above ambient	°C	0
N	bulk P-N emission coefficient	None	1.0
Tt	bulk P-N transit time		0.0
Ffe (Ef)	flicker noise frequency exponent	None	1.0
Imax	explosion current	A	10.0
Imelt	explosion current similar to Imax; defaults to Imax (refer to Note 2)	A	10.0
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvg	gate oxide breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
Acm	Area Calculation Method	None	0
Hdif	Length of heavily doped diffusion (ACM=2,3 only)	m	0.0

Ldif	Length of lightly doped diffusion adjacent to gate (ACM=1,2 only)	m	0.0
Wmlt	Width diffusion layer shrink reduction factor	None	1.0
Lmlt	Gate length shrink factor	None	1.0
Xw	Accounts for masking and etching effects	m	0.0
Rdc	Additional drain resistance due to contact resistance	Ohm	0.0
Rsc	Additional source resistance due to contact resistance	Ohm	0.0
MinR	minimum resistance value to be taken into consideration	Ohm	
AllParams	DataAccessComponent-based parameters	None	None
† Parameter value varies with temperature based on Tnom of model and Temp of device. †† Value of 0.0 is interpreted as infinity.			

- Imax and Imelt Parameters
  Imax and Imelt specify the P-N junction explosion current. Imax and Imelt can be specified in the device model or in the Options component; the device model value takes precedence over the Options value.
  If the Imelt value is less than the Imax value, the Imelt value is increased to the Imax value.
  If Imelt is specified (in the model or in Options) junction explosion current = Imelt; otherwise, if Imax is specified (in the model or in Options) junction explosion current = Imax; otherwise, junction explosion current = model Imelt default value (which is the same as the model Imax default value).
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to DataAccessComponent (Data Access Component)). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.

Additional Information

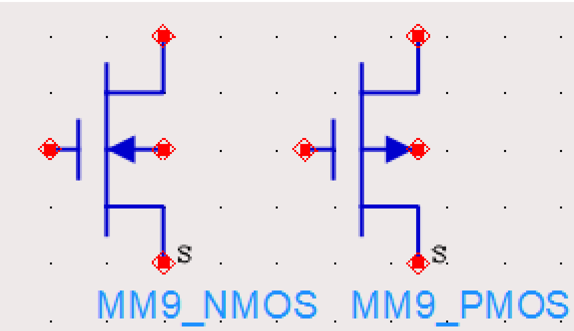
References

- J. A. Power and W. A. Lane, "An Enhanced Spice MOSFET Model Suitable for Analog Applications," IEEE Transactions on CAD, Vol 11, No. 11, November 1992.

MM9 NMOS, MM9 PMOS (Philips MOS Model 9, NMOS, PMOS)

MM9_NMOS, MM9_PMOS (Philips MOS Model 9, NMOS, PMOS)

Symbol



MOS Model 9 (version 903) is a compact MOS-transistor model intended for the simulation of circuit behavior with emphasis on analog applications. The model gives a complete description of all transistor action related quantities: nodal currents and charges, noise-power spectral densities and weak-avalanche currents. The equations describing these quantities are based on the gradual-channel approximation with a number of first-order corrections for small-size effects. The consistency is maintained by using the same carrier-density and electrical-field expressions in the calculation of all model quantities. The Philips JUNCAP model is implemented with the MM9 model to describe junction charges and leakage currents. More information about the model can be obtained from:

> http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/mos-models/model-9:MODEL9

Parameters

Name	Description	Units	Default
Model	Model instance name	None	MOSFETM1
Length †	channel length	m	1.0e-4
Width †	channel width	m	1.0e-4
Ab †	diffusion area	m2	1.0e-12

Name	Description	Units	Default
Ls †	length of sidewall not under gate	m	1.0e-4
Lg †	length of sidewall under gate	m	1.0e-4
Region	dc operating region: 0=off, 1=on, 2=rev, 3=sat	None	on
Temp (Ta)	device operating temperature	°C	25
Trise	temperature rise above ambient	°C	0
Mult	number of devices in parallel	None	1
Mode	device simulation mode: nonlinear, linear (refer to note 3)	None	nonlinear
Noise	Noise generation option; yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

† Each instance parameter whose dimension contains a power of meter will be multiplied by the Scale to the same power. For example, a parameter with a dimension of *m* will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. Note that only parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains *cm* instead of meter is not scaled.

- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Ib	Bulk current	amperes
Power	DC power dissipated	watts

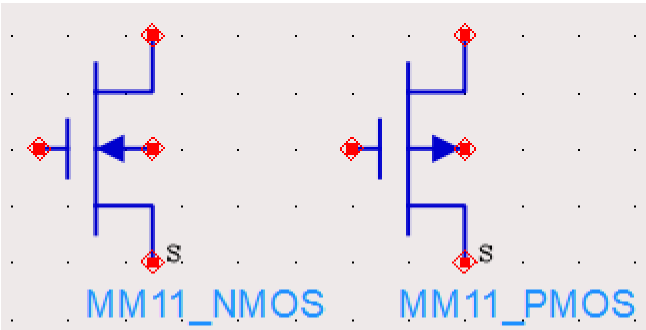
Name	Description	Units
Gid_ds	(dId/dVds)	siemens
Gid_gs	(dId/dVgs)	siemens
Gid_sb	(dId/dVsb)	siemens
Gib_ds	(dIb/dVds)	siemens
Gib_gs	(dIb/dVgs)	siemens
Gib_sb	(dIb/dVsb)	siemens
Gis_ds	(dIs/dVds)	siemens
Gis_gs	(dIs/dVgs)	siemens
Gis_sb	(dIs/dVsb)	siemens
Cg_ds	(dQg/dVds)	farads
Cg_gs	(dQg/dVgs)	farads
Cg_sb	(dQg/dVsb)	farads
Cb_ds	(dQb/dVds)	farads
Cb_gs	(dQb/dVgs)	farads
Cb_sb	(dQb/dVsb)	farads
Cs_ds	(dQs/dVds)	farads
Cs_gs	(dQs/dVgs)	farads
Cs_sb	(dQs/dVsb)	farads
Cd_ds	(dQd/dVds)	farads

Name	Description	Units
Cd_gs	(dQd/dVgs)	farads
Cd_sb	(dQd/dVsb)	farads
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts
Vbs	Bulk-source voltage	volts

MM11 NMOS, MM11 PMOS (Philips MOS Model 11 NMOS, PMOS)

MM11_NMOS, MM11_PMOS (Philips MOS Model 11 NMOS, PMOS)

Symbol



Parameters

Name	Description	Units	Default
Model	Model instance name	None	MOSFETM1
L †	channel length	m	2.0e-6
W †	channel width	m	1.0e-5
Temp (Ta)	device operating temperature	°C	25
Dta (Trise)	temperature offset of the device with respect to Temp	K	0.0
Mult	number of devices in parallel	None	1
Mode	device simulation mode: nonlinear, linear	None	nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
_M	number of devices in parallel	None	1

† Each instance parameter whose dimension contains a power of meter will be multiplied by the Scale to the same power. For example, a parameter with a dimension of *m* will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. Note that only parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains *cm* instead of meter is not scaled.

- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter, or Circuit Envelope analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point. In standard entry mode, the integer value 1 is used for a nonlinear device and 0 is used for a linear device.
- More information about the model can be obtained from:
  > http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/mos-models/model-11:MODEL11
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Ib	Bulk current	amperes
Power	DC power dissipated	watts
Gds	Output conductance (dIds/dVds)	siemens
Gm	Forward transconductance (dIds/dVgs)	siemens
Gmb	Backgate transconductance (dIds/dVbs)	siemens
Iavl	Drain-bulk weak avalanche current	amperes
Igs	Gate-source tunneling current	amperes
Igd	Gate-drain tunneling current	amperes
Igb	Gate-bulk tunneling current	amperes
Vto	Zero bias threshold voltage	volts
Vts	Threshold voltage including back-bias effects	volts

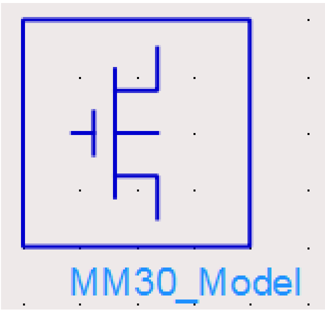
Name	Description	Units
Vth	Threshold voltage including back-bias and drain-bias effects	volts
Vgt	Effective gate drive voltage including back-bias and drain-bias effects	volts
Vdss	Drain saturation voltage	volts
Vsat	Saturation limit (Vds-Vdsat)	volts
Cdd	(dQd/dVds)	farads
Cdg	(-dQd/dVgs)	farads
Cds	(Cdd-Cdg-Cdb)	farads
Cdb	(dQd/dVsb)	farads
Cgd	(-dQg/dVds)	farads
Cgg	(dQg/dVgs)	farads
Cgs	(Cgg-Cgd-Cgb)	farads
Cgb	(dQg/dVsb)	farads
Csd	(-dQs/dVds)	farads
Csg	(-dQs/dVgs)	farads
Css	(Csg+Csd+Csb)	farads
Csb	(dQs/dVsb)	farads
Cbd	(-dQb/dVds)	farads
Cbg	(-dQb/dVgs)	farads
Cbs	(Cbb-Cbd-Cbg)	farads

Name	Description	Units
Cbb	(-dQb/dVsb)	farads
Cgdol	Gate-drain overlap capacitance	farads
Cgsol	Gate-source overlap capacitance	farads
Weff	Effective gate width	meters
Leff	Effective gate length	meters
Fknee	Flicker noise corner frequency	hertz
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts
Vbs	Bulk-source voltage	volts

MM30 Model (Philips MOS Model 30)

MM30_Model (Philips MOS Model 30)

Symbol



The junction-field-effect transistor (JFET) and the depletion mode metal-oxide (MOSFET) are semiconductor devices whose operation is achieved by depleting an already existing channel via a voltage-controlled P-N junction (JFET) or a gate-controlled surface depletion (MOSFET). These devices are often used as a load in high-voltage MOS devices. This long channel JFET/MOSFET model is specially developed to describe the drift region of LDMOS, EPMOS and VDMOS devices. Please refer to the NXP report *The MOS model, level 3002*. More information is available at the following web site:

> http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/high-voltage-models/model-31:MODEL31

Parameters

Name	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Ron	ohmic resistance at zero-bias	Ohm	1.0
Rsat	space charge resistance at zero-bias	Ohm	1.0
Vsat	critical drain-source voltage for hot carrier	V	10.0

Name	Description	Units	Default
Psat	velocity saturation coefficient	None	1.0
Vp	pinchoff voltage at zero gate and substrate voltages	V	-1.0
Tox	gate oxide thickness	cm	-1.0
Dch	doping level channel	cm^{-3}	1.0e+15
Dsub	doping level substrate	cm^{-3}	1.0e+15
Vsub	substrate diffusion voltage	V	0.6
Cgate	gate capacitance at zero-bias	F	0.0
Csub	substrate capacitance at zero-bias	F	0.0
Tausc	space charge transit time of the channel	F	0.0
Tref (Tr, Tnom)	reference temperature	°C	25.0
Trise	temperature rise above ambient	°C	0
Vgap	bandgap voltage channel	V	1.2
Ach	temperature coefficient resistivity of the channel	None	0.0
AllParams	Data Access Component (DAC) Based Parameters	None	None

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname MOS30 [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *MOS30*. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

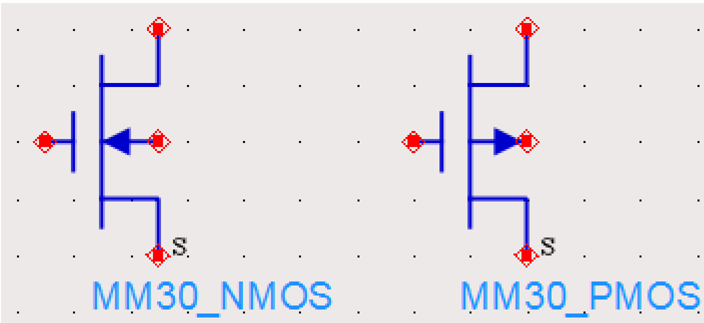
Example

```
model  Nch9 MOS30 \
  Ron=5 Dsub=3e NMOS=yes
```

MM30 NMOS, MM30 PMOS (Philips MOS Model 30, NMOS, PMOS)

MM30_NMOS, MM30_PMOS (Philips MOS Model 30, NMOS, PMOS)

Symbol



Parameters

Name	Description	Units	Default
Model	model instance name	None	MOSFETM1
Temp	temperature	°C	25
Trise	temperature rise above ambient	°C	0
Mult	multiplication factor	None	1.0
_M	number of devices in parallel	None	1

The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Ib	Bulk current	amperes
Power	DC power dissipated	watts
gds_s	(dIds/dVs)	siemens
gds_d	(dIds/dVd)	siemens
gds_g	(dIds/dVg)	siemens
gds_b	(dIds/dVb)	siemens
cgs_s	(dQgs/dVs)	farads
cgs_d	(dQgs/dVd)	farads
cgs_g	(dQgs/dVg)	farads
cgs_b	(dQgs/dVb)	farads
cgd_s	(dQgd/dVs)	farads
cgd_d	(dQgd/dVd)	farads
cgd_g	(dQgd/dVg)	farads
cgd_b	(dQgd/dVb)	farads
cbs_s	(dQbs/dVs)	farads
cbs_d	(dQbs/dVd)	farads

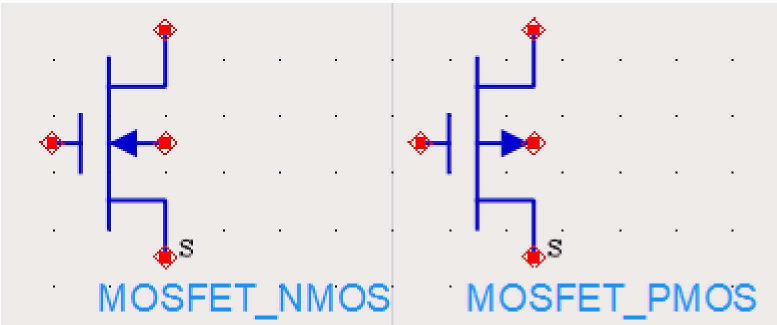
Name	Description	Units
cbs_g	(dQbs/dVg)	farads
cbs_b	(dQbs/dVb)	farads
cbd_s	(dQbd/dVs)	farads
cbd_d	(dQbd/dVd)	farads
cbd_g	(dQbd/dVg)	farads
cbd_b	(dQbd/dVb)	farads
cds_s	(dQds/dVs)	farads
cds_d	(dQds/dVd)	farads
cds_g	(dQds/dVg)	farads
cds_b	(dQds/dVb)	farads
Qgs	Gate-source charge	coulombs
Qgd	Gate-drain charge	coulombs
Qbs	Bulk-source charge	coulombs
Qbd	Bulk-drain charge	coulombs
Qds	Drain-source charge	coulombs
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts
Vbs	Bulk-source voltage	volts

- Parameter Ids is divided by $scale^2$.

MOSFET NMOS, MOSFET PMOS (Nonlinear MOSFETs, NMOS, PMOS)

MOSFET_NMOS, MOSFET_PMOS (Nonlinear MOSFETs, NMOS, PMOS)

Symbol



Range of Usage

> *Length, Width, Ad, As, Pd, Ps > 0*

Parameters

Name	Description	Units	Default
Model	Model instance name	None	MOSFETM1
Length †	channel length	m	1.0e-4
Width †	channel width	m	1.0e-4
Ad †	drain diffusion area	m^2	0.0
As †	source diffusion area	m^2	0.0
Pd †	drain junction perimeter	m	0.0
Ps †	source junction perimeter	m	0.0
Nrd	number of equivalent squares in drain diffusion region. Nrd is multiplied by Rsh (sheet resistance factor specified in Model) to get parasitic series drain resistance	None	1.0

Nrs	number of equivalent squares in source diffusion region. Nrs is multiplied by Rsh (sheet resistance factor specified in Model) to get parasitic series source resistance	None	1 .0
Mult	(obsolete: use _M instead)	None	None
Region	DC operating region, 0=off, 1=on, 2=rev, 3=sat	None	on
Temp	device operating temperature (refer to Note 1)	°C	25
Trise	temperature rise above ambient	°C	0
Mode	simulation mode for this device: nonlinear or linear (refer to Note 3)	None	nonlinear
Noise	noise generation option: yes=1, no=0	None	yes
Nqsmod	Non-Quasi Static Model Selector (BSIM3v3.2 only): 1=on or 0=off	None	0
Geo	source/drain sharing selector	None	0
_M	number of devices in parallel	None	1
Stimod ††	LOD stress effect model selector	None	0
Sa1 - Sa10 ††	Distance between OD edge to poly of one side (#1 - #10)	m	0
Sb1 - Sb10 ††	Distance between OD edge to poly of the other side (#1 - #10)	m	0
Sw1 - Sw10 ††	Width of Sa1/Sb1, Sa2/Sb2, Sa3/Sb3, etc.	m	Wdrawn for Sw1, 0 for Sw2 - Sw10
Sa ††	Alias for Sa1	m	Sa1
Sb ††	Alias for Sb1	m	Sb1

† Each instance parameter whose dimension contains a power of meter will be multiplied by the Scale to the same power. For example, a parameter with a dimension of *m* will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. Note that only parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains *cm* instead of meter is not scaled. †† Intended for Foundry use only.

- The Temp parameter specifies the physical (operating) temperature of the device. If this is different than the temperature at which the model parameters are valid or extracted (specified by the Tnom parameter of the associated model) certain model parameters are scaled such that the device is simulated at its operating temperature. Refer to the appropriate model to see which parameter values are scaled.
- The _M parameter affects MOSFET channel width, diode leakage, capacitors, and resistors in the following manner.
  Width: _M × Weff
  Areas and perimeters:

> $\_M \times Ad$
> $\_M \times As$
> $\_M \times Pd$
> $\_M \times Ps$

Diode leakage:

> *if (Js == 0), then Is = _M × Is*

Capacitors:

> *if (Cj == 0), then Cbd = _M × Cbd, Cbs = _M × Cbs*

Resistors:

> *if (Nrs × Rsh == 0), then Rs = Rs/_M; else Rs = (Nrs × Rsh)/_M*
> *if (Nrd × Rsh == 0), then Rd = Rd/_M; else Rd (Nrd × Rsh)/_M*

Due to second-order effects in some models (BSIM3 for example), the use of the _M parameter is not exactly equivalent to parallel multiple devices.

- The Mode parameter is used only during harmonic balance, oscillator, or large-signal S-parameter analysis. By identifying devices that are operating in their linear region, the simulation time may be decreased. Devices with Mode=linear are linearized about their DC operating point.
- The following table lists the DC operating point parameters that can be sent to the dataset.

DC Operating Point Information

Name	Description	Units
Id	Drain current	amperes
Ig	Gate current	amperes
Is	Source current	amperes
Ib	Bulk current	amperes
Power	DC power dissipated	watts
Gm	Forward transconductance (dIds/dVgs)	siemens
Gmb	Backgate transconductance (dIds/dVbs)	siemens
Gds	Output conductance (dIds/dVds)	siemens
Vth	Threshold voltage	volts
Vdsat	Drain-source saturation voltage	volts

Name	Description	Units
Capbd	Bulk-drain capacitance	farads
Capbs	Bulk-source capacitance	farads
CgdM	Gate-drain Meyer capacitance	farads
CgbM	Gate-bulk Meyer capacitance	farads
CgsM	Gate-source Meyer capacitance	farads
DqgDvgb	(dQg/dVgb)	farads
DqgDvdb	(dQg/dVdb)	farads
DqgDvsb	(dQg/dVsb)	farads
DqbDvgb	(dQb/dVgb)	farads
DqbDvdb	(dQb/dVdb)	farads
DqbDvsb	(dQb/dVsb)	farads
DqdDvgb	(dQd/dVgb)	farads
DqdDvdb	(dQd/dVdb)	farads
DqdDvsb	(dQd/dVsb)	farads
Vgs	Gate-source voltage	volts
Vds	Drain-source voltage	volts
Vbs	Bulk-source voltage	volts

- This device has no default artwork associated with it.

Additional Information

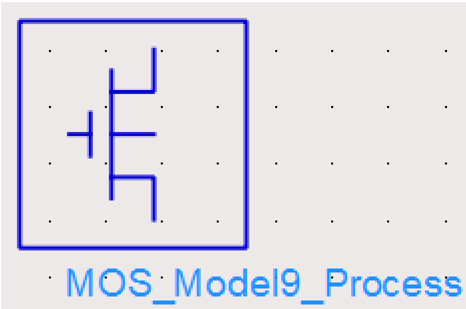
References

- H. Shichman and D. A. Hodges. "Modeling and simulation of insulated-gate field-effect transistor switching circuits," *IEEE Journal of Solid-State Circuits,* SC-3, 285, September 1968.
- A. Vladimirescu and S. Liu. *The Simulation of MOS Integrated Circuits Using SPICE2,* Memorandum No. M80/7, February 1980.
- P. Antognetti and G. Massobrio. *Semiconductor Device Modeling with SPICE,* McGraw-Hill, Inc., 1988.
- D. A. Divekar, *FET Modeling for Circuit Simulation* , Kluwer Academic Publishers, 1988.

MOS Model9 Process (Philips MOS Model 9, Process Based)

MOS_Model9_Process (Philips MOS Model 9, Process Based)

Symbol



Parameters

Name	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Type	Type of model: 1:SINGLE_DEVICE 2:PROCESS_BASED	None	2
Ler	effective channel length of reference transistor	m	1.0e-4
Wer	effective channel width of reference transistor	m	1.0e-4
Lvar	difference between actual and programmed poly-silicon gate length	m	0.0
Lap	effective channel length reduction per side due to lateral diffusion of source/drain dopant ions	m	0.0
Wvar	difference between actual and programmed field-oxide opening		0.0
Wot	effective channel width reduction per side due to lateral diffusion of channel-stop dopant ions	m	0.0

Name	Description	Units	Default
Tr (Tref, Tnom)	temperature for reference transistor	°C	25
Trise (Dta)	temperature rise above ambient	°C	0
Vtor	threshold voltage at zero back-bias	V	0.87505
Stvto	coefficient of temperature dependence of Vto	V/K	0.0
Slvto	coefficient of length dependence of Vto	V×m	0.0
Sl2vto	second coefficient of length dependence of Vto	V×m ^{2}	0.0
Swvto	coefficient of width dependence of Vto	V×m	0.0
Kor	low back-bias body factor	V $^{(1/2)}$	0.74368
Slko	coefficient of length dependence of Ko	m×V $^{(1/2)}$	0.0
Swko	coefficient of width dependence of Ko	m×V $^{(1/2)}$	0.0
Kr	high back-bias body factor	V $^{(1/2)}$	0.55237
Slk	coefficient of length dependence of K	m×V $^{(1/2)}$	0.0
Swk	coefficient of width dependence of K	m×V $^{(1/2)}$	0.0
Phibr	surface potential at strong inversion	V	0.65
Vsbxr	transition voltage for dual-k factor model	V	0.63304
Slvsbx	coefficient of length dependence of Vsbx	V×m	0.0
Swvsbx	coefficient of width dependence of Vsbx	V×m	0.0
Betsq	gain factor	A/V ^{2}	0.12069e-3

Name	Description	Units	Default
Etabet	exponent of temperature dependence of gain factor	None	0.0
The1r	coefficient of mobility due to gate-induced field	1/V	0.99507e-01
Stthe1r	coefficient of temperature dependence of The1	1/V/K	0.0
Slthe1r	coefficient of length dependence of The1	m/V	0.0
Stlthe1	coefficient of temperature dependence of length dependence of The1	m/V/K	0.0
Swthe1	coefficient of width dependence of The1	m/V	0.0
Wdog	characteristic drain gate width below which dogboning appears	m	0.0
Fthe1	coefficient describing the width dependence of The1 for W < Wdog	None	0.0
The2r	coefficient of mobility due to back-bias	$V^{(-1/2)}$	0.43225e-01
Stthe2r	coefficient of temperature dependence of The2	$V^{(-1/2)}$ /K	0.0
Slthe2r	coefficient of length dependence of The2	$m/V^{(1/2)}$	0.0
Stlthe2	coefficient of temperature dependence of length dependence of The2	$m/V^{(1/2)}$ / K	0.0
Swthe2	coefficient of width dependence of The2	$m/V^{(1/2)}$	0.0
The3r	coefficient of mobility due to lateral field	1/V	0.0
Stthe3r	coefficient of temperature dependence of The3	1/V/K	0.0
Slthe3r	coefficient of length dependence of The3	m/V	0.0
Stlthe3	coefficient of temperature dependence of length dependence of The3	m/V/K	0.0

Name	Description	Units	Default
Swthe3	coefficient of width dependence of The3	m/V	0.0
Gam1r	coefficient for drain-induced threshold shift for large gate drive	V	0.38096e-2
Slgam1	coefficient of length dependence of Gam1	V×m	0.0
Swgam1	coefficient of width dependence of Gam1	V×m	0.0
Etadsr	exponent of Vds dependence of Gam1	None	0.6
Alpr	factor of channel-length modulation	None	0.1e-1
Etaalp	exponent of length dependence of Alp	None	0.0
Slalp	coefficient of length dependence of Alp	m	0.0
Swalp	coefficient of width dependence of Alp	m	0.0
Vpr	characteristic voltage of channel length modulation	V	0.67876e1
Gamoor	coefficient of drain-induced threshold shift at zero gate drive	None	0.29702e-4
Slgamoo	coefficient of length dependence of Gamoo	m	0.0
Etagamr	exponent of back-bias dependence of Gamo	None	2.0
Mor	factor of subthreshold slope	None	0.44
Stmo	coefficient of temperature dependence of Mo	1/K	0.0
Slmo	coefficient of length dependence of Mo	$m^{(1/2)}$	0.0
Etamr	exponent of back-bias dependence of M	None	2.0
Zet1r	weak-inversion correction factor	None	0.20153e1
Etazet	exponent of length dependence of Zet	None	0.0

Name	Description	Units	Default
Slzet1	coefficient of length dependence of Zet		0.0
Vsbtr	limiting voltage of VSB dependence of M and Gamo	V	0.61268e1
Slvsbt	coefficient of length dependence of Vsbt	m×V	0.0
A1r	factor of weak-avalanche current	None	0.20348e2
Sta1	coefficient of temperature dependence of A1	1/K	0.0
Sla1	coefficient of length dependence of A1	m	0.0
Swa1	coefficient of width dependence of A1	m	0.0
A2r	exponent of weak-avalanche current	V	0.33932e2
Sla2	coefficient of length dependence of A2	m×V	0.0
Swa2	coefficient of width dependence of A2	m×V	0.0
A3r	factor of drain-source voltage above which weak-avalanche occurs	None	0.10078e1
Sla3	coefficient of length dependence of A3	m	0.0
Swa3	coefficient of width dependence of A3	m	0.0
Tox	thickness of oxide layer	m	1.0e-6
Col	gate overlap per unit channel width	F/m	0.0
Ntr	coefficient of thermal noise	None	0.0
Nfmod	noise model selector	None	0
Nfr	Coefficient of the Flicker Noise (Nfmod=0)	None	0.0
Nfar	first coefficient of flicker noise (Nfmod=1)	1/(V×m)	7.15e+22

Name	Description	Units	Default
Nfbr	second coefficient of flicker noise (Nfmod=1)	$1/(V \times m^2)$	2.16e+7
Nfcr	third coefficient of flicker noise (Nfmod=1)	1/V	0.0
Vr	voltage at which junction parameters have been determined	V	0.0
Jsgbr	bottom saturation current density due to electron-hole generation at V=Vr	A/m^2	1.0e-14
Jsdbr	bottom saturation current density due to diffusion from back contact	A/m^2	1.0e-14
Jsgsr	sidewall saturation current density due to electron-hole generation at V=Vr	A/m	1.0e-14
Jsdsr	sidewall saturation current density due to diffusion from back contact	A/m	1.0e-14
Jsggr	gate edge saturation current density due to electron-hole generation at V=Vr	A/m	1.0e-14
Jsdgr	gate edge saturation current density due to diffusion from back contact	A/m	1.0e-14
Cjbr	bottom junction capacitance at V=Vr	F/m^2	0.0
Cjsr	sidewall junction capacitance at V=Vr	F/m	0.0
Cjgr	gate edge junction capacitance at V=Vr	F/m	0.0
Vdbr	diffusion voltage of bottom junction at V=Vr	V	0.8
Vdsr	diffusion voltage of sidewall junction at V=Vr	V	0.8
Vdgr	diffusion voltage of gate edge junction at V=Vr	V	0.8
Pb	bottom-junction grading coefficient	None	0.5
Ps	sidewall-junction grading coefficient	None	0.5

Name	Description	Units	Default
Pg	gate-edge-junction grading coefficient	None	0.5
Nb	emission coefficient of bottom forward current	None	1.0
Ns	emission coefficient of sidewall forward current	None	1.0
Ng	emission coefficient of gate-edge forward current	None	1.0
wVsubfwd	substrate junction forward bias warning	V	None
wBvsub	substrate junction reverse breakdown voltage warning	V	None
wBvg	gate oxide breakdown voltage warning	V	None
wBvds	drain-source breakdown voltage warning	V	None
wIdsmax	maximum drain-source current warning	A	None
wPmax	maximum power dissipation warning	W	None
The3Clipping	flag for The3 clipping: no, yes	None	no
AllParams	Data Access Component (DAC) Based Parameters	None	None

- Information about this model is available at
  > http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/mos-models/model-9:MODEL9
- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.
- Each instance parameter whose dimension contains a power of meter will be multiplied by the *Scale* variable or the scale option to the same power. For example, a parameter with a dimension of m will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. The parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains cm instead of meter is not scaled.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname MOS9 [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *MOS9*. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

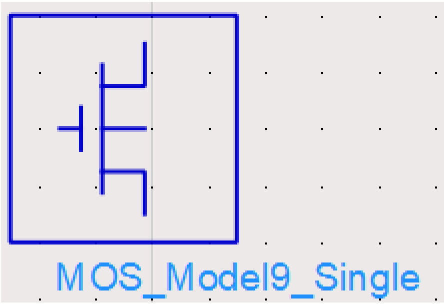
Example

```
model  Nch10 MOS9 \
  Vtor=0.7 Etabetr=0.4 NMOS=yes
```

MOS Model9 Single (Philips MOS Model 9, Single Device)

MOS_Model9_Single (Philips MOS Model 9, Single Device)

Symbol



Parameters

Name	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Type	Model type: 1:SINGLE_DEVICE 2:PROCESS_BASED	None	1
Vto	threshold voltage at zero back-bias	V	0.87505
Ko	low-back-bias body factor	$V^{(1/2)}$	0.74368
K	high-back-bias body factor	$V^{(1/2)}$	0.55237
Phib	surface potential at strong inversion	V	0.65
Vsbx	transition voltage for dual-k factor model	V	0.63304
Bet	gain factor	A/V^2	0.12069e-3

Name	Description	Units	Default
The1	coefficient of mobility reduction due to gate-induced field	1/V	0.99507e-01
The2	coefficient of mobility reduction due to back-bias	$V^{(-1/2)}$	0.43225e-01
The3	coefficient of mobility reduction due to lateral field	1/V	0.0
Gam1	coefficient for drain-induced threshold shift for large gate drive	V	0.38096e-2
Etads	exponent of VDS dependence of Gam1	None	0.6
Alp	factor of channel-length modulation	None	0.1e-1
Vp	characteristic voltage of channel length modulation	V	0.67876e1
Gamoo	coefficient of drain-induced threshold shift at zero gate drive	None	0.29702e-4
Etagam	exponent of back-bias dependence of Gamo	None	2.0
Mo	factor of subthreshold slope	None	0.44
Etam	exponent of back-bias dependence of M	None	2.0
Zet1	weak-inversion correction factor	None	0.20153e1
Vsbt	limiting voltage of vsb dependence of M and Gamo	V	0.61268e1
A1	factor of weak-avalanche current	None	0.20348e2
A2	exponent of weak-avalanche current	V	0.33932e2
A3	factor of drain-source voltage above which weak-avalanche occurs	None	0.10078e1
Cox	gate-to-channel capacitance	F	1e-12
Cgdo	gate-drain overlap capacitance	F	1e-12

Name	Description	Units	Default
Cgso	gate-source overlap capacitance	F	1e-12
Nt	coefficient of thermal noise	None	0.0
Nfmod	noise model selector	None	0
Nf	coefficient of flicker noise (Nfmod=0)	None	0.0
Nfa	first coefficient of flicker noise (Nfmod=1)	1/(V×m)	7.15e+22
Nfb	second coefficient of flicker noise (Nfmod=1)	1/(V×m ^{2})	2.16e+7
Nfc	third coefficient of flicker noise (Nfmod=1)	1/V	0.0
Tox	Thickness of the gate oxide layer (for Nfmod=1)	m	1.0e-6
Isgb	Bottom Saturation Current Density due to Electron-Hole generation	A	1.0e-14
Isdb	Bottom Saturation Current Density due to Diffusion from Back Contact	A	1.0e-14
Isgs	Sidewall Saturation Current Density due to Electron-Hole generation	A	1.0e-14
Isds	Sidewall Saturation Current Density due to Diffusion from Back Contact	A	1.0e-14
Isgg	Gate-Edge Saturation Current Density due to Electron-Hole Generation	A	1.0e-14
Isdg	Gate-Edge Saturation Current Density due to Diffusion from Back Contact	A	1.0e-14
Cjb	bottom junction capacitance	F	0.0
Cjs	sidewall junction capacitance	F	0.0
Cjg	gate edge junction capacitance	F	0.0

Name	Description	Units	Default
Vdb	diffusion voltage of bottom area Ab	V	0.8
Vds	diffusion voltage of Locos-edge Ls	V	0.8
Vdg	diffusion voltage of gate edge Lg	V	0.8
Pb	bottom-junction grading coefficient	None	0.5
Ps	sidewall-junction grading coefficient	None	0.5
Pg	gate-edge-junction grading coefficient	None	0.5
Nb	emission coefficient of bottom forward current	None	1.0
Ns	emission coefficient of sidewall forward current	None	1.0
Ng	emission coefficient of gate-edge forward current	None	1.0
wVsubfwd	substrate junction forward bias (warning)	V	None
wBvsub	substrate junction reverse breakdown voltage (warning)	V	None
wBvg	gate oxide breakdown voltage (warning)	V	None
wBvds	drain-source breakdown voltage (warning)	V	None
wIdsmax	maximum drain-source current (warning)	A	None
wPmax	maximum power dissipation (warning)	W	None
The3Clipping	flag for The3 clipping	None	no
AllParams	Data Access Component (DAC) Based Parameters	None	None

- Information about this model is available at
  http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/mos-models/model-9:MODEL9

- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.
- Each instance parameter whose dimension contains a power of meter will be multiplied by the *Scale* variable or the scale option to the same power. For example, a parameter with a dimension of m will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. The parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains cm instead of meter is not scaled.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to the *Design Kit Development*.

> *model modelname MOS9 [parm=value]**

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *MOS9*. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

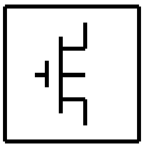
Example

```
model  Nch11 MOS9 \
  Vtor=0.7 Etabet=0.4 NMOS=yes
```

MOS Model11 Electrical (Philips MOS Model 11, Electrical)

MOS_Model11_Electrical (Philips MOS Model 11, Electrical)

Symbol



This model supplies values for an MM11 device. Information about this model is available at

> http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/mos-models/model-11:MODEL11

Parameters

Model parameters must be specified in SI units.

Parameter	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Level	Philips Level Name (1101=Electrical 11010=Physical 11011=Binned)	None	1101
Tr (Tref, Tnom)	Temperature at which the parameters for the reference transistor have been determined	°C	25
Vfb	Flat-band voltage for the reference transistor at the reference temperature	V	-1.05
Stvfb	Coefficient of the temperature dependence of VFB	V/K	0.5e-3
Ko	Low-back-bias body factor	$V^{(1/2)}$	0.5

Parameter	Description	Units	Default
Kpinv	Inverse of body-effect factor of the poly-silicon gate	$V^{(-1/2)}$	0.0
Phib	Surface potential at the onset of strong inversion	V	0.95
Stphib	Coefficient of the temperature dependence of PHIB	V/K	-8.5e-4
Bet	Gain factor for an infinite square transistor	A/V^2	1.9215e-3 (NMOS),
Etabet	Exponent of the temperature dependence of the gain factor	None	1.3 (NMOS)
Thesrr	Coefficient of the mobility reduction due to surface roughness scattering for the reference transistor at the reference temperature	V^{-1}	0.3562 (NMOS), 0.73 (PMOS)
Etasr	Exponent of the temperature dependence of THESR for the reference transistor	None	0.65 (NMOS)
Theph	Coefficient of the mobility reduction due to phonon scattering	V^{-1}	1.29e-2 (NMOS)
Etaph	Exponent of the temperature dependence of THESR for the reference transistor	None	1.35 (NMOS)
Etamob	Effective field parameter for dependence on depletion/ inversion charge	None	1.4 (NMOS)
Stetamob	Coefficient of the temperature dependence of ETAMOB	K^{-1}	0.0
Nu	Exponent of the field dependence of the mobility model minus 1 at the reference temperature	None	2.0
Nuexp	Exponent of the temperature dependence of NU	None	5.25 (NMOS)
Ther	Coefficient of the series resistance	V^{-1}	8.12e-2 (NMOS)
Etar	Exponent of the temperature dependence of ETA	None	0.95 (NMOS)
Ther1	Numerator of the gate voltage dependent part of series resistance for the reference transistor	V	0.0

Parameter	Description	Units	Default
Ther2	Denominator of the gate voltage dependent part of series resistance for the reference transistor	V	1.0
Thesat	Velocity saturation parameter due to optical/acoustic phonon scattering	V^{-1}	0.2513 (NMOS), 0.1728 (PMOS)
Etasat	Exponent of the temperature dependence of THESAT	None	1.04 (NMOS)
Theth	Coefficient on self-heating	V^{-3}	1.0e-5 (NMOS), 0.0 (PMOS)
Sdibl	Drain-induced barrier-lowering parameter	$V^{(-1/2)}$	8.53e-4 (NMOS), 3.551e-5 (PMOS)
Mo	Parameter fr short-channel subthreshold slope	None	0.0
Ssf	Static feedback parameter	$V^{(-1/2)}$	0.012 (NMOS), 0.01 (PMOS)
Alp	Factor of the channel-length modulation	None	0.025
Vp	Characteristic voltage of channel length modulation	V	0.05
Mexp	Smoothing factor for the actual transistor	None	5.0
A1	Factor of the weak-avalanche current	None	6.0221 (NMOS)
Sta1	Coefficient of the temperature dependence of A1	K^{-1}	0.0
A2	Exponent of the weak-avalanche current	V	38.017 (NMOS)
A3	Factor of the drain-source voltage above which weak-avalanche occurs	None	0.6407 (NMOS)
Iginv	Gain factor for intrinsic gate tunneling current in inversion	A/V^2	0.0
Binv	Probability factor for intrinsic gate tunneling current in inversion	V	48.0 (NMOS)

Parameter	Description	Units	Default
Igacc	Gain factor for intrinsic gate tunneling current in accumulation	A/V^2	0.0
Bacc	Probability factor for intrinsic gate tunneling current in accumulation	V	48.0
Vfbov	Flat-band voltage for the source/drain overlap extension	V	0.0
Kov	Body-effect factor for the source/drain overlap extension	$V^{(1/2)}$	2.5
Igov	Gain factor for source/drain overlap gate tunneling current	A/V^2	0.0
Cox	Gate-to-channel capacitance	F	2.980e-14 (NMOS)
Cgdo	G-D overlap capacitance	F	6.392e-15 (NMOS) 6.358e-15 (PMOS)
Cgso	G-S overlap capacitance	F	6.392e-15 (NMOS)
Gatenoise	Flag for in/exclusion of induced gate thermal noise	None	0
Nt	Coefficient of the thermal noise at the actual temperature	J	1.656e-20
Nfa	First coefficient of the flicker noise	$V^{-1} \times m^{-1}$	8.323e+22 (NMOS)
Nfb	Second coefficient of the flicker noise	$V^{-1} \times m^{-2}$	2.514e+7 (NMOS)
Nfc	Second coefficient of the flicker noise	$V^{-1} \times m^{-2}$	0.0 (NMOS)
Tox	Thickness of the gate oxide layer	m	3.2e-9
wVsubfwd	Substrate junction forward bias (warning)	V	None
wBvsub	Substrate junction reverse breakdown voltage (warning)	V	None
wBvg	Gate oxide breakdown voltage (warning)	V	None

Parameter	Description	Units	Default
wBvds	Drain-source breakdown voltage (warning)	V	None
wIdsmax	Maximum drain-source current (warning)	A	None
wPmax	Maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.
- Each instance parameter whose dimension contains a power of meter will be multiplied by the *Scale* variable or the scale option to the same power. For example, a parameter with a dimension of m will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. The parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains cm instead of meter is not scaled.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname MOS11 [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model. The third parameter indicates the type of model; for this model it is *MOS11*. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

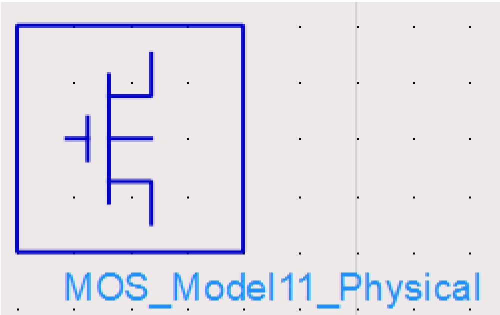
Example

```
modelNch12 MOS11 \
  Vfbr=-1.0 Phibr=0.8 NMOS=yes
```

MOS Model11 Physical (Philips MOS Model 11, Physical)

MOS_Model11_Physical (Philips MOS Model 11, Physical)

Symbol



This model supplies values for an MM11 device.

> http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/mos-models/model-11:MODEL11

Parameters

Model parameters must be specified in SI units.

Parameter	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Level	Philips Level Name (1101=Electrical 11010=Physical 11011=Binned)	None	11010
Lvar	Difference between the actual and the programmed poly-silicon gate length	m	0.0
Lap	Effective channel length reduction per side due to the lateral diffusion of the source/drain dopant ions	m	4.0e-8

Parameter	Description	Units	Default
Wvar	Difference between the actual and the programmed field-oxide opening	m	0.0
Wot	Effective reduction of the channel width per side due to the lateral diffusion of the channel-stop dopant ions	m	0.0
Tr (Tref, Tnom)	Temperature at which the parameters for the reference transistor have been determined	°C	21
Vfb	Flat-band voltage for the reference transistor at the reference temperature	V	-1.05
Stvfb	Coefficient of the temperature dependence of VFB	V/K	0.5e-3
Kor	Low-back-bias body factor for the reference transistor	$V^{(1/2)}$	0.5
Slko	Coefficient of the length dependence of KO	$m \times V^{(1/)2}$	0.0
Sl2ko	Second coefficient of the length dependence of KO	$m \times V^{(1/)2}$	0.0
Swko	Coefficient of the width dependence of KO	$m \times V^{(1/)2}$	0.0
Kpinv	Inverse of body-effect factor of the poly-silicon gate	$V^{(-1/2)}$	0.0
Phibr	Surface potential at the onset of strong inversion at the reference temperature	V	0.95
Stphib	Coefficient of the temperature dependence of PHIB	V/K	-8.5e-4
Slphib	Coefficient of the length dependence of PHIB	V×m	0.0
Sl2phib	Second coefficient of the length dependence of PHIB	$V \times m^2$	0.0
Swphib	Coefficient of the width dependence of PHIB	V×m	0.0
Betsq	Gain factor for an infinite square transistor at the reference temperature	A/V^2	3.709e-4 (NMOS),

Parameter	Description	Units	Default
Etabetr	Exponent of the temperature dependence of the gain factor	None	1.3 (NMOS)
Sletabet	Coefficient of the length dependence of ETABET	m	0.0
Fbet1	Relative mobility decrease due to first lateral profile	None	0.0
Lp1	Characteristic length of first lateral profile	m	0.8e-6
Fbet2	Relative mobility decrease due to second lateral profile	None	0.0
Lp2	Characteristic length of second lateral profile	m	0.8e-6
Thesrr	Coefficient of the mobility reduction due to surface roughness scattering for the reference transistor at the reference temperature	V^{-1}	0.4 (NMOS),
Etasr	Exponent of the temperature dependence of THESR for the reference transistor	None	0.65 (NMOS)
Swthesr	Coefficient of the width dependence of THESR	m	0.0
Thephr	Coefficient of the mobility reduction due to phonon scattering for the reference transistor at the reference temperature	V^{-1}	1.29e-2 (NMOS)
Etaph	Exponent of the temperature dependence of THESR for the reference transistor	None	1.35 (NMOS)
Swtheph	Coefficient of the width dependence of THEPH	m	0.0
Etamobr	Effective field parameter for dependence on depletion/ inversion charge for the reference transistor	None	1.4 (NMOS)
Stetamob	Coefficient of the temperature dependence of ETAMOB	K^{-1}	0.0
Swetamob	Coefficient of the width dependence of ETAMOB	m	0.0
Nu	Exponent of the field dependence of the mobility model minus 1 at the reference temperature	None	2.0
Nuexp	Exponent of the temperature dependence of NU	None	5.25 (NMOS)

Parameter	Description	Units	Default
Therr	Coefficient of the series resistance for the reference transistor at the reference temperature	V^{-1}	0.155 (NMOS),
Etar	Exponent of the temperature dependence of ETA	None	0.95 (NMOS)
Swther	Coefficient of the width dependence of THER	m	0.0
Ther1	Numerator of the gate voltage dependent part of series resistance for the reference transistor	V	0.0
Ther2	Denominator of the gate voltage dependent part of series resistance for the reference transistor	V	1.0
Thesatr	Velocity saturation parameter due to optical/acoustic phonon scattering for the reference transistor at the reference temperature	V^{-1}	0.5 (NMOS),
Etasat	Exponent of the temperature dependence of THESAT	None	1.04 (NMOS)
Slthesat	Coefficient of the length dependence of THESAT	None	1.0
Thesatexp	Exponent of the length dependence of THESAT	None	1.0
Swthesat	Coefficient of the width dependence of THESAT	m	0.0
Thethr	Coefficient on self-heating for the reference transistor at the reference temperature	V^{-3}	1.0e-3 (NMOS)
Thethexp	Exponent of the length dependence of THETH	None	1.0
Swtheth	Coefficient of the width dependence of THETH	m	0.0
Sdiblo	Drain-induced barrier-lowering parameter for the reference transistor	$V^{(-1/2)}$	1.0e-4
Sdiblexp	Exponent of the length dependence of SDIBLO	None	1.35
Mor	Parameter fr short-channel subthreshold slope for the reference transistor	None	0.0

Parameter	Description	Units	Default
Moexp	Exponent of the length dependence of MO	None	1.34
Ssfr	Static feedback parameter for the reference transistor	$V^{(-1/2)}$	6.25e-3
Slssf	Coefficient of the length dependence of SSF	m	1.0
Swssf	Coefficient of the width dependence of SSF	m	0.0
Alpr	Factor of the channel-length modulation for the reference transistor	None	0.01
Slalp	Coefficient of the length dependence of ALP	None	1.0
Alpexp	Exponent of the length dependence of ALP	None	1.0
Swalp	Coefficient of the width dependence of SSF	m	0.0
Vp	Characteristic voltage of channel length modulation	V	0.05
Lmin	Minimum effective channel length in technology, used for calculation of smoothing factor m	m	1.5e-7
A1r	Factor of the weak-avalanche current for the reference transistor at the reference temperature	None	6.0
Sta1	Coefficient of the temperature dependence of A1	K^{-1}	0.0
Sla1	Coefficient of the length dependence of A1	m	0.0
Swa1	coefficient of the width dependence of A1	m	0.0
A2r	Exponent of the weak-avalanche current for the reference transistor at the reference temperature	V	38.0
Sla2	Coefficient of the length dependence of A2	V×m	0.0
Swa2	Coefficient of the width dependence of A2	V×m	0.0

Parameter	Description	Units	Default
A3r	Factor of the drain-source voltage above which weak-avalanche occurs, for the reference transistor	None	1.0
Sla3	Coefficient of the length dependence of A3	m	0.0
Swa3	Coefficient of the width dependence of A3	m	0.0
Iginvr	Gain factor for intrinsic gate tunneling current in inversion for the reference transistor	A/V^2	0.0
Binv	Probability factor for intrinsic gate tunneling current in inversion	V	48.0 (NMOS)
Igaccr	Gain factor for intrinsic gate tunneling current in accumulation for the reference transistor	A/V^2	0.0
Bacc	Probability factor for intrinsic gate tunneling current in accumulation	V	48.0
Vfbov	Flat-band voltage for the source/drain overlap extension	V	0.0
Kov	Body-effect factor for the source/drain overlap extension	$V^{(1/2)}$	2.5
Igovr	Gain factor for source/drain overlap gate tunneling current for the reference transistor	A/V^2	0.0
Tox	Thickness of the gate oxide layer	m	3.2e-9
Col	Gate overlap capacitance per unit channel width	F	3.2e-16
Gatenoise	Flag for in/exclusion of induced gate thermal noise	None	0
Nt	Coefficient of the thermal noise at the actual temperature	J	1.656e-20
Nfar	First coefficient of the flicker noise for the reference transistor	$V^{-1}\times m^{-1}$	1.573e+23 (NMOS)
Nfbr	Second coefficient of the flicker noise for the reference transistor	$V^{-1}\times m^{-2}$	4.752e9 (NMOS)

Parameter	Description	Units	Default
Nfcr	Second coefficient of the flicker noise for the reference transistor	$V^{-1} \times m^{-2}$	0.0 (NMOS)
wVsubfwd	Substrate junction forward bias (warning)	V	None
wBvsub	Substrate junction reverse breakdown voltage (warning)	V	None
wBvg	Gate oxide breakdown voltage (warning)	V	None
wBvds	Drain-source breakdown voltage (warning)	V	None
wIdsmax	Maximum drain-source current (warning)	A	None
wPmax	Maximum power dissipation (warning)	W	None
AllParams	Data Access Component (DAC) Based Parameters	None	None

- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.
- Each instance parameter whose dimension contains a power of meter will be multiplied by the *Scale* variable or the scale option to the same power. For example, a parameter with a dimension of m will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. The parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains cm instead of meter is not scaled.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname MOS11 [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model.The third parameter indicates the type of model; for this model it is *MOS11*. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

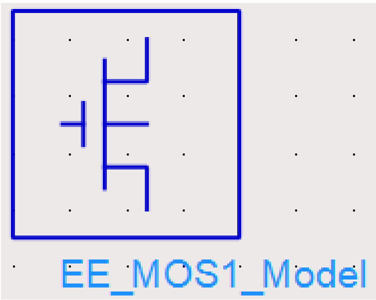
Example

```
modelNch12 MOS11 \
  Vfbr=-1.0 Phibr=0.8 NMOS=yes
```

MOS Model11 Binned (Philips MOS Model 11, Binned)

MOS_Model11_Binned (Philips MOS Model 11, Binned)

Symbol



This model supplies values for an MM11 device.

> http://www.nxp.com/products/developer-resources/models-and-test-data/compact-models-simkit/mos-models/model-11:MODEL11

Parameters

Model parameters must be specified in SI units.

Parameter	Description	Units	Default
NMOS	Model type: yes or no	None	yes
PMOS	Model type: yes or no	None	no
Level	Philips Level Name (1101=Electrical 11010=Physical 11011=Binned)	None	11011
Lvar	Difference between the actual and the programmed poly-silicon gate length	m	0.0
Lap	Effective channel length reduction per side due to the lateral diffusion of the source/drain dopant ions	m	4.0e-8

Parameter	Description	Units	Default
Wvar	Difference between the actual and the programmed field-oxide opening	m	0.0
Wot	Effective reduction of the channel width per side due to the lateral diffusion of the channel-stop dopant ions	m	0.0
Tr (Tref, Tnom)	Temperature at which the parameters for the reference transistor have been determined	°C	25
Vfb	Flat-band voltage for the reference transistor at the reference temperature	V	-1.05
Poko	Coefficient for the geometry independent part of KO	$V^{(1/2)}$	0.5
Plko	Coefficient for the length dependence of KO	$V^{(1/2)}$	0.0
Pwko	Coefficient for the width dependence of KO	$V^{(1/2)}$	0.0
Plwko	Coefficient for the length times width dependence of KO	$V^{(1/2)}$	0.0
Kpinv	Inverse of body-effect factor of the poly-silicon gate	$V^{(-1/2)}$	0.0
Pophib	Coefficient for the geometry independent part of PHIB	V	0.95
Plphib	Coefficient for the length dependence of PHIB	V	0.0
Pwphib	Coefficient for the width dependence of PHIB	V	0.0
Plwphib	Coefficient for the length times width dependence of PHIB	V	0.0
Pobet	Coefficient for the geometry independent part of BET	A/V^2	1.922e-3 (NMOS)
Plbet	Coefficient for the length dependence of BET	A/V^2	0.0
Pwbet	Coefficient for the width dependence of BET	A/V^2	0.0

Parameter	Description	Units	Default
Plwbet	Coefficient for the width over length dependence of BET	A/V^2	0.0
Pothesr	Coefficient for the geometry independent part of THES	V^{-1}	0.3562 (NMOS)
Plthesr	Coefficient for the length dependence of THES	V^{-1}	0.0
Pwthesr	Coefficient for the width dependence of THES	V^{-1}	0.0
Plwthesr	Coefficient for the length times width dependence of THES	V^{-1}	0.0
Potheph	Coefficient for the geometry independent part of THEPH	V^{-1}	1.0e-3 (NMOS)
Pltheph	Coefficient for the length dependence of THEPH	V^{-1}	0.0
Pwtheph	Coefficient for the width dependence of THEPH	V^{-1}	0.0
Plwtheph	Coefficient for the length times width dependence of THEPH	V^{-1}	0.0
Poetamob	Coefficient for the geometry independent part of ETAMOB	None	1.4 (NMOS)
Pletamob	Coefficient for the length dependence of ETAMOB	None	0.0
Pwetamob	Coefficient for the width dependence of ETAMOB	None	0.0
Plwetamob	Coefficient for the length times width dependence of ETAMOB	None	0.0
Pother	Coefficient for the geometry independent part of THER	V^{-1}	8.12e-2 (NMOS)
Plther	Coefficient for the length dependence of THER	V^{-1}	0.0
Pwther	Coefficient for the width dependence of THER	V^{-1}	0.0
Plwther	Coefficient for the length times width dependence of THER	V^{-1}	0.0

Parameter	Description	Units	Default
Ther1	Numerator of the gate voltage dependent part of series resistance for the reference transistor	V	0.0
Ther2	Denominator of the gate voltage dependent part of series resistance for the reference transistor	V	1.0
Pothesat	Coefficient for the geometry independent part of THESAT	V^{-1}	0.2513 (NMOS)
Plthesat	Coefficient for the length dependence of THESAT	V^{-1}	0.0
Pwthesat	Coefficient for the width dependence of THESAT	V^{-1}	0.0
Plwthesat	Coefficient for the length times width dependence of THESAT	V^{-1}	0.0
Potheth	Coefficient for the geometry independent part of THETH	V^{-3}	1.0e-5 (NMOS)
Pltheth	Coefficient for the length dependence of THETH	V^{-3}	0.0
Pwtheth	Coefficient for the width dependence of THETH	V^{-3}	0.0
Plwtheth	Coefficient for the length times width dependence of THETH	V^{-3}	0.0
Posdibl	Coefficient for the geometry independent part of SDIBL	$V^{(-1/2)}$	8.53e-4 (NMOS)
Plsdibl	Coefficient for the length dependence of SDIBL	$V^{(-1/2)}$	0.0
Pwsdibl	Coefficient for the width dependence of SDIBL	$V^{(-1/2)}$	0.0
Plwsdibl	Coefficient for the length times width dependence of SDIBL	$V^{-1/2}$	0.0
Pomo	Coefficient for the geometry independent part of MO	None	0.0
Plmo	Coefficient for the length dependence of MO	None	0.0
Pwmo	Coefficient for the width dependence of MO	None	0.0

Parameter	Description	Units	Default
Plwmo	Coefficient for the length times width dependence of MO	None	0.0
Possf	Coefficient for the geometry independent part of SSF	$V^{(-1/2)}$	0.012 (NMOS)
Plssf	Coefficient for the length dependence of SSF	$V^{(-1/2)}$	0.0
Pwssf	Coefficient for the width dependence of SSF	$V^{(-1/2)}$	0.0
Plwssf	Coefficient for the length times width dependence of SSF	$V^{(-1/2)}$	0.0
Poalp	Coefficient for the geometry independent part of ALP	None	0.025
Plalp	Coefficient for the length dependence of ALP	None	0.0
Pwalp	Coefficient for the width dependence of ALP	None	0.0
Plwalp	Coefficient for the length times width dependence of ALP	None	0.0
VP	Characteristic voltage of channel length modulation	V	0.05
Pomexp	Coefficient for the geometry independent part of 1/m	1/m	0.2
Plmexp	Coefficient for the length dependence of 1/m	1/m	0.0
Pwmexp	Coefficient for the width dependence of 1/m	1/m	0.0
Plwmexp	Coefficient for the length times width dependence of 1/m	1/m	0.0
Poa1	Coefficient for the geometry independent part of A1	None	6.022 (NMOS)
Pla1	Coefficient for the length dependence of A1	None	0.0
Pwa1	Coefficient for the width dependence of A1	None	0.0
Plwa1	Coefficient for the length times width dependence of A1	None	0.0

Parameter	Description	Units	Default
Poa2	Coefficient for the geometry independent part of A2	V	38.02 (NMOS)
Pla2	Coefficient for the length dependence of A2	V	0.0
Pwa2	Coefficient for the width dependence of A2	V	0.0
Plwa2	Coefficient for the length times width dependence of A2	V	0.0
Poa3	Coefficient for the geometry independent part of A3	None	0.6407 (NMOS)
Pla3	Coefficient for the length dependence of A3	None	0.0
Pwa3	Coefficient for the width dependence of A3	None	0.0
Plwa3	Coefficient for the length times width dependence of A3	None	0.0
Poiginv	Coefficient for the geometry independent part of IGINV	A/V	0.0
Pliginv	Coefficient for the length dependence of IGINV	None	0.0
Pwiginv	Coefficient for the width dependence of IGINV	None	0.0
Plwiginv	Coefficient for the length times width dependence of IGINV	None	0.0
Pobinv	Coefficient for the geometry independent part of BINV	V	48.0
Plbinv	Coefficient for the length dependence of BINV	V	0.0
Pwbinv	Coefficient for the width dependence of BINV	V	0.0
Plwbinv	Coefficient for the length times width dependence of BINV	V	0.0
Poigacc	Coefficient for the geometry independent part of IGACC	A/V^2	0.0
Pligacc	Coefficient for the length dependence of IGACC	A/V^2	0.0
Pwigacc	Coefficient for the width dependence of IGACC	A/V^2	0.0

Parameter	Description	Units	Default
Plwigacc	Coefficient for the length times width dependence of IGACC	A/V^2	0.0
Pobacc	Coefficient for the geometry independent part of BACC	V	48.0 (NMOS)
Plbacc	Coefficient for the length dependence of BACC	V	0.0
Pwbacc	Coefficient for the width dependence of BACC	V	0.0
Plwbacc	Coefficient for the length times width dependence of BACC	V	0.0
Vfbov	Flat-band voltage for source/drain overlap extension	V	0.0
Kov	Body-effect factor for source/drain overlap extension	$V^{(1/2)}$	2.5
Poigov	Coefficient for the geometry independent part of IGOV	A/V^2	0.0
Pligov	Coefficient for the length dependence of IGOV	A/V^2	0.0
Pwigov	Coefficient for the width dependence of IGOV	A/V^2	0.0
Plwigov	Coefficient for the width over length dependence of IGOV	A/V^2	0.0
Tox	Thickness of gate oxide layer	m	3.2e-9
Pocox	Coefficient for the geometry independent part of COX	F	2.980e-14 (NMOS)
Plcox	Coefficient for the length dependence of COX	F	0.0
Pwcox	Coefficient for the width dependence of COX	F	0.0
Plwcox	Coefficient for the width over length dependence COX	F	0.0
Pocgdo	Coefficient for the geometry independent part of CGDO	F	6.392e-15 (NMOS)
Plcgdo	Coefficient for the length dependence of CGDO	F	0.0

Parameter	Description	Units	Default
Pwcgdo	Coefficient for the width dependence of CGDO	F	0.0
Plwcgdo	Coefficient for the width over length dependence CGDO	F	0.0
Pocgso	Coefficient for the geometry independent part of CGSO	F	6.392e-15 (NMOS)
Plcgso	Coefficient for the length dependence of CGSO	F	0.0
Pwcgso	Coefficient for the width dependence of CGSO	F	0.0
Plwcgso	Coefficient for the width over length dependence CGSO	F	0.0
Gatenoise	Flag for in/exclusion of induced gate thermal noise	None	0
Nt	coefficient of thermal noise at actual temperature	J	1.656e-20
Ponfa	Coefficient for the geometry independent part of NFA	$V^{-1}{\times}m^{-1}$	8.323e+22 (NMOS)
Plnfa	Coefficient for the length dependence of NFA	$V^{-1}{\times}m^{-1}$	0.0
Pwnfa	Coefficient for the width dependence of NFA	$V^{-1}{\times}m^{-1}$	0.0
Plwnfa	Coefficient for the length times width dependence of NFA	$V^{-1}{\times}m^{-1}$	0.0
Ponfb	Coefficient for the geometry independent part of NFB	$V^{-1}{\times}m^{-2}$	2.514e7 (NMOS)
Plnfb	Coefficient for the length dependence of NFB	$V^{-1}{\times}m^{-2}$	0.0
Pwnfb	Coefficient for the width dependence of NFB	$V^{-1}{\times}m^{-2}$ 2	0.0
Plwnfb	Coefficient for the length times width dependence of NFB	$V^{-1}{\times}m^{-2}$	0.0
Ponfc	Coefficient for the geometry independent part of NFC	V^{-1}	0.0 (NMOS)

Parameter	Description	Units	Default
Plnfc	Coefficient for the length dependence of NFC	V^{-1}	0.0
Pwnfc	Coefficient for the width dependence of NFC	V^{-1}	0.0
Plwnfc	Coefficient for the length times width dependence of NFC	V^{-1}	0.0
Potvfb	Coefficient for the geometry independent part of STVFB	V/K	0.5e-3
Pltvfb	Coefficient for the length dependence of STVFB	V/K	0.0
Pwtvfb	Coefficient for the width dependence of STVFB	V/K	0.0
Plwtvfb	Coefficient for the length times width dependence of STVFB	V/K	0.0
Potphib	Coefficient for the geometry independent part of STPHIB	V/K	-0.85e-3
Pltphib	Coefficient for the length dependence of STPHIB	V/K	0.0
Pwtphib	Coefficient for the width dependence of STPHIB	V/K	0.0
Plwtphib	Coefficient for the length times width dependence of STPHIB	V/K	0.0
Potetabet	Coefficient for the geometry independent part of ETABET	None	1.3 (NMOS)
Pltetabet	Coefficient for the length dependence of ETABET	None	0.0
Pwtetabet	Coefficient for the width dependence of ETABET	None	0.0
Plwtetabet	Coefficient for the length times width dependence of ETABET	None	0.0
Potetasr	Coefficient for the geometry independent part of ETASR	None	0.65 (NMOS)
Pltetasr	Coefficient for the length dependence of ETASR	None	0.0
Pwtetasr	Coefficient for the width dependence of ETASR	None	0.0
Plwtetasr	Coefficient for the length times width dependence of ETASR	None	0.0

Parameter	Description	Units	Default
Potetaph	Coefficient for the geometry independent part of ETAPH	None	1.35 (NMOS)
Pltetaph	Coefficient for the length dependence of ETAPH	None	0.0
Pwtetaph	Coefficient for the width dependence of ETAPH	None	0.0
Plwtetaph	Coefficient for the length times width dependence of ETAPH	None	0.0
Potetamob	Coefficient for the geometry independent part of ETAMOB	K^{-1}	0.0
Pltetamob	Coefficient for the length dependence of ETAMOB	K^{-1}	0.0
Pwtetamob	Coefficient for the width dependence of ETAMOB	K^{-1}	0.0
Plwtetamob	Coefficient for the length times width dependence of ETAMOB	K^{-1}	0.0
Nu	Exponent of the field dependence of the mobility model minus 1 at the reference temperature	None	2.0
Potnuexp	Coefficient for the geometry independent part of NUEXP	None	5.25 (NMOS)
Pltnuexp	Coefficient for the length dependence of NUEXP	None	0.0
Pwtnuexp	Coefficient for the width dependence of NUEXP	None	0.0
Plwtnuexp	Coefficient for the length times width dependence of NUEXP	None	0.0
Potetar	Coefficient for the geometry independent part of ETAR	None	0.95 (NMOS)
Pltetar	Coefficient for the length dependence of ETAR	None	0.0
Pwtetar	Coefficient for the width dependence of ETAR	None	0.0
Plwtetar	Coefficient for the length times width dependence of ETAR	None	0.0
Potetasat	Coefficient for the geometry independent part of ETASAT	None	1.04 (NMOS)

Parameter	Description	Units	Default
Pltetasat	Coefficient for the length dependence of ETASAT	None	0.0
Pwtetasat	Coefficient for the width dependence of ETASAT	None	0.0
Plwtetasat	Coefficient for the length times width dependence of ETASAT	None	0.0
Pota1	Coefficient for the geometry independent part of STA1	K^{-1}	0.0
Plta1	Coefficient for the length dependence of STA1	K^{-1}	0.0
Pwta1	Coefficient for the width dependence of STA1	K^{-1}	0.0
Plwta1	Coefficient for the length times width dependence of STA1	K^{-1}	0.0
wVsubfwd	Substrate junction forward bias (warning)	V	None
wBvsub	Substrate junction reverse breakdown voltage (warning)	V	None
wBvg	Gate oxide breakdown voltage (warning)	V	None
wBvds	Drain-source breakdown voltage (warning)	V	None
wIdsmax	Maximum drain-source current (warning)	A	None
wPmax	Maximum power dissipation (warning)	W	None
AllParams	DataAccessComponent-based parameters	None	None

- Use AllParams with a DataAccessComponent to specify file-based parameters (refer to "DataAccessComponent" in *Introduction to Circuit Components*). Note that model parameters that are explicitly specified take precedence over those specified via AllParams. Set AllParams to the DataAccessComponent instance name.
- Each instance parameter whose dimension contains a power of meter will be multiplied by the *Scale* variable or the scale option to the same power. For example, a parameter with a dimension of m will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. The parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains cm instead of meter is not scaled.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to *Design Kit Development*.

```
model modelname MOS11 [parm=value]*
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by mosfet components to refer to the model.The third parameter indicates the type of model; for this model it is *MOS11*. Use either parameter NMOS=yes or PMOS=yes to set the transistor type. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Some model parameters have aliases, which are listed in parentheses after the main parameter name; these are parameter names that can be used instead of the primary parameter name. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to "ADS Simulator Input Syntax" in Using Circuit Simulators.

Example

```
model Nch12 MOS11 \
  Vfbr=-1.0 Phibr=0.8 NMOS=yes
```

MOSVAR (PSP-Based MOS Varactor Model)

MOSVAR (PSP-Based MOS Varactor Model)

Following are the supported versions of MOSVAR model.

- MOSVAR_1_0 (PSP-Based MOS Varactor Version 1.0 Model and Instance)
- MOSVAR_1_1 (PSP-Based MOS Varactor Version 1.1 Model and Instance)
- MOSVAR_1_2 (PSP-Based MOS Varactor Version 1.2 Model and Instance)
- MOSVAR_1_3 (PSP-Based MOS Varactor Version 1.3 Model and Instance)

MOSVAR_1_0 (PSP-Based MOS Varactor Version 1.0 Model and Instance)

MOSVAR_1_0 (PSP-Based MOS Varactor Version 1.0 Model and Instance)

Instance Parameters

Name	Description	Unit	Default	Min	Max
m	Multiplicity factor		1	0	
W	Design width of varactor	m	1.0e-6	0.0	
L	Design length of varactor	m	1.0e-6	0.0	
NGCON	Number of gate contacts		1	1	2
DTA	Local temperature delta to ambient	°C	0.0		
Scale †	value by which a parameter should be multiplied				

† Each instance parameter whose dimension contains a power of meter will be multiplied by the _Scale variable or the scale option to the same power. For example, a parameter with a dimension of m will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. The parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains cm instead of meter is not scaled.

Model Parameters

Name	Description	Units	Default	Min	Max
VERSION	Model version		1.0		
SUBVERSION	Model subversion		0.0		
REVERSION	Model reversion		0.0		
LEVEL	Model level		1000		

Name	Description	Units	Default	Min	Max
TMIN	Minimum reference/ambient temperature	°C	-100.0	-250.0	21.0
TMAX	Maxinum reference/ambient temperature	°C	500.0	21.0	1000.0
VMAX	Maximum voltage applied between nodes g and b	V	10000.0	0.5	
TR	Nominal (reference) temperature	°C	21.0	-250.0	1000.0
LMIN	Minimum allowed drawn length	m	1.0e-8	0.0	
LMAX	Maximum allowed drawn length	m	9.9e9	0.0	
WMIN	Minimum allowed drawn width	m	1.0e-8	0.0	
WMAX	Maximum allowed drawn width	m	9.9e9	0.0	
SWRES	Switch to control series resistance: 0=exclude and 1=include		1		
TYPE	Substrate doping TYPE: -1=n-TYPE and +1=p-TYPE		-1		
TYPEP	Polysilicon doping TYPE: -1=n-TYPE and +1=p-TYPE		-1		
TOXO	Oxide thickness	m	2.0e-9	5.0e-10	2.0e-8
TAU	Time constant for inversion charge recombination/generation	s	0.1	0	10.0
VFBO	Flatband voltage (for p-TYPE substrate)	V	0.0		
NSUBO	Substrate doping level	$/m^3$	3.0e23	1.0e22	1.0e25
MNSUBO	Maximum change in absolute doping, limited to 1 order of mag up		1.0	1.0	10.0

Name	Description	Units	Default	Min	Max
DNSUBO	Doping profile slope parameter		0.0	0.0	100.0
VNSUBO	Doping profile corner voltage parameter		0.0	-5.0	5.0
NSLPO	Doping profile smoothing parameter		0.1	0.1	1.0
NPO	Doping profile corner voltage parameter	$/m^3$	1.0e27	1.0e24	1.0e27
QMC	Quantum mechanical correction factor		1.0	0.0	
DLQ	Length delta for capacitor size	m	0.0		
DWQ	Width delta for capacitor size	m	0.0		
DWR	Width delta for substrate resistance calculation	m	0.0		
CFRL	Fringing capacitance in length direction	F/m	0.0	0.0	
CFRW	Fringing capacitance in width direction	F/m	0.0	0.0	
RSHG	Gate sheet resistance	Ω / sq	1.0	0.0	
RPV	Vertical resistance down through gate in units of $\Omega \times m^2$	$\Omega \times m^2$	0.0	0.0	
REND	End resistance (extrinsic well res. plus vertical contact res. to well) per width	Ω × m	1.0e-4	0.0	
RSHS	Substrate sheet resistance	Ω / sq	1000.0	0.0	10000.0
UAC	Accumulation layer zero bias mobility	m^2 / V / s	5.0e-2	0.0	
UACRED	Accumulation layer mobility degradation factor	/V	0.0	0.0	
STVFB	Temperature dependence of VFB	V / K	0.0		

Name	Description	Units	Default	Min	Max
STRSHG	Temperature dependence of RSHG		0.0		
STRPV	Temperature dependence of RPV		0.0		
STREND	Temperature dependence of REND		0.0		
STRSHS	Temperature dependence of RSHS		0.0		
STUAC	Temperature dependence of UAC		0.0		
STETA	Effective field parameter		1.0	0.0	
SWIGATE	Flag for gate current: 0=turn off and 1=turn on		0		
CHIBO	Tunneling barrier height for electrons	V	3.1	1.0	
CHIBOP	Tunneling barrier height for holes	V	4.5	1.0	
STIG	Common temperature coefficient for gate currents (ECB, HVB and HVB)		2.0		
LOV	Overlap length	m	0.0	0.0	
NOVO	Effective doping level of overlap regions	$/m^3$	5.0e25	1.0e22	1.0e26
IGINVLW	ECB gate channel current pre-factor for 1 μm^2 channel area	A	0.0	0.0	
IGOVW	ECB gate overlap current pre-factor for 1 µm wide gate overlap region	A	0.0	0.0	
GCOO	ECB gate tunneling energy adjustment		0.0	-10.0	10.0
GC2O	ECB gate current slope factor		0.375	0.0	10.0
GC3O	ECB gate current curvature factor		0.063	-10.0	10.0

Name	Description	Units	Default	Min	Max
IGCHVLM	HVB gate channel current pre-factor for 1 µm^2 channel area	A	0.0	0.0	
IGOVHVW	HVB gate overlap current pre-factor for 1 µm wide gate overlap region	A	0.0	0.0	
GCOHVO	HVB gate tunneling energy adjustment		0.0	-10.0	10.0
GC2HVO	HVB gate current slope factor		0.375	0.0	10.0
GC3HVO	HVB gate current curvature factor		0.063	-10.0	10.0
IGCEVLM	EVB gate channel current pre-factor for 1 µm^2 channel area	A	0.0	0.0	
IGOVEVW	EVB gate overlap current pre-factor for 1 µm wide gate overlap region	A	0.0	0.0	
GCOEVO	EVB gate tunneling energy adjustment		0.0	-10.0	10.0
GC2EVO	EVB gate current slope factor		0.375	0.0	10.0
GC3EVO	EVB gate current curvature factor		0.063	-10.0	10.0

Instance Netlist Format

```
modelName:instanceName g bi b [parm=value]
```

Example:

```
amos:X1 1 2 3 w=10 um l=10 um
```

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName mosvar [parm=value]
```

The model statement starts with the required keyword model. It is followed by the modelName that will be used by components to refer to the model. The third parameter indicates the type of model; for this model it is mosvar. Use the parameter gender to set the model parameters. Model parameters that are not specified take the default value. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example:

```
model model amos mosvar SWRES=1 TOXO=3.6e-9 VFBO=6.0e-2
```

MOSVAR_1_1 (PSP-Based MOS Varactor Version 1.1 Model and Instance)

MOSVAR_1_1 (PSP-Based MOS Varactor Version 1.1 Model and Instance)

Model Parameters

Name (Alias)	Description	Units	Default
Gender	+1=N-type, -1=P-type		1(n),-1(p)
Tnom (TR)	Parameter measurement temperature	deg C	21
Secured	Secured model parameters		0
VERSION	model version		1.1
SUBVERSION	model subversion		0
REVISION	model revision		0
LEVEL	model level		1000
TMIN	minimum reference/ambient temperature		-100
TMAX	maximum reference/ambient temperature		500
VMAX	maximum voltage applied between nodes g and b		10000
LMIN	minimum allowed drawn length		1e-08
LMAX	maximum allowed drawn length		9.9e+09
WMIN	minimum allowed drawn width		1e-08
WMAX	maximum allowed drawn width		9.9e+09
SWRES	switch to control series resistance: 0=exclude and 1=include		1

Name (Alias)	Description	Units	Default
TYPE	substrate doping TYPE: -1=n-TYPE and +1=p-TYPE		-1
TYPEP	polysilicon doping TYPE: -1=n-TYPE and +1=p-TYPE		-1
TOXO	oxide thickness		2e-09
TAU	time constant for inversion charge recombination/generation		0.1
VFBO	flatband voltage (for p-TYPE substrate)		0
NSUBO	substrate doping level		3e+23
MNSUBO	maximum change in absolute doping, limited to 1 order of mag up		1
DNSUBO	doping profile slope parameter		0
VNSUBO	doping profile corner voltage parameter		0
NSLPO	doping profile smoothing parameter		0.1
NPO	polysilicon doping level		1e+27
QMC	quantum mechanical correction factor		1
DLQ	length delta for capacitor size		0
DWQ	width delta for capacitor size		0
DWR	width delta for substrate resistance calculation		0
CFRL	fringing capacitance in length direction		0
CFRW	fringing capacitance in width direction		0
RSHG	gate sheet resistance		1
RPV	vertical resistance down through gate in units of ohm*m^2		0

Name (Alias)	Description	Units	Default
REND	end resistance (extrinsic well res. plus vertical contact res. to well) per width		0.0001
RSHS	substrate sheet resistance		1000
UAC	accumulation layer zero bias mobility		0.05
UACRED	accumulation layer mobility degradation factor		0
STVFB	temperature dependence of VFB		0
STRSHG	temperature dependence of RSHG		0
STRPV	temperature dependence of RPV		0
STREND	temperature dependence of REND		0
STRSHS	temperature dependence of RSHS		0
STUAC	temperature dependence of UAC		0
FETA	Effective field parameter		1
SWIGATE	flag for gate current: 0=turn off and 1=turn on		0
CHIBO	tunneling barrier height for electrons		3.1
CHIBPO	tunneling barrier height for holes		4.5
STIG	temperature dependence for gate current densities of ECB, HVB		2
LOV	overlap length		0
NOVO	effective doping level of overlap regions		5e+25
IGINVLW	ECB gate channel current pre-factor for 1 um^2 channel area		0

Name (Alias)	Description	Units	Default
IGOVW	ECB gate overlap current pre-factor for 1 um wide gate overlap region		0
GCOO	ECB gate tunneling energy adjustment		0
GC2O	ECB gate current slope factor		0.375
GC3O	ECB gate current curvature factor		0.063
IGCHVLW	HVB gate channel current pre-factor for 1 um^2 channel area		0
IGOVHVW	HVB gate overlap current pre-factor for 1 um wide gate overlap region		0
GCOHVO	HVB gate tunneling energy adjustment		0
GC2HVO	HVB gate current slope factor		0.375
GC3HVO	HVB gate current curvature factor		0.063
IGMAX	maximum gate tunneling current		1e-05

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName mosvar_1_1 [parm=value]*
```

Example:

```
model Nch mosvar_1_1 TOXO=2.15e-9
```

Instance Parameters

Name (Alias)	Description	Units	Default
Temp	Device operating temperature	deg C	25
Trise (DTA)	Temperature rise over ambient	deg C	0

Name (Alias)	Description	Units	Default
Mode	Nonlinear spectral model on/off		1
Noise	Noise generation on/off		1
m	multiplicity factor		1
W	design width of varactor		1e-06
L	design length of varactor		1e-06
NGCON	number of gate contacts		1
Scale †	value by which a parameter should be multiplied		

† Each instance parameter whose dimension contains a power of meter will be multiplied by the *Scale* variable or the scale option to the same power. For example, a parameter with a dimension of m will be multiplied by $scale^1$ and a parameter with a dimension of m^2 will be multiplied by $scale^2$. The parameters whose dimensions contain meter are scaled. For example, a parameter whose dimension contains cm instead of meter is not scaled.

Instance Netlist Format

```
modelName [:Name] d g s b
```

Example

```
Nch:M1 2 1 0 W=10u L=0.9u
```

DC Operating Point Information

Name	Description	Units
I	Current	A
V	Voltage	V
Cap	Capacitance	F

MOSVAR_1_2 (PSP-Based MOS Varactor Version 1.2 Model and Instance)

MOSVAR_1_2 (PSP-Based MOS Varactor Version 1.2 Model and Instance)

Model Parameters

Name (Alias)	Description	Units	Default
TR	Nominal (reference) temperature	deg C	21
VERSION	model version		1.1
REVISION	model revision		0
LEVEL	model level		1000
TMIN	minimum reference/ambient temperature	deg C	-100
TMAX	maximum reference/ambient temperature	deg C	500
VMAX	maximum voltage applied between nodes g and b	V	10000
LMIN	minimum allowed drawn length	m	1e-08
LMAX	maximum allowed drawn length	m	9.9e+09
WMIN	minimum allowed drawn width	m	1e-08
WMAX	maximum allowed drawn width	m	9.9e+09
TOXO	oxide thickness	m	2e-09
EPSROXO	Relative permittivity		3.9
VFBO	flatband voltage (for p-TYPE substrate)	V	0
NSUBO	substrate doping level	m^{-3}	3e+23

Name (Alias)	Description	Units	Default
MNSUBO	maximum change in absolute doping, limited to 1 order of mag up		1
DNSUBO	doping profile slope parameter		0
VNSUBO	doping profile corner voltage parameter		0
NSLPO	doping profile smoothing parameter		0.1
DLQ	length delta for capacitor size	m	0
DWQ	width delta for capacitor size	m	0
DWR	width delta for substrate resistance calculation	m	0
CFRL	fringing capacitance in length direction	F/m	0
CFRW	fringing capacitance in width direction	F/m	0
RSHG	gate sheet resistance	Ohm/sq	1
RPV	vertical resistance down through gate in units of ohm*m^2	Ohm*m^2	0
REND	end resistance (extrinsic well res. plus vertical contact res. to well) per width	Ohm*m	0.0001
RSHS	substrate sheet resistance	Ohm/sq	1000
UAC	accumulation layer zero bias mobility	m^2/V/s	0.05
UACRED	accumulation layer mobility degradation factor	V^{-1}	0
STVFB	temperature dependence of VFB	V/K	0
STRSHG	temperature dependence of RSHG		0
STRPV	temperature dependence of RPV		0

Name (Alias)	Description	Units	Default
STREND	temperature dependence of REND		0
STRSHS	temperature dependence of RSHS		0
STUAC	temperature dependence of UAC		0
FETA	Effective field parameter		1
SWRES	switch to control series resistance: 0=exclude and 1=include		1
TYPE	substrate doping TYPE: -1=n-TYPE and +1=p-TYPE		-1
TYPEP	polysilicon doping TYPE: -1=n-TYPE and +1=p-TYPE		-1
TAU	time constant for inversion charge recombination/generation	s	0.1
NPO	polysilicon doping level	m^{-3}	1e+27
QMC	quantum mechanical correction factor		1
SWIGATE	flag for gate current: 0=turn off and 1=turn on		0
RACNOISE	Rac noise model selector: 0=turn off; 1=use bias-independent conductance; 2=use bias-dependent conductance		1
CHIBO	tunneling barrier height for electrons	V	3.1
CHIBPO	tunneling barrier height for holes	V	4.5
LOV	overlap length	m	0
NOVO	effective doping level of overlap regions	m^{-3}	5e+25
IGINVLW	ECB gate channel current pre-factor for 1 um^2 channel area	A	0
IGOVW	ECB gate overlap current pre-factor for 1 um wide gate overlap region	A	0

Name (Alias)	Description	Units	Default
GCOO	ECB gate tunneling energy adjustment		0
GC2O	ECB gate current slope factor		0.375
GC3O	ECB gate current curvature factor		0.063
IGCHVLW	HVB gate channel current pre-factor for 1 um^2 channel area	A	0
IGOVHVW	HVB gate overlap current pre-factor for 1 um wide gate overlap region	A	0
GCOHVO	HVB gate tunneling energy adjustment		0
GC2HVO	HVB gate current slope factor		0.375
GC3HVO	HVB gate current curvature factor		0.063
IGMAX	maximum gate tunneling current		1e-05
Gender	+1=N-type, -1=P-type		1(n),-1(p)

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName mosvar_1_2 [parm=value]*
```

Example:

```
model Nch mosvar_1_2 TOXO=2.15e-9
```

Instance Parameters

Name (Alias)	Description	Units	Default	Min	Max
DTA	Local temperature offset with respect to ambient circuit temperature	deg C	0	-	-
m	multiplicity factor		1	0	-

Name (Alias)	Description	Units	Default	Min	Max
W	design width of varactor	m	1e-06	0	-
L	design length of varactor	m	1e-06	0	-
NGCON	number of gate contacts		1	1	2

Instance Netlist Format

```
modelName [:Name] d g s b
```

Example

```
Nch:M1 2 1 0 W=10u L=0.9u
```

DC Operating Point Information

Name	Description	Units
I	Current	A
V	Voltage	V
Cap	Capacitance	F

MOSVAR_1_3 (PSP-Based MOS Varactor Version 1.3 Model and Instance)

MOSVAR_1_3 (PSP-Based MOS Varactor Version 1.3 Model and Instance)

The MOSVAR version 1.3 is based on version 1.2. For Version 1.3, the acceptable ranges for TOXO and NSUBO have been extended and the calculation of Igov has been modified to depend on V(b_ov) and the calculation of Igc now depends on V(b_ci)

Model Parameters

Name (Alias)	Description	Units	Default
TR	Nominal (reference) temperature	deg C	21
VERSION	model version		1.1
REVISION	model revision		0
LEVEL	model level		1000
TMIN	minimum reference/ambient temperature	deg C	-100
TMAX	maximum reference/ambient temperature	deg C	500
VMAX	maximum voltage applied between nodes g and b	V	10000
LMIN	minimum allowed drawn length	m	1e-08
LMAX	maximum allowed drawn length	m	9.9e+09
WMIN	minimum allowed drawn width	m	1e-08
WMAX	maximum allowed drawn width	m	9.9e+09
TOXO	oxide thickness	m	2e-09
EPSROXO	Relative permittivity		3.9
VFBO	flatband voltage (for p-TYPE substrate)	V	0

Name (Alias)	Description	Units	Default
NSUBO	substrate doping level	m^{-3}	3e+23
MNSUBO	maximum change in absolute doping, limited to 1 order of mag up		1
DNSUBO	doping profile slope parameter		0
VNSUBO	doping profile corner voltage parameter		0
NSLPO	doping profile smoothing parameter		0.1
DLQ	length delta for capacitor size	m	0
DWQ	width delta for capacitor size	m	0
DWR	width delta for substrate resistance calculation	m	0
CFRL	fringing capacitance in length direction	F/m	0
CFRW	fringing capacitance in width direction	F/m	0
RSHG	gate sheet resistance	Ohm/sq	1
RPV	vertical resistance down through gate in units of ohm*m^2	Ohm*m^2	0
REND	end resistance (extrinsic well res. plus vertical contact res. to well) per width	Ohm*m	0.0001
RSHS	substrate sheet resistance	Ohm/sq	1000
UAC	accumulation layer zero bias mobility	m^2/V/s	0.05
UACRED	accumulation layer mobility degradation factor	V^{-1}	0
STVFB	temperature dependence of VFB	V/K	0
STRSHG	temperature dependence of RSHG		0

Name (Alias)	Description	Units	Default
STRPV	temperature dependence of RPV		0
STREND	temperature dependence of REND		0
STRSHS	temperature dependence of RSHS		0
STUAC	temperature dependence of UAC		0
FETA	Effective field parameter		1
SWRES	switch to control series resistance: 0=exclude and 1=include		1
TYPE	substrate doping TYPE: -1=n-TYPE and +1=p-TYPE		-1
TYPEP	polysilicon doping TYPE: -1=n-TYPE and +1=p-TYPE		-1
TAU	time constant for inversion charge recombination/generation	s	0.1
NPO	polysilicon doping level	m^{-3}	1e+27
QMC	quantum mechanical correction factor		1
SWIGATE	flag for gate current: 0=turn off and 1=turn on		0
RACNOISE	Rac noise model selector: 0=turn off; 1=use bias-independent conductance; 2=use bias-dependent conductance		1
CHIBO	tunneling barrier height for electrons	V	3.1
CHIBPO	tunneling barrier height for holes	V	4.5
LOV	overlap length	m	0
NOVO	effective doping level of overlap regions	m^{-3}	5e+25
IGINVLW	ECB gate channel current pre-factor for 1 um^2 channel area	A	0

Name (Alias)	Description	Units	Default
IGOVW	ECB gate overlap current pre-factor for 1 um wide gate overlap region	A	0
GCOO	ECB gate tunneling energy adjustment		0
GC2O	ECB gate current slope factor		0.375
GC3O	ECB gate current curvature factor		0.063
IGCHVLW	HVB gate channel current pre-factor for 1 um^2 channel area	A	0
IGOVHVW	HVB gate overlap current pre-factor for 1 um wide gate overlap region	A	0
GCOHVO	HVB gate tunneling energy adjustment		0
GC2HVO	HVB gate current slope factor		0.375
GC3HVO	HVB gate current curvature factor		0.063
IGMAX	maximum gate tunneling current		1e-05
Gender	+1=N-type, -1=P-type		1(n),-1(p)

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName mosvar_1_2 [parm=value]*
```

Example:

```
model Nch mosvar_1_2 TOXO=2.15e-9
```

Instance Parameters

Name (Alias)	Description	Units	Default	Min	Max
DTA	Local temperature offset with respect to ambient circuit temperature	deg C	0	-	-
m	multiplicity factor		1	0	-
W	design width of varactor	m	1e-06	0	-
L	design length of varactor	m	1e-06	0	-
NGCON	number of gate contacts		1	1	2

Instance Netlist Format

```
modelName [:Name] d g s b
```

Example

```
Nch:M1 2 1 0 W=10u L=0.9u
```

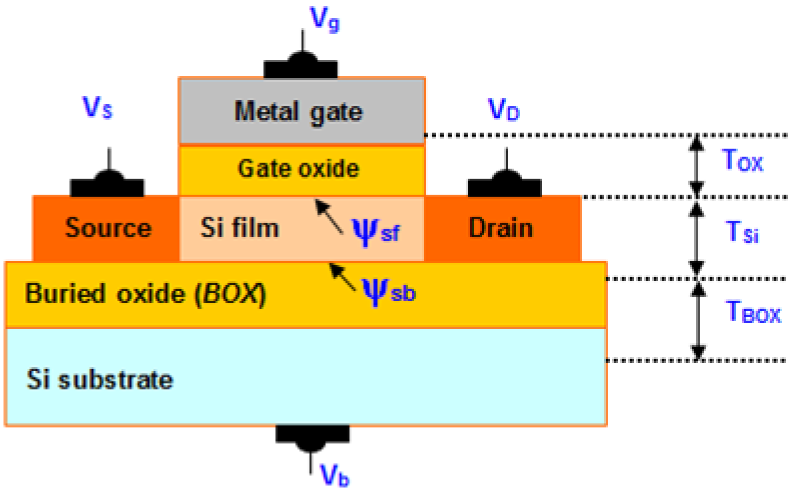
DC Operating Point Information

Name	Description	Units
I	Current	A
V	Voltage	V
Cap	Capacitance	F

LETI-UTSOI (Ultra Thin Fully Depleted SOI MOSFET Model)

LETI-UTSOI (Ultra Thin Fully Depleted SOI MOSFET Model)

The UTSOI model is developed by CEA-LETI. It is a surface-potential based model dedicated to Planar Ultra-Thin Silicon-On-Insulator (SOI) MOSFET [1] device. It has been designed to be user-friendly for the PSP [2] users. The following figure illustrates the device structure.



The UTSOI model is designed for transistors with a lightly doped silicon film. The silicon film thickness is typically less than 10nm. This model is compatible with the use of thin buried oxide (typically 10nm). The model is not designed for double gate transistor where the back Si-SiO2 interface can be in inversion.

Supported Versions

Following versions of the UTSOI model are supported:

- UTSOI 1.14
- UTSOI 2
- UTSOI 2.1
- UTSOI 2.11
- UTSOI 2.20
- UTSOI 2.30

References

[1] Surface potential based model of ultra-thin fully depleted SOI MOSFET for IC simulations, O. Rozeau, M.-A. Jaud, T. Poiroux and M. Benosman, 2011, IEEE International SOI conference, Tempe Arizona, USA, October 2011.
[2] PSP: An Advanced Surface-Potential-Based MOSFET Model for Circuit Simulation, G. Gildenblat,

X. Li, W. Wu, H. Wang, A. Jha, R. van Langevelde, G. D. J. Smit, A. J. Scholten and D. B. M. Klaassen, IEEE Trans. on Electron Devices, Vol. 53, No. 9, Sept. 2006.

UTSOI 1.14

UTSOI 1.14 (Ultra Thin Fully Depleted SOI MOSFET Model)

Model Parameters

Following table lists the model parameters.

Name	Description	Default	Min.	Max.	Unit
GENDER	Channel type parameter, +1=NMOS, -1=PMOS	1	-1	1	
TR	Reference temperature	21	-273		°C
SWSCALE	Flag for scaling rules, 0=local parameter set, 1=global parameter set	0	0	1	
VERSION	Flag for model version, 1.11=old version, 1.14= new version	1.11			
SWIGATE	Flag for gate current, 0=turn off	0	0	1	
SWGIDL	Flag for GIDL current, 0=turn off	0	0	1	
SWSHE	Flag for self heating effect, 0=turn off	0	0	1	
SWRSMOD	Flag for access resistance calculation, 0=includes in mobility model, 1=using internal nodes	0	0	1	
SWIGN	Flag for induced gate noise, 0=turn off	1	0	1	

Parameters at local level (SWSCALE=0)

Instance Parameters for local mode

Name	Description	Default	Min.	Max.	Unit
ASOURCE	Source region area	10^{-12}	0		m^2

Name	Description	Default	Min.	Max.	Unit
ADRAIN	Drain region area	10^{-12}	0		m^2
PSOURCE	Source region perimeter	10^{-6}	0		m
PDRAIN	Drain region perimeter	10^{-6}	0		m
MULT	Number of device in parallel	1	1		

Parameters for local mode

Name	Description	Default	Min.	Max.	Unit
VFB	Flat-band voltage at TR	0			V
STVFB	Temperature dependence of VFB	5.10^{-4}			V/K
TOX	Gate oxide thickness	2.10^{-9}	10^{-10}		m
EPSROX	Relative permittivity of gate dielectric	3.9	1		
TSI	Silicon film thickness	10^{-8}	10^{-9}	10^{-7}	m
EPSRSI	Relative permittivity of silicon film	11.8	11.8	16.5	
EG	Band-gap of silicon film at 300K	1.179	0.6	1.2	V
STEG1	First temperature coefficient of EG	$9{,}025.10^{-5}$			V/°C
STEG2	Second temperature coefficient of EG	$3{,}05.10^{-7}$			V/°C^2
NI	Intrinsic doping of silicon film at 300K	$1{,}45.10^{10}$	10^{10}	10^{14}	cm^{-3}
STNI	Temperature dependence factor of NI	1.5	0.5	3	

Name	Description	Default	Min.	Max.	Unit
TBOX	Buried oxide thickness	10^{-7}	10^{-8}	10^{-6}	m
NSI	Lightly silicon film doping, 0=undoped	0		10^{18}	cm^{-3}
NSUB	Substrate doping, negative value=N-type, positive value=P-type	3.10^{18}	10^{16}	10^{21}	cm^{-3}
DVFBB	Offset of back-gate flat-band voltage	0			V
CT	Interface states factor	0	0		
TOXOV	Overlap oxide thickness	2.10^{-9}	10^{-10}		m
NOV	Effective doping of overlap region, 0=no doping effect	0	10^{17}	10^{21}	cm^{-3}
QMC	Quantum correction factor	1	0		
CIC	Substrate bias dependence factor of interface coupling	1	0.1	10	
PSCE	SCE-parameter above threshold	0	0		
CF	DIBL-parameter	0	0		V^{-1}
CFB	Substrate bias dependence of CF	0	0		V^{-1}
STCF	Temperature dependence of CF	0			
BETN	Channel aspect ratio times zero-field mobility	5.10^{-2}	10^{-10}		$m^2/V/s$
STBET	Temperature dependence of BETN	1			
MUE	Mobility reduction coefficient at TR	0.5	0		m/V
STMUE	Temperature dependence of MUE	0			

Name	Description	Default	Min.	Max.	Unit
THEMU	Mobility reduction exponent at TR	1.5	0		
STTHEMU	Temperature dependence of THEMU	1.5			
CS	Remote Coulomb scattering parameter at TR	0	0		
CSB	Substrate bias dependence of CS	0			
THECS	Remote Coulomb scattering exponent at TR	1.5	0		
STTHECS	Temperature dependence of THECS	1.5			
STCS	Temperature dependence of CS	0			
XCOR	Non-universality factor	0	0		V^{-1}
STXCOR	Temperature dependence of XCOR	0			
FETA	Effective field parameter	1	0		
RS	Source/Drain series resistance at TR	30	0		ohm
RSG	Gate bias dependence of RS	0	-0.5		
THERSG	Gate bias dependence exponent of RS	2	0		
STRS	Temperature dependence of RS	1			
THESAT	Velocity saturation parameter at TR	0	0		V^{-1}
STTHESAT	Temperature dependence of THESAT	1			
THESATB	Substrate bias dependence of velocity saturation	0	-0.5		
THESATG	Gate bias dependence of velocity saturation	0	0		V^{-1}
AX	Linear/saturation transition factor	10	1	10	

Name	Description	Default	Min.	Max.	Unit
ALP	Channel length modulation (CLM) pre-factor	0	0		
ALP1	CLM enhancement factor above threshold	0	0		V
VP	CLM logarithm dependence factor	0.05	10^{-10}		V
GCO	Gate tunneling energy adjustment	0	-10	10	
IGINV	Gate to channel current pre-factor in inversion	0	0		A
IGOVINV	Gate to overlap current pre-factor in inversion	0	0		A
IGOVACC	Gate to overlap current pre-factor in accumulation	0	0		A
GC2CH	Gate current slope factor for gate to channel current	0.375	0	10	
GC3CH	Gate current curvature factor for gate to channel current	0.063	-2	2	
GC2OV	Gate current slope factor for overlap currents	0.375	0	10	
GC3OV	Gate current curvature factor for overlap currents	0.063	-2	2	
STIG	Temperature dependence of all gate currents	2			
CHIB	Tunneling barrier height	3.1	1		V
AGIDL	GIDL pre-factor	0	0		A/V^3
BGIDL	GIDL probability factor at TR	41	0		V
STBGIDL	Temperature dependence of BGIDL	0			V/K
CGIDL	Substrate bias dependence of GIDL	0			
COX	Oxide capacitance for intrinsic channel	10^{-14}	0		F

Name	Description	Default	Min.	Max.	Unit
CBOX	Unit area buried oxide capacitance of drain/ source region	5.10^{-4}	0		F/m^2
CGBOV	Oxide capacitance for gate-substrate overlap	0	0		F
COV	Overlap capacitance	0	0		F
CFR	Outer fringe capacitance	0	0		F
CSDO	Outer drain-source capacitance	0 0		F	
CSDBP	Drain/source to substrate perimeter capacitance	0	0		F/m
RTH	Substrate thermal resistance	1500	0		°C/W
STRTH	Temperature dependence of RTH	0	0		
CTH	Substrate thermal capacitance	5.10^{-10}	0		W.s /°C
FNT	Thermal noise coefficient	1	0		
NFA	First coefficient of flicker noise	8.10^{22}	0		V^{-1}/m^4
NFB	Second coefficient of flicker noise	3.10^7	0		V^{-1}/m^2
NFC	Third coefficient of flicker noise	0	0		V^{-1}
EF	Frequency coefficient of flicker noise	1	0.1		

Parameters at global level (SWSCALE=1)

Instance Parameters for global level

Name	Description	Default	Min.	Max.	Unit
L	Drawn channel length	10^{-6}	10^{-9}		m

Name	Description	Default	Min.	Max.	Unit
W	Drawn channel width	10^{-6}	10^{-9}		m
SA	Distance between OD-edge and gate at source side	0			m
SB	Distance between OD-edge and gate at drain side	0			m
SD	Distance between neighboring fingers	0			m
ASOURCE	Source region area	10^{-12}	0		m^2
ADRAIN	Drain region area	10^{-12}	0		m^2
PSOURCE	Source region perimeter	10^{-6}	0		m
PDRAIN	Drain region perimeter	10^{-6}	0		m
NF	Number of fingers	1	1		
MULT	Number of device in parallel	1	1		

Parameters for global level

Name	Description	Default	Min.	Max.	Unit
LVAR0	Geometry-independent difference between physical and drawn gate lengths	0			m
LVARL	Length dependence of ΔLPS	0			
LVARW	Width dependence of ΔLPS	0			
LAP	Effective channel length reduction per side	0			m
WVARO	Geometry-independent difference between physical and drawn field-oxide opening	0			m

Name	Description	Default	Min.	Max.	Unit
WVARL	Length dependence of ΔWOD	0			
WVARW	Width dependence of ΔWOD	0			
WOT	Effective reduction of channel width per side	0			m
DLQ	Effective channel length offset for CV	0			m
DWQ	Effective channel width offset for CV	0			m
SAREF	Reference distance between OD edge to poly from one side	10^{-6}	10^{-9}		m
SBREF	Reference distance between OD edge to poly from other side	10^{-6}	10^{-9}		m
WLOD	Width parameter	0			m
KUO	Mobility degradation/enhancement coefficient	0			m
KVSAT	Saturation velocity degradation/enhancement parameter	0	-1	1	m
TKUO	Temperature coefficient of KUO	0			
LKUO	Length dependence of KUO	0			
WKUO	Width dependence of KUO	0			
PKUO	Cross-term dependence of KUO	0			
LLODKUO	Length parameter for mobility stress effect	0	0		
VFBO	Geometry-independent flat-band voltage at TR	0			V
VFBL	Length dependence of VFB	0			
VFBLEXP	Exponent describing length dependence of VFB	1			

Name	Description	Default	Min.	Max.	Unit
VFBW	Width dependence of VFB	0			
VFBLW	Area dependence of VFB	0			
STVFBO	Geometry-independent temperature dependence of VFB	5.10^{-4}			V/K
STVFBL	Length dependence of STVFB	0			
STVFBW	Width dependence of STVFB	0			
STVFBLW	Area dependence of STVFB	0			
TOXO	Gate oxide thickness	2.10^{-9}	10^{-10}		m
EPSROXO	Relative permittivity of gate dielectric	3.9	1		
TSIO	Silicon film thickness	10^{-8}	10^{-9}	10^{-7}	m
EPSRSIO	Relative permittivity of silicon film	11.8	11.8	16.5	
EGO	Band-gap of silicon film at 300K	1.179	0.6	1.2	V
STEG1O	First temperature coefficient of EG	$9{,}025.10^{-5}$			V/°C
STEG2O	Second temperature coefficient of EG	$3{,}05.10^{-7}$			V/°C^2
NIO	Intrinsic doping of silicon film at 300K	$1{,}45.10^{10}$	10^{10}	10^{14}	cm^{-3}
STNIO	Temperature dependence factor of NI	1.5	0.5	3	
TBOXO	Buried oxide thickness	10^{-7}	10^{-8}	10^{-6}	m
NSIO	Lightly silicon film doping, 0=intrinsic doping	0			cm^{-3}
NSUBO	Substrate doping, negative value=N-type, positive value=P-type	-3.10^{18}	10^{16}	10^{21}	cm^{-3}

Name	Description	Default	Min.	Max.	Unit
DVFBBO	Offset of back-gate flat-band voltage	0			V
CTO	Interface states factor	0	0		
TOXOVO	Overlap oxide thickness	2.10^{-9}	10^{-10}		m
LOV	Length of gate/drain and date/source overlaps	0	0		m
NOVO	Effective doping of overlap region, 0=No doping effect	0	10^{17}	10^{21}	cm^{-3}
QMC	Quantum correction factor	1	0		
CICO	Geometry-independent part of substrate bias dependence factor of interface coupling	1	0.1	10	
CICL	Length dependence of CIC	0			
CICLEXP	Exponent describing length dependence of CIC	1			
CICW	Width dependence of CIC	0			
CICLW	Area dependence of CIC	0			
PSCEL	Length dependence of short channel effect above threshold	0	0		
PSCELEXP	Exponent describing length dependence of PSCE	1			
PSCEW	Width dependence of PSCE	0	0		
CFL	Length dependence of DIBL-parameter	0	0		V^{-1}
CFLEXP	Exponent for length dependence of CF	2			
CFW	Width dependence of CF	0			

Name	Description	Default	Min.	Max.	Unit
CFBO	Substrate bias dependence of CF	0	0		
STCFO	Temperature dependence of CF	0			
UO	Zero-field mobility at TR	5.10^{-2}			$m^2/V/s$
BETNL	Second order length dependence of BETN	0			
BETNLEXP	Exponent for second order length dependence of BETN	1			
BETNW	Second order width dependence of BETN	0			
STBETO	Geometry-independent part of temperature dependence of BETN	1			
STBETL	Length dependence of STBET	0			
STBETW	Width dependence of STBET	0			
STBETLW	Area dependence of STBET	0			
MUEO	Mobility reduction coefficient at TR	0.5	0		m/V
STMUEO	Temperature dependence of MUE	0			
THEMUO	Mobility reduction exponent at TR	1.5	0		
STTHEMUO	Temperature dependence of THEMU	1.5			
CSO	Geometry-independent part of remote coulomb scattering parameter at TR	0			
CSL	Length dependence of CS	0			
CSLEXP	Exponent describing length dependence of CS	1			
CSW	Width dependence of CS	0			

Name	Description	Default	Min.	Max.	Unit
CSLW	Area dependence of CS	0			
CSBO	Back bias dependence of CS	0	0		
THECSO	Remote coulomb scattering exponent at TR3	1.5	0		
STCSO	Temperature dependence of CS	0			
STTHECSO	Temperature dependence of THECS	1.5			
XCORO	Geometry-independent part non-universality factor	0			V^{-1}
XCORL	Length dependence of XCOR	0			
XCORLEXP	Exponent describing length dependence of XCOR	1			
XCORW	Width dependence of XCOR	0			
XCORLW	Area dependence of XCOR	0			
STXCORO	Temperature dependence of XCOR	0			
FETAO	Effective field parameter	1	0		
RSW1	Source/Drain series resistance for channel width WEN at TR	30			Ohm
RSW2	Higher-order width scaling of source/drain series resistance	0			
RSGO	Gate-bias dependence of RS	0	-0.5		
THERSGO	Gate-bias dependence exponent of RS	2			
STRSO	Temperature dependence of RS	1			

Name	Description	Default	Min.	Max.	Unit
THESATO	Geometry-independent Velocity saturation parameter at TR	0	0		V^{-1}
THESATL	Length dependence of THESAT	0			
THESATLEXP	Exponent for length dependence of THESAT	1			
THESATW	Width dependence of THESAT	0			
THESATLW	Area dependence of THESAT	0			
THESATGO	Geometry-independent gate bias dependence of velocity saturation parameter at TR	0	0		V^{-1}
STTHESATO	Geometry-independent of temperature dependence of THESAT	1			
STTHESATL	Length dependence of STTHESAT	0			
STTHESATW	Width dependence of STTHESAT	0			
STTHESATLW	Area dependence of STTHESAT	0			
THESATBO	Substrate bias dependence of velocity saturation	0	-0.5	1	V^{-1}
AXO	Geometry-independent of linear/saturation transition factor	10			
AXL	Length dependence of AX	0	0		
AXLEXP	Exponent for length dependence of AX	1	0		
ALPL1	Length dependence of CLM pre-factor ALP	0	0		
ALPLEXP	Exponent for length dependence of ALP	1			
ALPL2	Second order length dependence of ALP	0			

Name	Description	Default	Min.	Max.	Unit
ALPW	Width dependence of ALP	0			
ALP1L1	Length dependence of CLM enhancement factor	0	0		V
ALP1LEXP	Exponent for length dependence of ALP1	1			
ALP1L2	Second order length dependence of ALP1	0			
ALP1W	Width dependence of ALP1	0			
VPO	CLM logarithm dependence factor	0.05	10^{-10}		V
GCOO	Gate tunneling energy adjustment	0	-10	10	
IGINVLW	Gate channel cu1.0rrent pre-factor for a channel area of WEN.LEN	0	0		A
IGOVINVW	Gate to overlap current pre-factor in inversion for an overlap of WEN.LOV	0	0		A
IGOVACCW	Gate to overlap current pre-factor in accumulation overlap of WEN.LOV	0	0		A
GC2CHO	Gate current slope factor for gate to channel current	0.375	0	10	
GC3CHO	Gate current curvature factor for gate to channel current	0.063	-2	2	
GC2OVO	Gate current slope factor for overlap currents	0.375	0	10	
GC3OVO	Gate current curvature factor for overlap currents	0.063	-2	2	
STIGO	Temperature dependence of all gate currents	2			
CHIBO	Tunneling barrier height	3.1	1		V
AGIDLW	Width dependence of GIDL pre-factor	0	0		A/V^3

Name	Description	Default	Min.	Max.	Unit
BGIDLO	GIDL probability factor at TR	41	0		V
STBGIDLO	Temperature dependence of BGIDL	0			V/K
CGIDLO	Substrate bias dependence of GIDL	0			
CGBOVL	Oxide capacitance for gate-substrate overlap	0	0		F
CFRW	Outer fringe capacitance	0	0		F
CSDBPO	Drain/source to substrate perimeter capacitance	0	0		F/m
RTHO	Geometry-independent part of substrate thermal resistance	1500	0		°C/W
RTHL	Length dependence of RTH	0			
RTHW	Width dependence of RTH	0			
RTHLW	Area dependence of RTH	0			
CTHO	Geometry-independent part of substrate thermal capacitance	5.10^{-10}	0		W.s/°C
STRTHO	Temperature dependence of substrate thermal resistance	0			
FNTO	Thermal noise coefficient	1	0		
NFALW	First coefficient of flicker noise	8.1022	0		V^{-1}/m^4
NFBLW	Second coefficient of flicker noise	3.107	0		V^{-1}/m^2
NFCLW	Third coefficient of flicker noise	0	0		V^{-1}
EFO	Frequency coefficient of flicker noise	1	0.1		

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName utsoi [param=value]
```

Example:model utsoimodel utsoi type=n

Instance Netlist Format

```
modelName [:Name] d g s b
```

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example: utsoimodel:M1 d g s b MULT=1

DC Operating Point

Name	Description	Unit
Ide	Total DC drain current	A
Ige	Total DC gate current	A
Ise	Total DC source current	A
Ibe	Total DC bulk current	A
Ids	DC Drain current, excluding avalanche, tunnel, GISL, GIDL, and junction currents	A
Idb	DC drain-bulk current	A
Isb	DC source-bulk current	A
Vds	Drain-Source DC voltage	V
Vsb	Source-Bulk DC voltage	V
Vgs	Gate-Source DC voltage	V
Gm	DC transconductance	S
Gmb	DC bulk transconductance	S

Name	Description	Unit
Gds	DC output conductance	S
Cdd	AC drain capacitance	F
Cdg	AC drain to gate capacitance	F
Cdb	AC drain to bulk capacitance	F
Cds	AC drain to source capacitance	F
Cgd	AC gate to drain capacitance	F
Cgg	AC gate capacitance	F
Cgb	AC gate to bulk capacitance	F
Cgs	AC gate to source capacitance	F
Cbd	AC bulk to drain capacitance	F
Cbg	AC bulk to gate capacitance	F
Cbb	AC bulk capacitance	F
Cbs	AC bulk to source capacitance	F
Csd	AC source to drain capacitance	F
Csg	AC source to gate capacitance	F
Csb	AC source to bulk capacitance	F
Css	AC source capacitance	F
Vth	Threshold voltage including back bias and drain bias effects	V
Vgt	Effective gate drive voltage including back bias and drain bias effects	V

Name	Description	Unit
Vdss	Drain saturation voltage at actual bias	V
Vsat_marg	Vds margin	V
Self_gain	Transistor self gain	
Rout	AC output resistor	Ohm
Beff	Gain factor	A/V^2
Fug	Unity gain frequency at actual bias	Hz
Rgate	MOS gate resistance (not includes in this version)	Ohm
Gmoverid	Gm over Id	1/V
Vearly	Equivalent early voltage	V

UTSOI 2

UTSOI 2.00 (Ultra Thin Fully Depleted SOI MOSFET Model)

Model Parameters

The following table lists the model parameters.

Name	Description	Default	Min.	Max.	Unit
SWSCALE	Flag for scaling rules, 0=local parameter set, 1=global parameter set	0			
VERSION	Flag for model version	2.00			
SWSUBDEP	Flag for backplane depletion effect	0			
SWIGATE	Flag for gate current, 0=turn off	0			
SWGIDL	Flag for gate induced source/drain leakage model, 0=turn off	0			
SWSHE	Flag for self heating effect, 0=turn off	0			
SWJUNASYM	Flag for source/drain junction asymmetry	0			
SWIGN	Flag for induced gate noise, 0=turn off	1	0	1	
QMC	Quantum confinement coefficient	1.0	0.0		
GENDER	Channel type: +1 = NMOS, -1 = PMOS	1			
TR	Reference temperature	21	-273		°C

Instance Parameters

Name	Description	Default	Min.	Max.	Unit
L	Drawn channel length	10^{-6}	10^{-9}		m
W	Drawn channel width	10^{-6}	10^{-9} x NF		m
SA	Distance between active edge and poly at source side	0	0		m
SB	Distance between active edge and poly at drain side	0	0		m
SD	Distance between neighboring fingers	0	0		m
ASOURCE	Source region area	10^{-12}	0		m^2
ADRAIN	Drain region area	10^{-12}	0		m^2
PSOURCE	Source region perimeter	10^{-6}	0		m
PDRAIN	Drain region perimeter	10^{-6}	0		m
NF	Number of fingers	1	1		
MULT	Number of device in parallel	1	1		
DELVTO	Threshold voltage shift parameter	0			V
FACTUO	Low field mobility pre-factor	1.0	0.0		

Scaling Parameters

Name	Description	Default	Min.	Max.	Unit
LVARO	Geometry-independent difference between physical and drawn gate lengths	0			m
LVARL	Length dependence of physical to drawn gate length difference	0			

Name	Description	Default	Min.	Max.	Unit
LVARW	Width dependence of physical to drawn gate length difference	0			
LAP	Effective channel length reduction per side	0			m
WVARO	Geometry-independent difference between physical and drawn field-oxide opening	0			m
WVARL	Length dependence of physical to drawn active width difference	0			
WVARW	Width dependence of physical to drawn active width difference	0			
WOT	Effective reduction of channel width per side	0			m
DLQ	Effective channel length offset for CV	0			m
DWQ	Effective channel width offset for CV	0			m

Stress Model Parameters

Name	Description	Default	Min.	Max.	Unit
SAREF	Reference distance between active edge to poly from one side	10^{-6}	10^{-9}		m
SBREF	Reference distance between active edge to poly from other side	10^{-6}	10^{-9}		m
WLOD	Width parameter	0			m
KUO	Mobility degradation/enhancement coefficient	0			m
KVSAT	Saturation velocity degradation/enhancement parameter	0	-1	1	m
TKUO	Temperature coefficient of KUO	0			
LKUO	Length dependence of KUO	0			

Name	Description	Default	Min.	Max.	Unit
WKUO	Width dependence of KUO	0			
PKUO	Cross-term dependence of KUO	0			
LLODKUO	Length parameter for mobility stress effect	0	0		
WLODKUO	Width parameter for mobility stress effect	0	0		
KVTHO	Threshold voltage shift parameter	0			
LKVTHO	Length dependence of KVTHO	0			
WKVTHO	Width dependence of KVTHO	0			
PKVTHO	Cross-term dependence of KVTHO	0			
LLODVTH	Length parameter for threshold voltage stress effect	0	0		
WLODVTH	Width parameter for threshold voltage stress effect	0	0		
STETAO	ETAO shift factor related to threshold voltage change	0			m
LODETAO	ETAO shift modification factor	1	0		

Local Level Parameters

Name	Description	Default	Min.	Max.	Unit
TOXE	Front gate equivalent oxide thickness (EOT)	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
TSI	Silicon or SiGe film thickness	10^{-8}	$3\ 10^{-9}$	$2\ 10^{-8}$	m
XGE	Fraction of germanium content in the channel	0.0	0.0	1.0	
TBOX	Back gate equivalent oxide thickness (EOT)	10^{-7}	$3\ 10^{-10}$	10^{-6}	m

Name	Description	Default	Min.	Max.	Unit
NSUB	Backplane doping level: positive = p-type, negative = n-type	$3\ 10^{18}$	10^{16}	10^{21}	cm^{-3}
CT	Interface states factor	0.0	0.0		
TOXP	Front gate physical oxide thickness	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
NOV	Effective doping level of overlap-LDD regions	10^{20}	10^{15}	10^{21}	cm^{-3}
NOVD	Effective doping level of overlap-LDD regions at drain side	10^{20}	10^{15}	10^{21}	cm^{-3}
VFB	Front gate workfunction referenced to Si midgap at TR	0.0			V
VFBB	Back gate workfunction offset at TR	0.0			V
STVFB	Temperature dependence of VFB and VFBB	0.0			V/K
CICF	Long channel front interface coupling coefficient	1.0	0.1	10.0	
CIC	Long channel back interface coupling coefficient	1.0	0.1	10.0	
PSCE	Short channel coupling attenuation parameter	0.0	-0.5	5.0	
PSCEB	Short channel back to front interface asymmetry factor	1.0	0.0		
CF	Drain Induced Barrier Lowering (DIBL) parameter at TR	0.0	0.0		
CFB	DIBL back to front interface asymmetry factor	1.0	0.0		
STCF	Temperature dependence of CF	0.0			K^{-1}
CFD	Drain voltage dependence parameter of DIBL	0.2	0.05		V
BETN	Front channel aspect ratio times low field mobility at TR	0.05	10^{-10}		m^2/Vs

Name	Description	Default	Min.	Max.	Unit
BETNB	Back channel over front channel low field mobility ratio	1.0	0.1	10.0	
STBET	Temperature dependence exponent of BETN	1.5			
CS	Coulomb scattering parameter at TR	0.0	0.0		
STCS	Temperature dependence exponent of CS	0			
THECS	Coulomb scattering exponent at TR	1.5	0		
STTHECS	Temperature dependence exponent of THECS	0			
CSTHR	Coulomb scattering threshold level	2	0.001		
MUE	High field mobility reduction coefficient at TR	0	0		cm/MV
STMUE	Temperature dependence exponent of MUE	0			
THEMU	High field mobility reduction exponent at TR	1.5	0		
STTHEMU	Temperature dependence exponent of THEMU	0			
XCOR	High field mobility non universality factor at TR	0			V^{-1}
STXCOR	Temperature dependence exponent of XCOR	0			
FETA	Transverse effective field parameter	1	0		
RS	Source/drain series resistance at TR	30	0		Ω
STRS	Temperature dependence exponent of RS	0			
RSG	Transverse electric field dependence of RS	0	-0.5		
THERSG	Transverse electric field exponent of RS	2			

Name	Description	Default	Min.	Max.	Unit
THESAT	Velocity saturation parameter at TR	0	0		V^{-1}
STTHESAT	Temperature dependence exponent of THESAT	-0.1			
THESATG	Front gate bias dependence of velocity saturation	0	-0.5		
THESATB	Back gate bias dependence of velocity saturation	0	-0.5		
AX	Linear/saturation transition exponent	8	1	12	
ALP	Channel length modulation pre-factor	0	0		
ALP1	Channel length modulation enhancement above threshold	0	0		V
VP	Channel length modulation logarithm dependence factor	0.05	10^{-10}		V
GCO	Gate tunnelling energy adjustment in inversion mode	0	-10	10	
IGINV	Gate to channel current pre-factor	0	0		A
IGOVINV	Gate–overlap current pre-factor in inversion	0	0		A
IGOVINVD	Gate–overlap current pre-factor in inversion at drain side	0	0		A
IGOVACC	Gate–overlap current pre-factor in accumulation	0	0		A
IGOVACCD	Gate–overlap current pre-factor in accumulation at drain side	0	0		A
STIG	Temperature dependence of all gate current pre-factors	0			
GC2CH	Gate to channel current slope factor	0.375	0	10	
GC3CH	Gate to channel current curvature factor	0.063	-2	2	

Name	Description	Default	Min.	Max.	Unit
GC2OV	Gate–overlap current slope factor	0.375	0	10	
GC3OV	Gate–overlap current curvature factor	0.063	-2	2	
CHIB	Tunneling barrier height	3.1	1		eV
AGIDL	GIDL/GISL current pre-factor	0	0		A/V^3
AGIDLD	GIDL current pre-factor at drain side	0	0		A/V^3
BGIDL	GIDL/GISL probability factor at TR	41	0		V
BGIDLD	GIDL probability factor at TR at drain side	41	0		V
STBGIDL	Temperature dependence of BGIDL	0			V/K
STBGIDLD	Temperature dependence of BGIDLD	0			V/K
CGIDL	Substrate bias dependence of GIDL/GISL	0			
CGIDLD	Substrate bias dependence of GIDL at drain side	0			
AREAQ	Effective channel area for intrinsic charge model	10_{-12}	10_{-18}		m^2
CGBOV	Oxide capacitance for gate to substrate overlap	0	0		F
COV	Overlap capacitance per side	0	0		F
COVD	Overlap capacitance at drain side	0	0		F
CFR	Outer fringe capacitance per side	0	0		F
CFRD	Outer fringe capacitance at drain side	0	0		F
CSD	Drain to source direct capacitance	0	0		F
CSDBP	Drain/source to substrate perimeter capacitance	0	0		F/m

Name	Description	Default	Min.	Max.	Unit
RTH	Thermal resistance	10^{4}	10_{-6}		K/W
STRTH	Temperature dependence of RTH	0.0			
CTH	Thermal capacitance	10_{-11}	0.0		J/K
FNT	Thermal noise coefficient	1.0	0.0		
NFA	First coefficient of flicker noise	$8\ 10^{22}$	0.0		$V_{-1}\ m_{-4}$
NFB	Second coefficient of flicker noise	$3\ 10^{7}$	0.0		$V_{-1}\ m_{-2}$
NFC	Third coefficient of flicker noise	0.0	0.0		V^{-1}
NFE	Front interface transverse field effect coefficient	0.0	-1.0	1.0	
NFEB	Back interface transverse field effect coefficient	0.0	-1.0	1.0	
EF	Frequency dependence exponent of flicker noise	1.0	0.1		

Global Level Parameters

Name	Description	Default	Min.	Max.	Unit
TOXEO	Geometry independent global scale parameter for TOXE	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
TSIO	Geometry independent global scale parameter for TSI	10^{-8}	$3\ 10^{-9}$	$2\ 10^{-8}$	m
TBOXO	Geometry independent global scale parameter for TBOX	10^{-7}	$3\ 10^{-10}$	10^{-6}	m
XGEO	Geometry independent global scale parameter for XGE	0.0	0.0	1.0	
NSUBO	Geometry independent global scale parameter for NSUB	$3\ 10^{18}$	10^{16}	10^{21}	cm^{-3}

Name	Description	Default	Min.	Max.	Unit
CTO	Geometry independent global scale parameter for CT	0.0	0.0		
TOXPO	Geometry independent global scale parameter for TOXP	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
NOVO	Geometry independent global scale parameter for NOV	10^{20}	10^{15}	10^{21}	cm^{-3}
NOVDO	Geometry independent global scale parameter for NOVD	10^{20}	10^{15}	10^{21}	cm^{-3}
VFBO	Long and wide channel value of VFB	0.0			V
VFBL	Channel length scaling parameter of VFB	0.0			V
VFBLEXP	Channel length scaling exponent of VFB	2.0			
VFBW	Channel width scaling parameter of VFB	0.0			V
VFBLW	Channel area scaling parameter of VFB	0.0			
VFBBO	Long and wide channel value of VFBB	0.0			V
VFBLBO	Back to front interface asymmetry factor applied to VFBL	1.0	0.0		
STVFBO	Long and wide channel value of STVFB	0.0			V/K
STVFBL	Channel length scaling parameter of STVFB	0.0			
STVFBW	Channel width scaling parameter of STVFB	0.0			
STVFBLW	Channel area scaling parameter of STVFB	0.0			
CICFO	Geometry independent global scale parameter for CICF	1.0	0.1	10.0	
CICO	Geometry independent global scale parameter for CIC	1.0	0.1	10.0	

Name	Description	Default	Min.	Max.	Unit
PSCEL	Channel length scaling parameter of PSCE	0.0			
PSCELEXP	Channel length scaling exponent of PSCE	2.0			
PSCEW	Channel width scaling parameter of PSCE	0.0			
PSCEBO	Geometry independent global scale parameter for PSCEB	1.0	0.0		
CFL	Channel length scaling parameter of CF	0. 0			
CFLEXP	Channel length scaling exponent of CF	2.0			
CFW	Channel width scaling parameter of CF	0.0			
CFBO	Geometry independent global scale parameter for CFB	1.0	0.0		
STCFO	Geometry independent global scale parameter for STCF	0.0			K^{-1}
CFDO	Geometry independent global scale parameter for CFD	0.2	0.05		V
UO	Front channel low field mobility at TR	0.05			m^2/Vs
BETNL	Second order channel length dependence of BETN	0.0			
BETNLEXP	Second order channel length exponent of BETN	1.0			
BETNW	Second order channel width dependence of BETN	0.0			
BETNBO	Geometry independent global scale parameter for BETNB	1.0	0.0		
STBETO	Long and wide channel value of STBET	1.5			
STBETL	Channel length scaling parameter of STBET	0.0			

Name	Description	Default	Min.	Max.	Unit
STBETW	Channel width scaling parameter of STBET	0.0			
STBETLW	Channel area scaling parameter of STBET	0.0			
CSO	Long and wide channel value of CS	0.0			
CSL	Channel length scaling parameter of CS	0.0			
CSLEXP	Geometry independent global scale parameter for CS	1.0			
CSW	Channel width scaling parameter of CS	0.0			
CSLW	Channel area scaling parameter of CS	0.0			
STCSO	Geometry independent global scale parameter for STCS	0			
THECSO	Geometry independent global scale parameter for THECS	1.5	0		
STTHECSO	Geometry independent global scale parameter for STTHECS	0			
CSTHRO	Geometry independent global scale parameter for CSTHR	2	0.001		
MUEO	Geometry independent global scale parameter for MUE	0	0		cm/MV
STMUEO	Geometry independent global scale parameter for STMUE	0			
THEMUO	Geometry independent global scale parameter for THEMU	1.5	0		
STTHEMUO	Geometry independent global scale parameter for STTHEMU	0			
XCORO	Long and wide channel value of XCOR	0			V^{-1}

Name	Description	Default	Min.	Max.	Unit
XCORL	Channel length scaling parameter of XCOR	0			
XCORLEXP	Channel length scaling exponent of XCOR	1			
XCORW	Channel width scaling parameter of XCOR	0			
XCORLW	Channel area scaling parameter of XCOR	0			
STXCORO	Geometry independent global scale parameter for STXCOR	0			
FETAO	Geometry independent global scale parameter for FETA	1	0		
RSW1	Source/drain series resistance for a WEN width at TR	30			Ω
RSW2	Second order width scaling parameter of RS	0			
STRSO	Geometry independent global scale parameter for STRS	0			
RSGO	Geometry independent global scale parameter for RSG	0	-0.5		
THERSGO	Geometry independent global scale parameter for THERSG	2			
THESATO	Long and wide channel parameter for THESAT	0	0		V^{-1}
THESATL	Channel length scaling parameter of THESAT	0			
THESATLEXP	Channel length scaling exponent of THESAT	1			
THESATW	Channel width scaling parameter of THESAT	0			
THESATLW	Channel area scaling parameter of THESAT	0			
STTHESATO	Long and wide channel value of STTHESAT	-0.1			

Name	Description	Default	Min.	Max.	Unit
STTHESATL	Channel length scaling parameter of STTHESAT	0			
STTHESATW	Channel width scaling parameter of STTHESAT	0			
STTHESATLW	Channel area scaling parameter of STTHESAT	0			
THESATGO	Geometry independent global scale parameter for THESATG	0	-0.5		
THESATBO	Geometry independent global scale parameter for THESATB	0	-0.5		
AXO	Long and wide channel value of AX	8			
AXL	Channel length scaling parameter of AX	0	0		
AXLEXP	Channel length scaling exponent of AX	1			
ALPL1	Channel length scaling parameter of ALP	0			
ALPLEXP	Channel length scaling exponent of ALP	1			
ALPL2	Second order channel length dependence of ALP	0	0		
ALPW	Channel width scaling parameter of ALP	0			
ALP1L1	Channel length scaling parameter of ALP1	0			
ALP1LEXP	Channel length scaling exponent of ALP1	0.5			
ALP1L2	Second order channel length dependence of ALP1	0	0		
ALP1W	Channel width scaling parameter of ALP1	0			
VPO	Geometry independent global scale parameter for VP	0.05	10^{-10}		V

Name	Description	Default	Min.	Max.	Unit
GCOO	Geometry independent global scale parameter for GCO	0	-10	10	
IGINVLW	IGINV value for a LEN.WEN area	0	0		A
IGOVINVW	IGOVINV value for a WEN width	0	0		A
IGOVINVDW	IGOVINVD for a WEN width	0	0		A
IGOVACCW	IGOVACC value for a WEN width	0	0		A
IGOVACCDW	IGOVACCD value for a WEN width	0	0		A
STIGO	Geometry independent global scale parameter for STIG	0			
GC2CHO	Geometry independent global scale parameter for GC2CH	0.375	0	10	
GC3CHO	Geometry independent global scale parameter for GC3CH	0.063	-2	2	
GC2OVO	Geometry independent global scale parameter for GC2OV	0.375	0	10	
GC3OVO	Geometry independent global scale parameter for GC3OV	0.063	-2	2	
CHIBO	Geometry independent global scale parameter for CHIB	3.1	1		eV
AGIDLW	AGIDL value for a WEN width	0	0		A/V^3
AGIDLDW	AGIDLD value for a WEN width	0	0		A/V^3
BGIDLO	Geometry independent global scale parameter for BGIDL	41	0		V
BGIDLDO	Geometry independent global scale parameter for BGIDLD	41	0		V

Name	Description	Default	Min.	Max.	Unit
STBGIDLO	Geometry independent global scale parameter for STBGIDL	0			V/K
STBGIDLDO	Geometry independent global scale parameter for STBGIDLD	0			V/K
CGIDLO	Geometry independent global scale parameter for CGIDL	0			
CGIDLDO	Geometry independent global scale parameter for CGIDLD	0			
CGBOVL	CGBOV value for a LEN length	0	0		F
LOVO	Overlap length for gate/source-drain overlap capacitance	0	0		m
LOVDO	Overlap length for gate/drain overlap capacitance	0	0		m
CFRO	Corner related outer fringe capacitance	0			F
CFRW	Outer fringe capacitance per side for a WEN width	0			F
CFRDO	Corner related outer fringe capacitance at drain side	0			F
CFRDW	Outer fringe capacitance at drain side for a WEN width	0			F
CSDO	Drain to source direct capacitance correction factor	1	0		
CSDBPO	Geometry independent global scale parameter for CSDBP	0	0		F/m
RTHO	Geometry independent global scale parameter for RTH	10^5			K/W
RTHL	Channel length scaling parameter of RTH and CTH	0.0			

Name	Description	Default	Min.	Max.	Unit
RTHW	Channel width scaling parameter of RTH and CTH	0.0			
RTHLW	Channel area scaling parameter of RTH and CTH	9.0			
STRTHO	Geometry independent global scale parameter for STRTH	0.0			
CTHO	Geometry independent global scale parameter for CTH	10_{-12}			J/K
FNTO	Geometry independent global scale parameter for FNT	1.0	0.0		
NFALW	NFA value for a LEN.WEN area	$8\ 10^{22}$	0.0		$V_{-1}\ m_{-4}$
NFBLW	NFB value for a LEN.WEN area	$3\ 10^{7}$	0.0		$V_{-1}\ m_{-2}$
NFCLW	NFC value for a LEN.WEN area	0.0	0.0		V^{-1}
NFEO	Geometry independent global scale parameter for NFE	0.0	-1.0	1.0	
NFEBO	Geometry independent global scale parameter for NFEB	0.0	-1.0	1.0	
EFO	Geometry independent global scale parameter for EF	1.0	0.1		

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName utsoi2 [param=value]
```

Example:model utsoi2model utsoi2 GENDER=1

Instance Netlist Format

```
modelName [:Name] d g s b
```

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example: utsoi2model:M1 d g s b MULT=1

UTSOI 2.1

UTSOI 2.1 (Ultra Thin Fully Depleted SOI MOSFET Model)

Model Parameters

The following table lists the model parameters.

Name	Description	Default	Min.	Max.	Unit
SWSCALE	Flag for scaling rules, 0=local parameter set, 1=global parameter set	0			
VERSION	Flag for model version	2.1			
SWCLIPCHK	Flag for warnings about parameter clipping	0			
SWSUBDEP	Flag for backplane depletion effect	0			
SWIGATE	Flag for gate current, 0=turn off	0			
SWGIDL	Flag for gate induced source/drain leakage model, 0=turn off	0			
SWSHE	Flag for self heating effect, 0=turn off	0			
SWJUNASYM	Flag for source/drain junction asymmetry	0			
SWIGN	Flag for induced gate noise, 0=turn off	1	0	1	
QMC	Quantum confinement coefficient	1.0	0.0		
GENDER	Channel type: +1 = NMOS, -1 = PMOS	1			
TR	Reference temperature	21	-273		°C

Instance Parameters

Name	Description	Default	Min.	Max.	Unit
L	Drawn channel length	10^{-6}	10^{-9}		m
W	Drawn channel width	10^{-6}	10^{-9} x NF		m
SA	Distance between active edge and poly at source side	0	0		m
SB	Distance between active edge and poly at drain side	0	0		m
SD	Distance between neighboring fingers	0	0		m
ASOURCE	Source region area	10^{-12}	0		m^2
ADRAIN	Drain region area	10^{-12}	0		m^2
PSOURCE	Source region perimeter	10^{-6}	0		m
PDRAIN	Drain region perimeter	10^{-6}	0		m
NF	Number of fingers	1	1		
MULT	Number of device in parallel	1	1		
DELVTO	Threshold voltage shift parameter	0			V
FACTUO	Low field mobility pre-factor	1.0	0.0		

Scaling Parameters

Name	Description	Default	Min.	Max.	Unit
LVARO	Geometry-independent difference between physical and drawn gate lengths	0			m
LVARL	Length dependence of physical to drawn gate length difference	0			

Name	Description	Default	Min.	Max.	Unit
LVARW	Width dependence of physical to drawn gate length difference	0			
LAP	Effective channel length reduction per side	0			m
WVARO	Geometry-independent difference between physical and drawn field-oxide opening	0			m
WVARL	Length dependence of physical to drawn active width difference	0			
WVARW	Width dependence of physical to drawn active width difference	0			
WOT	Effective reduction of channel width per side	0			m
DLQ	Effective channel length offset for CV	0			m
DWQ	Effective channel width offset for CV	0			m

Stress Model Parameters

Name	Description	Default	Min.	Max.	Unit
SAREF	Reference distance between active edge to poly from one side	10^{-6}	10^{-9}		m
SBREF	Reference distance between active edge to poly from other side	10^{-6}	10^{-9}		m
WLOD	Width parameter	0			m
KUO	Mobility degradation/enhancement coefficient	0			m
KVSAT	Saturation velocity degradation/enhancement parameter	0	-1	1	m
TKUO	Temperature coefficient of KUO	0			
LKUO	Length dependence of KUO	0			

Name	Description	Default	Min.	Max.	Unit
WKUO	Width dependence of KUO	0			
PKUO	Cross-term dependence of KUO	0			
LLODKUO	Length parameter for mobility stress effect	0	0		
WLODKUO	Width parameter for mobility stress effect	0	0		
KVTHO	Threshold voltage shift parameter	0			
LKVTHO	Length dependence of KVTHO	0			
WKVTHO	Width dependence of KVTHO	0			
PKVTHO	Cross-term dependence of KVTHO	0			
LLODVTH	Length parameter for threshold voltage stress effect	0	0		
WLODVTH	Width parameter for threshold voltage stress effect	0	0		
STETAO	ETAO shift factor related to threshold voltage change	0			m
LODETAO	ETAO shift modification factor	1	0		

Local Level Parameters

Name	Description	Default	Min.	Max.	Unit
TOXE	Front gate equivalent oxide thickness (EOT)	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
TSI	Silicon or SiGe film thickness	10^{-8}	$3\ 10^{-9}$	$2\ 10^{-8}$	m
XGE	Fraction of germanium content in the channel	0.0	0.0	1.0	
TBOX	Back gate equivalent oxide thickness (EOT)	10^{-7}	$3\ 10^{-10}$	10^{-6}	m

Name	Description	Default	Min.	Max.	Unit
NSUB	Backplane doping level: positive = p-type, negative = n-type	$3\ 10^{18}$	10^{16}	10^{21}	cm^{-3}
CT	Interface states factor	0.0	0.0		
TOXP	Front gate physical oxide thickness	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
NOV	Effective doping level of overlap-LDD regions	10^{20}	10^{15}	10^{21}	cm^{-3}
NOVD	Effective doping level of overlap-LDD regions at drain side	10^{20}	10^{15}	10^{21}	cm^{-3}
VFB	Front gate workfunction referenced to Si midgap at TR	0.0			V
VFBB	Back gate workfunction offset at TR	0.0			V
STVFB	Temperature dependence of VFB and VFBB	0.0			V/K
CICF	Long channel front interface coupling coefficient	1.0	0.1	10.0	
CIC	Long channel back interface coupling coefficient	1.0	0.1	10.0	
PSCE	Short channel coupling attenuation parameter	0.0	-0.5	5.0	
PSCEB	Short channel back to front interface asymmetry factor	1.0	0.0		
PSCEDL	Short channel modulation due to Leff dependence on biases	0	0		
PNCE	Narrow channel effect on body factor	0	-1	1	
CF	Drain Induced Barrier Lowering (DIBL) parameter at TR	0.0	0.0		
CFB	DIBL back to front interface asymmetry factor	1.0	0.0		
STCF	Temperature dependence of CF	0.0			K^{-1}

Name	Description	Default	Min.	Max.	Unit
CFD	Drain voltage dependence parameter of DIBL	0.2	0.05		V
CFDL	DIBL modulation due to Leff dependence on biases	0			
BETN	Front channel aspect ratio times low field mobility at TR	0.05	10^{-10}		m^2/Vs
BETNB	Back channel over front channel low field mobility ratio	1.0	0.1	10.0	
STBET	Temperature dependence exponent of BETN	1.5			
CS	Coulomb scattering parameter at TR	0.0	0.0		
STCS	Temperature dependence exponent of CS	0			
THECS	Coulomb scattering exponent at TR	1.5	0		
STTHECS	Temperature dependence exponent of THECS	0			
CSTHR	Coulomb scattering threshold level	2	0.001		
MUE	High field mobility reduction coefficient at TR	0	0		cm/MV
STMUE	Temperature dependence exponent of MUE	0			
THEMU	High field mobility reduction exponent at TR	1.5	0		
STTHEMU	Temperature dependence exponent of THEMU	0			
XCOR	High field mobility non universality factor at TR	0			V^{-1}
STXCOR	Temperature dependence exponent of XCOR	0			
FETA	Transverse effective field parameter	1	0		
RS	Source/drain series resistance at TR	30	0		Ω

Name	Description	Default	Min.	Max.	Unit
STRS	Temperature dependence exponent of RS	0			
RSG	Transverse electric field dependence of RS	0	-0.5		
THERSG	Transverse electric field exponent of RS	2			
THESAT	Velocity saturation parameter at TR	0	0		V^{-1}
STTHESAT	Temperature dependence exponent of THESAT	-0.1			
THESATG	Front gate bias dependence of velocity saturation	0	-0.5		
THESATB	Back gate bias dependence of velocity saturation	0	-0.5		
AX	Linear/saturation transition exponent	8	1	12	
ALP	Channel length modulation pre-factor	0	0		
ALP1	Channel length modulation enhancement above threshold	0	0		V
VP	Channel length modulation logarithm dependence factor	0.05	10^{-10}		V
GCO	Gate tunnelling energy adjustment in inversion mode	0	-10	10	
IGINV	Gate to channel current pre-factor	0	0		A
IGOVINV	Gate–overlap current pre-factor in inversion	0	0		A
IGOVINVD	Gate–overlap current pre-factor in inversion at drain side	0	0		A
IGOVACC	Gate–overlap current pre-factor in accumulation	0	0		A
IGOVACCD	Gate–overlap current pre-factor in accumulation at drain side	0	0		A

Name	Description	Default	Min.	Max.	Unit
STIG	Temperature dependence of all gate current pre-factors	0			
GC2CH	Gate to channel current slope factor	0.375	0	10	
GC3CH	Gate to channel current curvature factor	0.063	-2	2	
GC2OVINV	Gate–overlap current slope factor in inversion	0.375	0	10	
GC3OVINV	Gate–overlap current curvature factor in inversion	0.063	-2	2	
GC2OVACC	Gate-overlap current slope factor in accumulation	0.375	0	10	
GS3OVACC	Gate-overlap current curvature factor in accumulation	0.063	-2	2	
CHIB	Tunneling barrier height	3.1	1		eV
NIGINV	Gate tunneling slope adjustment in subthreshold regime	0	0		
AGIDL	GIDL/GISL current pre-factor	0	0		A/V^3
AGIDLD	GIDL current pre-factor at drain side	0	0		A/V^3
BGIDL	GIDL/GISL probability factor at TR	41	0		V
BGIDLD	GIDL probability factor at TR at drain side	41	0		V
STBGIDL	Temperature dependence of BGIDL	0			V/K
STBGIDLD	Temperature dependence of BGIDLD	0			V/K
CGIDL	Substrate bias dependence of GIDL/GISL	0			
CGIDLD	Substrate bias dependence of GIDL at drain side	0			
AREAQ	Effective channel area for intrinsic charge model	10_{-12}	10_{-18}		m^2

Name	Description	Default	Min.	Max.	Unit
CGBOV	Oxide capacitance for gate to substrate overlap	0	0		F
COV	Overlap capacitance per side	0	0		F
COVD	Overlap capacitance at drain side	0	0		F
COVDL	Overlap capacitance modulation due to Leff bias-dependence	0	0		
CFR	Outer fringe capacitance per side	0	0		F
CFRD	Outer fringe capacitance at drain side	0	0		F
CSD	Drain to source direct capacitance	0	0		F
CSDBP	Drain/source to substrate perimeter capacitance	0	0		F/m
RTH	Thermal resistance	10^{4}	10_{-6}		K/W
STRTH	Temperature dependence of RTH	0.0			
CTH	Thermal capacitance	10_{-11}	0.0		J/K
FNT	Thermal noise coefficient	1.0	0.0		
NFA	First coefficient of flicker noise	$8\ 10^{22}$	0.0		$V_{-1}\ m_{-4}$
NFB	Second coefficient of flicker noise	$3\ 10^{7}$	0.0		$V_{-1}\ m_{-2}$
NFC	Third coefficient of flicker noise	0.0	0.0		V^{-1}
NFE	Front interface transverse field effect coefficient	0.0	-1.0	1.0	
NFEB	Back interface transverse field effect coefficient	0.0	-1.0	1.0	
EF	Frequency dependence exponent of flicker noise	1.0	0.1		

Global Level Parameters

Name	Description	Default	Min.	Max.	Unit
TOXEO	Geometry independent global scale parameter for TOXE	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
TSIO	Geometry independent global scale parameter for TSI	10^{-8}	$3\ 10^{-9}$	$2\ 10^{-8}$	m
TBOXO	Geometry independent global scale parameter for TBOX	10^{-7}	$3\ 10^{-10}$	10^{-6}	m
XGEO	Geometry independent global scale parameter for XGE	0.0	0.0	1.0	
NSUBO	Geometry independent global scale parameter for NSUB	$3\ 10^{18}$	10^{16}	10^{21}	cm^{-3}
CTO	Geometry independent global scale parameter for CT	0.0	0.0		
TOXPO	Geometry independent global scale parameter for TOXP	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
NOVO	Geometry independent global scale parameter for NOV	10^{20}	10^{15}	10^{21}	cm^{-3}
NOVDO	Geometry independent global scale parameter for NOVD	10^{20}	10^{15}	10^{21}	cm^{-3}
VFBO	Long and wide channel value of VFB	0.0			V
VFBL	Channel length scaling parameter of VFB	0.0			V
VFBLEXP	Channel length scaling exponent of VFB	2.0			
VFBW	Channel width scaling parameter of VFB	0.0			V
VFBLW	Channel area scaling parameter of VFB	0.0			
VFBBO	Long and wide channel value of VFBB	0.0			V

Name	Description	Default	Min.	Max.	Unit
VFBLBO	Back to front interface asymmetry factor applied to VFBL	1.0	0.0		
STVFBO	Long and wide channel value of STVFB	0.0			V/K
STVFBL	Channel length scaling parameter of STVFB	0.0			
STVFBW	Channel width scaling parameter of STVFB	0.0			
STVFBLW	Channel area scaling parameter of STVFB	0.0			
CICFO	Geometry independent global scale parameter for CICF	1.0	0.1	10.0	
CICO	Geometry independent global scale parameter for CIC	1.0	0.1	10.0	
PSCEL	Channel length scaling parameter of PSCE	0.0			
PSCELEXP	Channel length scaling exponent of PSCE	2.0			
PSCEW	Channel width scaling parameter of PSCE	0.0			
PSCEBO	Geometry independent global scale parameter for PSCEB	1.0	0.0		
PSCEDLL	Channel length scaling parameter of PSCEDL	0			
PSCEDLW	Channel width scaling parameter of PSCEDL	0			
PNCEW	Channel width scaling parameter of PNCE	0			
CFL	Channel length scaling parameter of CF	0. 0			
CFLEXP	Channel length scaling exponent of CF	2.0			
CFW	Channel width scaling parameter of CF	0.0			
CFBO	Geometry independent global scale parameter for CFB	1.0	0.0		

Name	Description	Default	Min.	Max.	Unit
STCFO	Geometry independent global scale parameter for STCF	0.0			K^{-1}
CFDO	Geometry independent global scale parameter for CFD	0.2	0.05		V
CFDLL	Channel length scaling parameter of CFDL	0			
CFDLW	Channel length scaling parameter of CFDL	0			
UO	Front channel low field mobility at TR	0.05			m^2/Vs
BETNL	Second order channel length dependence of BETN	0.0			
BETNLEXP	Second order channel length exponent of BETN	1.0			
BETNW	Second order channel width dependence of BETN	0.0			
BETNBO	Geometry independent global scale parameter for BETNB	1.0	0.0		
STBETO	Long and wide channel value of STBET	1.5			
STBETL	Channel length scaling parameter of STBET	0.0			
STBETW	Channel width scaling parameter of STBET	0.0			
STBETLW	Channel area scaling parameter of STBET	0.0			
CSO	Long and wide channel value of CS	0.0			
CSL	Channel length scaling parameter of CS	0.0			
CSLEXP	Geometry independent global scale parameter for CS	1.0			
CSW	Channel width scaling parameter of CS	0.0			
CSLW	Channel area scaling parameter of CS	0.0			

Name	Description	Default	Min.	Max.	Unit
STCSO	Geometry independent global scale parameter for STCS	0			
THECSO	Geometry independent global scale parameter for THECS	1.5	0		
STTHECSO	Geometry independent global scale parameter for STTHECS	0			
CSTHRO	Geometry independent global scale parameter for CSTHR	2	0.001		
MUEO	Geometry independent global scale parameter for MUE	0	0		cm/MV
STMUEO	Geometry independent global scale parameter for STMUE	0			
THEMUO	Geometry independent global scale parameter for THEMU	1.5	0		
STTHEMUO	Geometry independent global scale parameter for STTHEMU	0			
XCORO	Long and wide channel value of XCOR	0			V^{-1}
XCORL	Channel length scaling parameter of XCOR	0			
XCORLEXP	Channel length scaling exponent of XCOR	1			
XCORW	Channel width scaling parameter of XCOR	0			
XCORLW	Channel area scaling parameter of XCOR	0			
STXCORO	Geometry independent global scale parameter for STXCOR	0			
FETAO	Geometry independent global scale parameter for FETA	1	0		

Name	Description	Default	Min.	Max.	Unit
RSW1	Source/drain series resistance for a WEN width at TR	30			Ω
RSW2	Second order width scaling parameter of RS	0			
STRSO	Geometry independent global scale parameter for STRS	0			
RSGO	Geometry independent global scale parameter for RSG	0	-0.5		
THERSGO	Geometry independent global scale parameter for THERSG	2			
THESATO	Long and wide channel parameter for THESAT	0	0		V^{-1}
THESATL	Channel length scaling parameter of THESAT	0			
THESATLEXP	Channel length scaling exponent of THESAT	1			
THESATW	Channel width scaling parameter of THESAT	0			
THESATLW	Channel area scaling parameter of THESAT	0			
STTHESATO	Long and wide channel value of STTHESAT	-0.1			
STTHESATL	Channel length scaling parameter of STTHESAT	0			
STTHESATW	Channel width scaling parameter of STTHESAT	0			
STTHESATLW	Channel area scaling parameter of STTHESAT	0			
THESATGO	Geometry independent global scale parameter for THESATG	0	-0.5		
THESATBO	Geometry independent global scale parameter for THESATB	0	-0.5		
AXO	Long and wide channel value of AX	8			

Name	Description	Default	Min.	Max.	Unit
AXL	Channel length scaling parameter of AX	0	0		
AXLEXP	Channel length scaling exponent of AX	1			
ALPL1	Channel length scaling parameter of ALP	0			
ALPLEXP	Channel length scaling exponent of ALP	1			
ALPL2	Second order channel length dependence of ALP	0	0		
ALPW	Channel width scaling parameter of ALP	0			
ALP1L1	Channel length scaling parameter of ALP1	0			
ALP1LEXP	Channel length scaling exponent of ALP1	0.5			
ALP1L2	Second order channel length dependence of ALP1	0	0		
ALP1W	Channel width scaling parameter of ALP1	0			
VPO	Geometry independent global scale parameter for VP	0.05	10^{-10}		V
GCOO	Geometry independent global scale parameter for GCO	0	-10	10	
IGINVLW	IGINV value for a LEN.WEN area	0	0		A
IGOVINVW	IGOVINV value for a WEN width	0	0		A
IGOVINVDW	IGOVINVD for a WEN width	0	0		A
IGOVACCW	IGOVACC value for a WEN width	0	0		A
IGOVACCDW	IGOVACCD value for a WEN width	0	0		A
STIGO	Geometry independent global scale parameter for STIG	0			

Name	Description	Default	Min.	Max.	Unit
GC2CHO	Geometry independent global scale parameter for GC2CH	0.375	0	10	
GC3CHO	Geometry independent global scale parameter for GC3CH	0.063	-2	2	
GC2OVINVO	Geometry independent global scale parameter for GC2OVINV	0.375	0	10	
GC3OVINVO	Geometry independent global scale parameter for GC3OVINV	0.063	-2	2	
GC2OVACCO	Geometry independent global scale parameter for GC2OVACC	0.375	0	10	
GC3OVACCO	Geometry independent global scale parameter for GC3OVACC	0.063	-2	2	
CHIBO	Geometry independent global scale parameter for CHIB	3.1	1		eV
NIGINVO	Geometry independent global scale parameter for NIGINV	0	0		
AGIDLW	AGIDL value for a WEN width	0	0		A/V^3
AGIDLDW	AGIDLD value for a WEN width	0	0		A/V^3
BGIDLO	Geometry independent global scale parameter for BGIDL	41	0		V
BGIDLDO	Geometry independent global scale parameter for BGIDLD	41	0		V
STBGIDLO	Geometry independent global scale parameter for STBGIDL	0			V/K
STBGIDLDO	Geometry independent global scale parameter for STBGIDLD	0			V/K
CGIDLO	Geometry independent global scale parameter for CGIDL	0			

Name	Description	Default	Min.	Max.	Unit
CGIDLDO	Geometry independent global scale parameter for CGIDLD	0			
CGBOVL	CGBOV value for a LEN length	0	0		F
LOVO	Overlap length for gate/source-drain overlap capacitance	0	0		m
LOVDO	Overlap length for gate/drain overlap capacitance	0	0		m
COVDLO	Wide channel parameter for COVDL	0			
COVDLW	Channel width scaling parameter of COVDL	0			
CFRO	Corner related outer fringe capacitance	0			F
CFRW	Outer fringe capacitance per side for a WEN width	0			F
CFRDO	Corner related outer fringe capacitance at drain side	0			F
CFRDW	Outer fringe capacitance at drain side for a WEN width	0			F
CSDO	Drain to source direct capacitance correction factor	1	0		
CSDBPO	Geometry independent global scale parameter for CSDBP	0	0		F/m
RTHO	Geometry independent global scale parameter for RTH	10^5			K/W
RTHL	Channel length scaling parameter of RTH and CTH	0.0			
RTHW	Channel width scaling parameter of RTH and CTH	0.0			
RTHLW	Channel area scaling parameter of RTH and CTH	9.0			

Name	Description	Default	Min.	Max.	Unit
STRTHO	Geometry independent global scale parameter for STRTH	0.0			
CTHO	Geometry independent global scale parameter for CTH	10_{-12}			J/K
FNTO	Geometry independent global scale parameter for FNT	1.0	0.0		
NFALW	NFA value for a LEN.WEN area	$8\ 10^{22}$	0.0		$V_{-1}\ m_{-4}$
NFBLW	NFB value for a LEN.WEN area	$3\ 10^{7}$	0.0		$V_{-1}\ m_{-2}$
NFCLW	NFC value for a LEN.WEN area	0.0	0.0		V^{-1}
NFEO	Geometry independent global scale parameter for NFE	0.0	-1.0	1.0	
NFEBO	Geometry independent global scale parameter for NFEB	0.0	-1.0	1.0	
EFO	Geometry independent global scale parameter for EF	1.0	0.1		

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName utsoi21 [param=value]
```

Example:model utsoi2model utsoi21 GENDER=1

Instance Netlist Format

```
modelName [:Name] d g s b
```

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example: utsoi2model:M1 d g s b MULT=1

UTSOI 2.11

UTSOI 2.11 (Ultra Thin Fully Depleted SOI MOSFET Model)

Version 2.11 is based on version 2.10 with the following changes:

- The parameter TMAX was added to limit the self-heating temperature
- The parameter DVFBOV was added to model the flat-band voltage change from overlap capacitance
- Additional parameters are now clipped (TOX1, TOX2, PSCE1, PSCEDL, PNCE, CF1, CF2, CFDL, AX, CG20VINV, GC30VINV, GC20VACC, GC30VACC, NIGINV)

Model Parameters

The following table lists the model parameters.

Name	Description	Default	Min.	Max.	Unit
SWSCALE	Flag for scaling rules, 0=local parameter set, 1=global parameter set	0			
VERSION	Flag for model version	2.11			
SWCLIPCHK	Flag for warnings about parameter clipping	0			
SWSUBDEP	Flag for backplane depletion effect	0			
SWIGATE	Flag for gate current, 0=turn off	0			
SWGIDL	Flag for gate induced source/drain leakage model, 0=turn off	0			
SWSHE	Flag for self heating effect, 0=turn off	0			
SWJUNASYM	Flag for source/drain junction asymmetry	0			
SWIGN	Flag for induced gate noise, 0=turn off	1	0	1	
QMC	Quantum confinement coefficient	1.0	0.0		
GENDER	Channel type: +1 = NMOS, -1 = PMOS	1			

Name	Description	Default	Min.	Max.	Unit
TR	Reference temperature	21	-273		°C
TMAX	Maximum self-heating temperature elevation	150	0		°C

Instance Parameters

Name	Description	Default	Min.	Max.	Unit
L	Drawn channel length	10^{-6}	10^{-9}		m
W	Drawn channel width	10^{-6}	10^{-9} x NF		m
SA	Distance between active edge and poly at source side	0	0		m
SB	Distance between active edge and poly at drain side	0	0		m
SD	Distance between neighboring fingers	0	0		m
ASOURCE	Source region area	10^{-12}	0		m^2
ADRAIN	Drain region area	10^{-12}	0		m^2
PSOURCE	Source region perimeter	10^{-6}	0		m
PDRAIN	Drain region perimeter	10^{-6}	0		m
NF	Number of fingers	1	1		
MULT	Number of device in parallel	1	1		
DELVTO	Threshold voltage shift parameter	0			V
FACTUO	Low field mobility pre-factor	1.0	0.0		

Scaling Parameters

Name	Description	Default	Min.	Max.	Unit
LVARO	Geometry-independent difference between physical and drawn gate lengths	0			m
LVARL	Length dependence of physical to drawn gate length difference	0			
LVARW	Width dependence of physical to drawn gate length difference	0			
LAP	Effective channel length reduction per side	0			m
WVARO	Geometry-independent difference between physical and drawn field-oxide opening	0			m
WVARL	Length dependence of physical to drawn active width difference	0			
WVARW	Width dependence of physical to drawn active width difference	0			
WOT	Effective reduction of channel width per side	0			m
DLQ	Effective channel length offset for CV	0			m
DWQ	Effective channel width offset for CV	0			m

Stress Model Parameters

Name	Description	Default	Min.	Max.	Unit
SAREF	Reference distance between active edge to poly from one side	10^{-6}	10^{-9}		m
SBREF	Reference distance between active edge to poly from other side	10^{-6}	10^{-9}		m
WLOD	Width parameter	0			m
KUO	Mobility degradation/enhancement coefficient	0			m

Name	Description	Default	Min.	Max.	Unit
KVSAT	Saturation velocity degradation/enhancement parameter	0	-1	1	m
TKUO	Temperature coefficient of KUO	0			
LKUO	Length dependence of KUO	0			
WKUO	Width dependence of KUO	0			
PKUO	Cross-term dependence of KUO	0			
LLODKUO	Length parameter for mobility stress effect	0	0		
WLODKUO	Width parameter for mobility stress effect	0	0		
KVTHO	Threshold voltage shift parameter	0			
LKVTHO	Length dependence of KVTHO	0			
WKVTHO	Width dependence of KVTHO	0			
PKVTHO	Cross-term dependence of KVTHO	0			
LLODVTH	Length parameter for threshold voltage stress effect	0	0		
WLODVTH	Width parameter for threshold voltage stress effect	0	0		
STETAO	ETAO shift factor related to threshold voltage change	0			m
LODETAO	ETAO shift modification factor	1	0		

Local Level Parameters

Name	Description	Default	Min.	Max.	Unit
TOXE	Front gate equivalent oxide thickness (EOT)	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m

Name	Description	Default	Min.	Max.	Unit
TSI	Silicon or SiGe film thickness	10^{-8}	$3\ 10^{-9}$	$2\ 10^{-8}$	m
XGE	Fraction of germanium content in the channel	0.0	0.0	1.0	
TBOX	Back gate equivalent oxide thickness (EOT)	10^{-7}	$3\ 10^{-10}$	10^{-6}	m
NSUB	Backplane doping level: positive = p-type, negative = n-type	$3\ 10^{18}$	10^{16}	10^{21}	cm^{-3}
CT	Interface states factor	0.0	0.0		
TOXP	Front gate physical oxide thickness	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
NOV	Effective doping level of overlap-LDD regions	10^{20}	10^{15}	10^{21}	cm^{-3}
NOVD	Effective doping level of overlap-LDD regions at drain side	10^{20}	10^{15}	10^{21}	cm^{-3}
VFB	Front gate workfunction referenced to Si midgap at TR	0.0			V
VFBB	Back gate workfunction offset at TR	0.0			V
STVFB	Temperature dependence of VFB and VFBB	0.0			V/K
CICF	Long channel front interface coupling coefficient	1.0	0.1	10.0	
CIC	Long channel back interface coupling coefficient	1.0	0.1	10.0	
PSCE	Short channel coupling attenuation parameter	0.0	-0.5	5.0	
PSCEB	Short channel back to front interface asymmetry factor	1.0	0.0		
PSCEDL	Short channel modulation due to Leff dependence on biases	0	0		
PNCE	Narrow channel effect on body factor	0	-1	1	

Name	Description	Default	Min.	Max.	Unit
CF	Drain Induced Barrier Lowering (DIBL) parameter at TR	0.0	0.0		
CFB	DIBL back to front interface asymmetry factor	1.0	0.0		
STCF	Temperature dependence of CF	0.0			K^{-1}
CFD	Drain voltage dependence parameter of DIBL	0.2	0.05		V
CFDL	DIBL modulation due to Leff dependence on biases	0			
BETN	Front channel aspect ratio times low field mobility at TR	0.05	10^{-10}		m^2/Vs
BETNB	Back channel over front channel low field mobility ratio	1.0	0.1	10.0	
STBET	Temperature dependence exponent of BETN	1.5			
CS	Coulomb scattering parameter at TR	0.0	0.0		
STCS	Temperature dependence exponent of CS	0			
THECS	Coulomb scattering exponent at TR	1.5	0		
STTHECS	Temperature dependence exponent of THECS	0			
CSTHR	Coulomb scattering threshold level	2	0.001		
MUE	High field mobility reduction coefficient at TR	0	0		cm/MV
STMUE	Temperature dependence exponent of MUE	0			
THEMU	High field mobility reduction exponent at TR	1.5	0		
STTHEMU	Temperature dependence exponent of THEMU	0			
XCOR	High field mobility non universality factor at TR	0			V^{-1}

Name	Description	Default	Min.	Max.	Unit
STXCOR	Temperature dependence exponent of XCOR	0			
FETA	Transverse effective field parameter	1	0		
RS	Source/drain series resistance at TR	30	0		Ω
STRS	Temperature dependence exponent of RS	0			
RSG	Transverse electric field dependence of RS	0	-0.5		
THERSG	Transverse electric field exponent of RS	2			
THESAT	Velocity saturation parameter at TR	0	0		V^{-1}
STTHESAT	Temperature dependence exponent of THESAT	-0.1			
THESATG	Front gate bias dependence of velocity saturation	0	-0.5		
THESATB	Back gate bias dependence of velocity saturation	0	-0.5		
AX	Linear/saturation transition exponent	8	1	12	
ALP	Channel length modulation pre-factor	0	0		
ALP1	Channel length modulation enhancement above threshold	0	0		V
VP	Channel length modulation logarithm dependence factor	0.05	10^{-10}		V
GCO	Gate tunnelling energy adjustment in inversion mode	0	-10	10	
IGINV	Gate to channel current pre-factor	0	0		A
IGOVINV	Gate–overlap current pre-factor in inversion	0	0		A

Name	Description	Default	Min.	Max.	Unit
IGOVINVD	Gate–overlap current pre-factor in inversion at drain side	0	0		A
IGOVACC	Gate–overlap current pre-factor in accumulation	0	0		A
IGOVACCD	Gate–overlap current pre-factor in accumulation at drain side	0	0		A
STIG	Temperature dependence of all gate current pre-factors	0			
GC2CH	Gate to channel current slope factor	0.375	0	10	
GC3CH	Gate to channel current curvature factor	0.063	-2	2	
GC2OVINV	Gate–overlap current slope factor in inversion	0.375	0	10	
GC3OVINV	Gate–overlap current curvature factor in inversion	0.063	-2	2	
GC2OVACC	Gate-overlap current slope factor in accumulation	0.375	0	10	
GS3OVACC	Gate-overlap current curvature factor in accumulation	0.063	-2	2	
CHIB	Tunneling barrier height	3.1	1		eV
NIGINV	Gate tunneling slope adjustment in subthreshold regime	0	0		
AGIDL	GIDL/GISL current pre-factor	0	0		A/V^3
AGIDLD	GIDL current pre-factor at drain side	0	0		A/V^3
BGIDL	GIDL/GISL probability factor at TR	41	0		V
BGIDLD	GIDL probability factor at TR at drain side	41	0		V
STBGIDL	Temperature dependence of BGIDL	0			V/K
STBGIDLD	Temperature dependence of BGIDLD	0			V/K

Name	Description	Default	Min.	Max.	Unit
CGIDL	Substrate bias dependence of GIDL/GISL	0			
CGIDLD	Substrate bias dependence of GIDL at drain side	0			
AREAQ	Effective channel area for intrinsic charge model	10_{-12}	10_{-18}		m^2
CGBOV	Oxide capacitance for gate to substrate overlap	0	0		F
COV	Overlap capacitance per side	0	0		F
COVD	Overlap capacitance at drain side	0	0		F
COVDL	Overlap capacitance modulation due to Leff bias-dependence	0	0		
CFR	Outer fringe capacitance per side	0	0		F
CFRD	Outer fringe capacitance at drain side	0	0		F
CSD	Drain to source direct capacitance	0	0		F
CSDBP	Drain/source to substrate perimeter capacitance	0	0		F/m
RTH	Thermal resistance	10^4	10_{-6}		K/W
STRTH	Temperature dependence of RTH	0.0			
CTH	Thermal capacitance	10_{-11}	0.0		J/K
FNT	Thermal noise coefficient	1.0	0.0		
NFA	First coefficient of flicker noise	$8\ 10^{22}$	0.0		$V_{-1}\ m_{-4}$
NFB	Second coefficient of flicker noise	$3\ 10^7$	0.0		$V_{-1}\ m_{-2}$
NFC	Third coefficient of flicker noise	0.0	0.0		V^{-1}

Name	Description	Default	Min.	Max.	Unit
NFE	Front interface transverse field effect coefficient	0.0	-1.0	1.0	
NFEB	Back interface transverse field effect coefficient	0.0	-1.0	1.0	
EF	Frequency dependence exponent of flicker noise	1.0	0.1		

Global Level Parameters

Name	Description	Default	Min.	Max.	Unit
TOXEO	Geometry independent global scale parameter for TOXE	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
TSIO	Geometry independent global scale parameter for TSI	10^{-8}	$3\ 10^{-9}$	$2\ 10^{-8}$	m
TBOXO	Geometry independent global scale parameter for TBOX	10^{-7}	$3\ 10^{-10}$	10^{-6}	m
XGEO	Geometry independent global scale parameter for XGE	0.0	0.0	1.0	
NSUBO	Geometry independent global scale parameter for NSUB	$3\ 10^{18}$	10^{16}	10^{21}	cm^{-3}
CTO	Geometry independent global scale parameter for CT	0.0	0.0		
TOXPO	Geometry independent global scale parameter for TOXP	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
NOVO	Geometry independent global scale parameter for NOV	10^{20}	10^{15}	10^{21}	cm^{-3}
NOVDO	Geometry independent global scale parameter for NOVD	10^{20}	10^{15}	10^{21}	cm^{-3}
VFBO	Long and wide channel value of VFB	0.0			V
VFBL	Channel length scaling parameter of VFB	0.0			V

Name	Description	Default	Min.	Max.	Unit
VFBLEXP	Channel length scaling exponent of VFB	2.0			
VFBW	Channel width scaling parameter of VFB	0.0			V
VFBLW	Channel area scaling parameter of VFB	0.0			
VFBBO	Long and wide channel value of VFBB	0.0			V
VFBLBO	Back to front interface asymmetry factor applied to VFBL	1.0	0.0		
STVFBO	Long and wide channel value of STVFB	0.0			V/K
STVFBL	Channel length scaling parameter of STVFB	0.0			
STVFBW	Channel width scaling parameter of STVFB	0.0			
STVFBLW	Channel area scaling parameter of STVFB	0.0			
CICFO	Geometry independent global scale parameter for CICF	1.0	0.1	10.0	
CICO	Geometry independent global scale parameter for CIC	1.0	0.1	10.0	
PSCEL	Channel length scaling parameter of PSCE	0.0			
PSCELEXP	Channel length scaling exponent of PSCE	2.0			
PSCEW	Channel width scaling parameter of PSCE	0.0			
PSCEBO	Geometry independent global scale parameter for PSCEB	1.0	0.0		
PSCEDLL	Channel length scaling parameter of PSCEDL	0			
PSCEDLW	Channel width scaling parameter of PSCEDL	0			
PNCEW	Channel width scaling parameter of PNCE	0			

Name	Description	Default	Min.	Max.	Unit
CFL	Channel length scaling parameter of CF	0. 0			
CFLEXP	Channel length scaling exponent of CF	2.0			
CFW	Channel width scaling parameter of CF	0.0			
CFBO	Geometry independent global scale parameter for CFB	1.0	0.0		
STCFO	Geometry independent global scale parameter for STCF	0.0			K^{-1}
CFDO	Geometry independent global scale parameter for CFD	0.2	0.05		V
CFDLL	Channel length scaling parameter of CFDL	0			
CFDLW	Channel length scaling parameter of CFDL	0			
UO	Front channel low field mobility at TR	0.05			m^2/Vs
BETNL	Second order channel length dependence of BETN	0.0			
BETNLEXP	Second order channel length exponent of BETN	1.0			
BETNW	Second order channel width dependence of BETN	0.0			
BETNBO	Geometry independent global scale parameter for BETNB	1.0	0.0		
STBETO	Long and wide channel value of STBET	1.5			
STBETL	Channel length scaling parameter of STBET	0.0			
STBETW	Channel width scaling parameter of STBET	0.0			
STBETLW	Channel area scaling parameter of STBET	0.0			
CSO	Long and wide channel value of CS	0.0			

Name	Description	Default	Min.	Max.	Unit
CSL	Channel length scaling parameter of CS	0.0			
CSLEXP	Geometry independent global scale parameter for CS	1.0			
CSW	Channel width scaling parameter of CS	0.0			
CSLW	Channel area scaling parameter of CS	0.0			
STCSO	Geometry independent global scale parameter for STCS	0			
THECSO	Geometry independent global scale parameter for THECS	1.5	0		
STTHECSO	Geometry independent global scale parameter for STTHECS	0			
CSTHRO	Geometry independent global scale parameter for CSTHR	2	0.001		
MUEO	Geometry independent global scale parameter for MUE	0	0		cm/MV
STMUEO	Geometry independent global scale parameter for STMUE	0			
THEMUO	Geometry independent global scale parameter for THEMU	1.5	0		
STTHEMUO	Geometry independent global scale parameter for STTHEMU	0			
XCORO	Long and wide channel value of XCOR	0			V^{-1}
XCORL	Channel length scaling parameter of XCOR	0			
XCORLEXP	Channel length scaling exponent of XCOR	1			
XCORW	Channel width scaling parameter of XCOR	0			

Name	Description	Default	Min.	Max.	Unit
XCORLW	Channel area scaling parameter of XCOR	0			
STXCORO	Geometry independent global scale parameter for STXCOR	0			
FETAO	Geometry independent global scale parameter for FETA	1	0		
RSW1	Source/drain series resistance for a WEN width at TR	30			Ω
RSW2	Second order width scaling parameter of RS	0			
STRSO	Geometry independent global scale parameter for STRS	0			
RSGO	Geometry independent global scale parameter for RSG	0	-0.5		
THERSGO	Geometry independent global scale parameter for THERSG	2			
THESATO	Long and wide channel parameter for THESAT	0	0		V^{-1}
THESATL	Channel length scaling parameter of THESAT	0			
THESATLEXP	Channel length scaling exponent of THESAT	1			
THESATW	Channel width scaling parameter of THESAT	0			
THESATLW	Channel area scaling parameter of THESAT	0			
STTHESATO	Long and wide channel value of STTHESAT	-0.1			
STTHESATL	Channel length scaling parameter of STTHESAT	0			
STTHESATW	Channel width scaling parameter of STTHESAT	0			
STTHESATLW	Channel area scaling parameter of STTHESAT	0			

Name	Description	Default	Min.	Max.	Unit
THESATGO	Geometry independent global scale parameter for THESATG	0	-0.5		
THESATBO	Geometry independent global scale parameter for THESATB	0	-0.5		
AXO	Long and wide channel value of AX	8			
AXL	Channel length scaling parameter of AX	0	0		
AXLEXP	Channel length scaling exponent of AX	1			
ALPL1	Channel length scaling parameter of ALP	0			
ALPLEXP	Channel length scaling exponent of ALP	1			
ALPL2	Second order channel length dependence of ALP	0	0		
ALPW	Channel width scaling parameter of ALP	0			
ALP1L1	Channel length scaling parameter of ALP1	0			
ALP1LEXP	Channel length scaling exponent of ALP1	0.5			
ALP1L2	Second order channel length dependence of ALP1	0	0		
ALP1W	Channel width scaling parameter of ALP1	0			
VPO	Geometry independent global scale parameter for VP	0.05	10^{-10}		V
GCOO	Geometry independent global scale parameter for GCO	0	-10	10	
IGINVLW	IGINV value for a LEN.WEN area	0	0		A
IGOVINVW	IGOVINV value for a WEN width	0	0		A

Name	Description	Default	Min.	Max.	Unit
IGOVINVDW	IGOVINVD for a WEN width	0	0		A
IGOVACCW	IGOVACC value for a WEN width	0	0		A
IGOVACCDW	IGOVACCD value for a WEN width	0	0		A
STIGO	Geometry independent global scale parameter for STIG	0			
GC2CHO	Geometry independent global scale parameter for GC2CH	0.375	0	10	
GC3CHO	Geometry independent global scale parameter for GC3CH	0.063	-2	2	
GC2OVINVO	Geometry independent global scale parameter for GC2OVINV	0.375	0	10	
GC3OVINVO	Geometry independent global scale parameter for GC3OVINV	0.063	-2	2	
GC2OVACCO	Geometry independent global scale parameter for GC2OVACC	0.375	0	10	
GC3OVACCO	Geometry independent global scale parameter for GC3OVACC	0.063	-2	2	
CHIBO	Geometry independent global scale parameter for CHIB	3.1	1		eV
NIGINVO	Geometry independent global scale parameter for NIGINV	0	0		
AGIDLW	AGIDL value for a WEN width	0	0		A/V^3
AGIDLDW	AGIDLD value for a WEN width	0	0		A/V^3
BGIDLO	Geometry independent global scale parameter for BGIDL	41	0		V
BGIDLDO	Geometry independent global scale parameter for BGIDLD	41	0		V

Name	Description	Default	Min.	Max.	Unit
STBGIDLO	Geometry independent global scale parameter for STBGIDL	0			V/K
STBGIDLDO	Geometry independent global scale parameter for STBGIDLD	0			V/K
CGIDLO	Geometry independent global scale parameter for CGIDL	0			
CGIDLDO	Geometry independent global scale parameter for CGIDLD	0			
CGBOVL	CGBOV value for a LEN length	0	0		F
LOVO	Overlap length for gate/source-drain overlap capacitance	0	0		m
LOVDO	Overlap length for gate/drain overlap capacitance	0	0		m
COVDLO	Wide channel parameter for COVDL	0			
COVDLW	Channel width scaling parameter of COVDL	0			
CFRO	Corner related outer fringe capacitance	0			F
CFRW	Outer fringe capacitance per side for a WEN width	0			F
CFRDO	Corner related outer fringe capacitance at drain side	0			F
CFRDW	Outer fringe capacitance at drain side for a WEN width	0			F
CSDO	Drain to source direct capacitance correction factor	1	0		
CSDBPO	Geometry independent global scale parameter for CSDBP	0	0		F/m
RTHO	Geometry independent global scale parameter for RTH	10^5			K/W

Name	Description	Default	Min.	Max.	Unit
RTHL	Channel length scaling parameter of RTH and CTH	0.0			
RTHW	Channel width scaling parameter of RTH and CTH	0.0			
RTHLW	Channel area scaling parameter of RTH and CTH	9.0			
STRTHO	Geometry independent global scale parameter for STRTH	0.0			
CTHO	Geometry independent global scale parameter for CTH	10_{-12}			J/K
FNTO	Geometry independent global scale parameter for FNT	1.0	0.0		
NFALW	NFA value for a LEN.WEN area	$8\ 10^{22}$	0.0		$V_{-1}\ m_{-4}$
NFBLW	NFB value for a LEN.WEN area	$3\ 10^{7}$	0.0		$V_{-1}\ m_{-2}$
NFCLW	NFC value for a LEN.WEN area	0.0	0.0		V^{-1}
NFEO	Geometry independent global scale parameter for NFE	0.0	-1.0	1.0	
NFEBO	Geometry independent global scale parameter for NFEB	0.0	-1.0	1.0	
EFO	Geometry independent global scale parameter for EF	1.0	0.1		

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName utsoi211 [param=value]
```

Example:model utsoi2model utsoi211 GENDER=1

Instance Netlist Format

```
modelName [:Name] d g s b
```

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example: utsoi2model:M1 d g s b MULT=1

UTSOI 2.20

UTSOI 2.20 (Ultra Thin Fully Depleted SOI MOSFET Model)

Version 2.20 is based on version 2.11 with the following changes:

Bug fixes

- Parameters **DLQ** and **DWQ** were involved in device effective length and width, respectively, for computation of external parasitic capacitances, such as external fringe capacitance or gate to substrate one. This is no longer the case, and these capacitances are now calculated with the physical length and width of the device.
- In the scaling law of velocity saturation parameter **THESAT**, **THESATO** and **THESATL** were not treated similarly. This has been modified for more consistent description of this scaling law.

Accuracy improvements

- Additional flexibility has been introduced in channel length modulation model for more accurate description of current and conductances over applied biases.
- Model has been extended to the case of doped thin film transistors, with introduction of channel doping level local parameter **NCH**.
- Channel length dependence over front and back bias in subthreshold and moderate inversion regimes has been introduced in Leti-UTSOI 2.1. This part of the model has been improved for better accuracy, with a physical description of source/drain depletion effect.
- Mobility model accuracy has been improved, in particular with the introduction of transverse field dependence of Coulomb scattering component.
- Series resistance model flexibility has been increased, with introduction of source/drain extension component and explicit back bias dependence.
- Gate-overlap tunneling current description at high drain voltage has been improved.
- Introduction high longitudinal field dependence of GISL/GIDL currents.
- Introduction of a physical inner fringe capacitance model, including source/drain depletion effect (see AP3), for better description of short channel capacitances.
- Overlap capacitance model flexibility has been increased to account for source/drain depletion effect introduced in DC model (see AP3).
- Global scale parameters **VFBL2** and **VFBLEXP2** have been added for more flexibility in **VFB** scaling description.
- Global scale parameters **ALPLEXP2** and **ALP1LEXP2** have been added for more flexibility in **ALP** and **ALP1** scaling description, respectively.
- Description of edge effect in gate to substrate parasitic capacitance has been introduced through global scale parameter **CGBOVO**.
- Geometrical dependences of thermal resistance and thermal capacitance have been extended to multifinger transistors, by accounting for thermal coupling between fingers.
- A new strain relaxation model, dedicated to strained-SOI technologies, has been introduced besides existing STI-based stress model.
- High order drivability of the model around null source-drain voltage has been improved.

Changes in model inputs and outputs

- Warnings about clipping of instance, global and local parameters, as well as channel temperature elevation, have been updated. Display is still controlled through **SWCLIPCHK** flag.

Model Parameters

The following table lists the model parameters.

Name	Description	Default	Min.	Max.	Unit
SWSCALE	Flag for scaling rules, 0=local parameter set, 1=global parameter set	0			
VERSION	Flag for model version	2.20			
SWCLIPCHK	Flag for warnings about parameter clipping	0			
SWSUBDEP	Flag for backplane depletion effect	0			
SWIGATE	Flag for gate current, 0=turn off	0			
SWGIDL	Flag for gate induced source/drain leakage model, 0=turn off	0			
SWSHE	Flag for self heating effect, 0=turn off	0			
SWJUNASYM	Flag for source/drain junction asymmetry	0			
SWIGN	Flag for induced gate noise, 0=turn off	1	0	1	
QMC	Quantum confinement coefficient	1.0	0.0		
GENDER	Channel type: +1 = NMOS, -1 = PMOS	1			
TR	Reference temperature	21	-273		°C
TMAX	Maximum self-heating temperature elevation	150	0		°C

Instance Parameters

Name	Description	Default	Min.	Max.	Unit
L	Drawn channel length	10^{-6}	10^{-9}		m
W	Drawn channel width	10^{-6}	10^{-9} x NF		m
SA	Distance between active edge and poly at source side	0	0		m
SB	Distance between active edge and poly at drain side	0	0		m
SD	Distance between neighboring fingers	0	0		m
ASOURCE	Source region area	10^{-12}	0		m^2
ADRAIN	Drain region area	10^{-12}	0		m^2
PSOURCE	Source region perimeter	10^{-6}	0		m
PDRAIN	Drain region perimeter	10^{-6}	0		m
NF	Number of fingers	1	1		
MULT	Number of device in parallel	1	1		
DELVTO	Threshold voltage shift parameter	0			V
FACTUO	Low field mobility pre-factor	1.0	0.0		

Scaling Parameters

Name	Description	Default	Min.	Max.	Unit
LVARO	Geometry-independent difference between physical and drawn gate lengths	0			m
LVARL	Length dependence of physical to drawn gate length difference	0			

Name	Description	Default	Min.	Max.	Unit
LVARW	Width dependence of physical to drawn gate length difference	0			
LAP	Effective channel length reduction per side	0			m
WVARO	Geometry-independent difference between physical and drawn field-oxide opening	0			m
WVARL	Length dependence of physical to drawn active width difference	0			
WVARW	Width dependence of physical to drawn active width difference	0			
WOT	Effective reduction of channel width per side	0			m
DLQ	Effective channel length offset for CV	0			m
DWQ	Effective channel width offset for CV	0			m

Stress Model Parameters

Name	Description	Default	Min.	Max.	Unit
SAREF	Reference distance between active edge to poly from one side	10^{-6}	10^{-9}		m
SBREF	Reference distance between active edge to poly from other side	10^{-6}	10^{-9}		m
WLOD	Width parameter	0			m
KUO	Mobility degradation/enhancement coefficient	0			m
KVSAT	Saturation velocity degradation/enhancement parameter	0	-1	1	m
TKUO	Temperature coefficient of KUO	0			
LKUO	Length dependence of KUO	0			

Name	Description	Default	Min.	Max.	Unit
WKUO	Width dependence of KUO	0			
PKUO	Cross-term dependence of KUO	0			
LLODKUO	Length parameter for mobility stress effect	0	0		
WLODKUO	Width parameter for mobility stress effect	0	0		
KVTHO	Threshold voltage shift parameter	0			
LKVTHO	Length dependence of KVTHO	0			
WKVTHO	Width dependence of KVTHO	0			
PKVTHO	Cross-term dependence of KVTHO	0			
LLODVTH	Length parameter for threshold voltage stress effect	0	0		
WLODVTH	Width parameter for threshold voltage stress effect	0	0		
STETAO	ETAO shift factor related to threshold voltage change	0			m
LODETAO	ETAO shift modification factor	1	0		

Local Level Parameters

Name	Description	Default	Min.	Max.	Unit
TOXE	Front gate equivalent oxide thickness (EOT)	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
TSI	Silicon or SiGe film thickness	10^{-8}	$3\ 10^{-9}$	$2\ 10^{-8}$	m
XGE	Fraction of germanium content in the channel	0.0	0.0	1.0	
TBOX	Back gate equivalent oxide thickness (EOT)	10^{-7}	$3\ 10^{-10}$	10^{-6}	m

Name	Description	Default	Min.	Max.	Unit
NSUB	Backplane doping level: positive = p-type, negative = n-type	$3\ 10^{18}$	10^{16}	10^{21}	cm^{-3}
CT	Interface states factor	0.0	0.0		
TOXP	Front gate physical oxide thickness	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
NOV	Effective doping level of overlap-LDD regions	10^{20}	10^{15}	10^{21}	cm^{-3}
NOVD	Effective doping level of overlap-LDD regions at drain side	10^{20}	10^{15}	10^{21}	cm^{-3}
VFB	Front gate workfunction referenced to Si midgap at TR	0.0			V
VFBB	Back gate workfunction offset at TR	0.0			V
STVFB	Temperature dependence of VFB and VFBB	0.0			V/K
CICF	Long channel front interface coupling coefficient	1.0	0.1	10.0	
CIC	Long channel back interface coupling coefficient	1.0	0.1	10.0	
PSCE	Short channel coupling attenuation parameter	0.0	-0.5	5.0	
PSCEB	Short channel back to front interface asymmetry factor	1.0	0.0		
PSCEDL	Short channel modulation due to Leff dependence on biases	0	0		
PNCE	Narrow channel effect on body factor	0	-1	1	
CF	Drain Induced Barrier Lowering (DIBL) parameter at TR	0.0	0.0		
CFB	DIBL back to front interface asymmetry factor	1.0	0.0		
STCF	Temperature dependence of CF	0.0			K^{-1}

Name	Description	Default	Min.	Max.	Unit
CFD	Drain voltage dependence parameter of DIBL	0.2	0.05		V
CFDL	DIBL modulation due to Leff dependence on biases	0			
BETN	Front channel aspect ratio times low field mobility at TR	0.05	10^{-10}		m^2/Vs
BETNB	Back channel over front channel low field mobility ratio	1.0	0.1	10.0	
STBET	Temperature dependence exponent of BETN	1.5			
CS	Coulomb scattering parameter at TR	0.0	0.0		
STCS	Temperature dependence exponent of CS	0			
THECS	Coulomb scattering exponent at TR	1.5	0		
STTHECS	Temperature dependence exponent of THECS	0			
CSTHR	Coulomb scattering threshold level	2	0.001		
MUE	High field mobility reduction coefficient at TR	0	0		cm/MV
STMUE	Temperature dependence exponent of MUE	0			
THEMU	High field mobility reduction exponent at TR	1.5	0		
STTHEMU	Temperature dependence exponent of THEMU	0			
XCOR	High field mobility non universality factor at TR	0			V^{-1}
STXCOR	Temperature dependence exponent of XCOR	0			
FETA	Transverse effective field parameter	1	0		
RS	Source/drain series resistance at TR	30	0		Ω

Name	Description	Default	Min.	Max.	Unit
STRS	Temperature dependence exponent of RS	0			
RSG	Transverse electric field dependence of RS	0	-0.5		
THERSG	Transverse electric field exponent of RS	2			
THESAT	Velocity saturation parameter at TR	0	0		V^{-1}
STTHESAT	Temperature dependence exponent of THESAT	-0.1			
THESATG	Front gate bias dependence of velocity saturation	0	-0.5		
THESATB	Back gate bias dependence of velocity saturation	0	-0.5		
AX	Linear/saturation transition exponent	8	1	12	
ALP	Channel length modulation pre-factor	0	0		
ALP1	Channel length modulation enhancement above threshold	0	0		V
VP	Channel length modulation logarithm dependence factor	0.05	10^{-10}		V
GCO	Gate tunneling energy adjustment in inversion mode	0	-10	10	
IGINV	Gate to channel current pre-factor	0	0		A
IGOVINV	Gate–overlap current pre-factor in inversion	0	0		A
IGOVINVD	Gate–overlap current pre-factor in inversion at drain side	0	0		A
IGOVACC	Gate–overlap current pre-factor in accumulation	0	0		A
IGOVACCD	Gate–overlap current pre-factor in accumulation at drain side	0	0		A

Name	Description	Default	Min.	Max.	Unit
STIG	Temperature dependence of all gate current pre-factors	0			
GC2CH	Gate to channel current slope factor	0.375	0	10	
GC3CH	Gate to channel current curvature factor	0.063	-2	2	
GC2OVINV	Gate–overlap current slope factor in inversion	0.375	0	10	
GC3OVINV	Gate–overlap current curvature factor in inversion	0.063	-2	2	
GC2OVACC	Gate-overlap current slope factor in accumulation	0.375	0	10	
GS3OVACC	Gate-overlap current curvature factor in accumulation	0.063	-2	2	
CHIB	Tunneling barrier height	3.1	1		eV
NIGINV	Gate tunneling slope adjustment in subthreshold regime	0	0		
AGIDL	GIDL/GISL current pre-factor	0	0		A/V^3
AGIDLD	GIDL current pre-factor at drain side	0	0		A/V^3
BGIDL	GIDL/GISL probability factor at TR	41	0		V
BGIDLD	GIDL probability factor at TR at drain side	41	0		V
STBGIDL	Temperature dependence of BGIDL	0			V/K
STBGIDLD	Temperature dependence of BGIDLD	0			V/K
CGIDL	Substrate bias dependence of GIDL/GISL	0			
CGIDLD	Substrate bias dependence of GIDL at drain side	0			
AREAQ	Effective channel area for intrinsic charge model	10_{-12}	10_{-18}		m^2

Name	Description	Default	Min.	Max.	Unit
CGBOV	Oxide capacitance for gate to substrate overlap	0	0		F
COV	Overlap capacitance per side	0	0		F
COVD	Overlap capacitance at drain side	0	0		F
COVDL	Overlap capacitance modulation due to Leff bias-dependence	0	0		
CFR	Outer fringe capacitance per side	0	0		F
CFRD	Outer fringe capacitance at drain side	0	0		F
CSD	Drain to source direct capacitance	0	0		F
CSDBP	Drain/source to substrate perimeter capacitance	0	0		F/m
RTH	Thermal resistance	10^{4}	10_{-6}		K/W
STRTH	Temperature dependence of RTH	0.0			
CTH	Thermal capacitance	10_{-11}	0.0		J/K
FNT	Thermal noise coefficient	1.0	0.0		
NFA	First coefficient of flicker noise	$8\ 10^{22}$	0.0		$V_{-1}\ m_{-4}$
NFB	Second coefficient of flicker noise	$3\ 10^{7}$	0.0		$V_{-1}\ m_{-2}$
NFC	Third coefficient of flicker noise	0.0	0.0		V^{-1}
NFE	Front interface transverse field effect coefficient	0.0	-1.0	1.0	
NFEB	Back interface transverse field effect coefficient	0.0	-1.0	1.0	
EF	Frequency dependence exponent of flicker noise	1.0	0.1		

Global Level Parameters

Name	Description	Default	Min.	Max.	Unit
TOXEO	Geometry independent global scale parameter for TOXE	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
TSIO	Geometry independent global scale parameter for TSI	10^{-8}	$3\ 10^{-9}$	$2\ 10^{-8}$	m
TBOXO	Geometry independent global scale parameter for TBOX	10^{-7}	$3\ 10^{-10}$	10^{-6}	m
XGEO	Geometry independent global scale parameter for XGE	0.0	0.0	1.0	
NSUBO	Geometry independent global scale parameter for NSUB	$3\ 10^{18}$	10^{16}	10^{21}	cm^{-3}
CTO	Geometry independent global scale parameter for CT	0.0	0.0		
TOXPO	Geometry independent global scale parameter for TOXP	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
NOVO	Geometry independent global scale parameter for NOV	10^{20}	10^{15}	10^{21}	cm^{-3}
NOVDO	Geometry independent global scale parameter for NOVD	10^{20}	10^{15}	10^{21}	cm^{-3}
VFBO	Long and wide channel value of VFB	0.0			V
VFBL	Channel length scaling parameter of VFB	0.0			V
VFBLEXP	Channel length scaling exponent of VFB	2.0			
VFBW	Channel width scaling parameter of VFB	0.0			V
VFBLW	Channel area scaling parameter of VFB	0.0			
VFBBO	Long and wide channel value of VFBB	0.0			V
VFBLBO	Back to front interface asymmetry factor applied to VFBL	1.0	0.0		

Name	Description	Default	Min.	Max.	Unit
STVFBO	Long and wide channel value of STVFB	0.0			V/K
STVFBL	Channel length scaling parameter of STVFB	0.0			
STVFBW	Channel width scaling parameter of STVFB	0.0			
STVFBLW	Channel area scaling parameter of STVFB	0.0			
CICFO	Geometry independent global scale parameter for CICF	1.0	0.1	10.0	
CICO	Geometry independent global scale parameter for CIC	1.0	0.1	10.0	
PSCEL	Channel length scaling parameter of PSCE	0.0			
PSCELEXP	Channel length scaling exponent of PSCE	2.0			
PSCEW	Channel width scaling parameter of PSCE	0.0			
PSCEBO	Geometry independent global scale parameter for PSCEB	1.0	0.0		
PSCEDLL	Channel length scaling parameter of PSCEDL	0			
PSCEDLW	Channel width scaling parameter of PSCEDL	0			
PNCEW	Channel width scaling parameter of PNCE	0			
CFL	Channel length scaling parameter of CF	0. 0			
CFLEXP	Channel length scaling exponent of CF	2.0			
CFW	Channel width scaling parameter of CF	0.0			
CFBO	Geometry independent global scale parameter for CFB	1.0	0.0		
STCFO	Geometry independent global scale parameter for STCF	0.0			K^{-1}
CFDO	Geometry independent global scale parameter for CFD	0.2	0.05		V

Name	Description	Default	Min.	Max.	Unit
CFDLL	Channel length scaling parameter of CFDL	0			
CFDLW	Channel length scaling parameter of CFDL	0			
UO	Front channel low field mobility at TR	0.05			m^2/Vs
BETNL	Second order channel length dependence of BETN	0.0			
BETNLEXP	Second order channel length exponent of BETN	1.0			
BETNW	Second order channel width dependence of BETN	0.0			
BETNBO	Geometry independent global scale parameter for BETNB	1.0	0.0		
STBETO	Long and wide channel value of STBET	1.5			
STBETL	Channel length scaling parameter of STBET	0.0			
STBETW	Channel width scaling parameter of STBET	0.0			
STBETLW	Channel area scaling parameter of STBET	0.0			
CSO	Long and wide channel value of CS	0.0			
CSL	Channel length scaling parameter of CS	0.0			
CSLEXP	Geometry independent global scale parameter for CS	1.0			
CSW	Channel width scaling parameter of CS	0.0			
CSLW	Channel area scaling parameter of CS	0.0			
STCSO	Geometry independent global scale parameter for STCS	0			
THECSO	Geometry independent global scale parameter for THECS	1.5	0		
STTHECSO	Geometry independent global scale parameter for STTHECS	0			

Name	Description	Default	Min.	Max.	Unit
CSTHRO	Geometry independent global scale parameter for CSTHR	2	0.001		
MUEO	Geometry independent global scale parameter for MUE	0	0		cm/MV
STMUEO	Geometry independent global scale parameter for STMUE	0			
THEMUO	Geometry independent global scale parameter for THEMU	1.5	0		
STTHEMUO	Geometry independent global scale parameter for STTHEMU	0			
XCORO	Long and wide channel value of XCOR	0			V^{-1}
XCORL	Channel length scaling parameter of XCOR	0			
XCORLEXP	Channel length scaling exponent of XCOR	1			
XCORW	Channel width scaling parameter of XCOR	0			
XCORLW	Channel area scaling parameter of XCOR	0			
STXCORO	Geometry independent global scale parameter for STXCOR	0			
FETAO	Geometry independent global scale parameter for FETA	1	0		
RSW1	Source/drain series resistance for a WEN width at TR	30			Ω
RSW2	Second order width scaling parameter of RS	0			
STRSO	Geometry independent global scale parameter for STRS	0			
RSGO	Geometry independent global scale parameter for RSG	0	-0.5		
THERSGO	Geometry independent global scale parameter for THERSG	2			
THESATO	Long and wide channel parameter for THESAT	0	0		V^{-1}

Name	Description	Default	Min.	Max.	Unit
THESATL	Channel length scaling parameter of THESAT	0			
THESATLEXP	Channel length scaling exponent of THESAT	1			
THESATW	Channel width scaling parameter of THESAT	0			
THESATLW	Channel area scaling parameter of THESAT	0			
STTHESATO	Long and wide channel value of STTHESAT	-0.1			
STTHESATL	Channel length scaling parameter of STTHESAT	0			
STTHESATW	Channel width scaling parameter of STTHESAT	0			
STTHESATLW	Channel area scaling parameter of STTHESAT	0			
THESATGO	Geometry independent global scale parameter for THESATG	0	-0.5		
THESATBO	Geometry independent global scale parameter for THESATB	0	-0.5		
AXO	Long and wide channel value of AX	8			
AXL	Channel length scaling parameter of AX	0	0		
AXLEXP	Channel length scaling exponent of AX	1			
ALPL1	Channel length scaling parameter of ALP	0			
ALPLEXP	Channel length scaling exponent of ALP	1			
ALPL2	Second order channel length dependence of ALP	0	0		
ALPW	Channel width scaling parameter of ALP	0			
ALP1L1	Channel length scaling parameter of ALP1	0			

Name	Description	Default	Min.	Max.	Unit
ALP1LEXP	Channel length scaling exponent of ALP1	0.5			
ALP1L2	Second order channel length dependence of ALP1	0	0		
ALP1W	Channel width scaling parameter of ALP1	0			
VPO	Geometry independent global scale parameter for VP	0.05	10^{-10}		V
GCOO	Geometry independent global scale parameter for GCO	0	-10	10	
IGINVLW	IGINV value for a LEN.WEN area	0	0		A
IGOVINVW	IGOVINV value for a WEN width	0	0		A
IGOVINVDW	IGOVINVD for a WEN width	0	0		A
IGOVACCW	IGOVACC value for a WEN width	0	0		A
IGOVACCDW	IGOVACCD value for a WEN width	0	0		A
STIGO	Geometry independent global scale parameter for STIG	0			
GC2CHO	Geometry independent global scale parameter for GC2CH	0.375	0	10	
GC3CHO	Geometry independent global scale parameter for GC3CH	0.063	-2	2	
GC2OVINVO	Geometry independent global scale parameter for GC2OVINV	0.375	0	10	
GC3OVINVO	Geometry independent global scale parameter for GC3OVINV	0.063	-2	2	
GC2OVACCO	Geometry independent global scale parameter for GC2OVACC	0.375	0	10	
GC3OVACCO	Geometry independent global scale parameter for GC3OVACC	0.063	-2	2	
CHIBO	Geometry independent global scale parameter for CHIB	3.1	1		eV

Name	Description	Defaul t	Min.	Max.	Unit
NIGINVO	Geometry independent global scale parameter for NIGINV	0	0		
AGIDLW	AGIDL value for a WEN width	0	0		A/V^3
AGIDLDW	AGIDLD value for a WEN width	0	0		A/V^3
BGIDLO	Geometry independent global scale parameter for BGIDL	41	0		V
BGIDLDO	Geometry independent global scale parameter for BGIDLD	41	0		V
STBGIDLO	Geometry independent global scale parameter for STBGIDL	0			V/K
STBGIDLDO	Geometry independent global scale parameter for STBGIDLD	0			V/K
CGIDLO	Geometry independent global scale parameter for CGIDL	0			
CGIDLDO	Geometry independent global scale parameter for CGIDLD	0			
CGBOVL	CGBOV value for a LEN length	0	0		F
LOVO	Overlap length for gate/source-drain overlap capacitance	0	0		m
LOVDO	Overlap length for gate/drain overlap capacitance	0	0		m
COVDLO	Wide channel parameter for COVDL	0			
COVDLW	Channel width scaling parameter of COVDL	0			
CFRO	Corner related outer fringe capacitance	0			F
CFRW	Outer fringe capacitance per side for a WEN width	0			F
CFRDO	Corner related outer fringe capacitance at drain side	0			F
CFRDW	Outer fringe capacitance at drain side for a WEN width	0			F
CSDO	Drain to source direct capacitance correction factor	1	0		

Name	Description	Default	Min.	Max.	Unit
CSDBPO	Geometry independent global scale parameter for CSDBP	0	0		F/m
RTHO	Geometry independent global scale parameter for RTH	10^5			K/W
RTHL	Channel length scaling parameter of RTH and CTH	0.0			
RTHW	Channel width scaling parameter of RTH and CTH	0.0			
RTHLW	Channel area scaling parameter of RTH and CTH	9.0			
STRTHO	Geometry independent global scale parameter for STRTH	0.0			
CTHO	Geometry independent global scale parameter for CTH	10_{-12}			J/K
FNTO	Geometry independent global scale parameter for FNT	1.0	0.0		
NFALW	NFA value for a LEN.WEN area	$8\ 10^{22}$	0.0		V_{-1} m_{-4}
NFBLW	NFB value for a LEN.WEN area	$3\ 10^7$	0.0		V_{-1} m_{-2}
NFCLW	NFC value for a LEN.WEN area	0.0	0.0		V^{-1}
NFEO	Geometry independent global scale parameter for NFE	0.0	-1.0	1.0	
NFEBO	Geometry independent global scale parameter for NFEB	0.0	-1.0	1.0	
EFO	Geometry independent global scale parameter for EF	1.0	0.1		

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName utsoi211 [param=value]
```

Example: model utsoi2model utsoi211 GENDER=1

Instance Netlist Format

```
modelName [:Name] d g s b
```

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example: utsoi2model:M1 d g s b MULT=1

UTSOI 2.30

UTSOI 2.30 (Ultra Thin Fully Depleted SOI MOSFET Model)

Version 2.30 is based on version 2.20 with the following changes:

Bug fixes

- Correction of an undesired W-scaling of Cbs and Cbd capacitances that was induced in Leti-UTSOI 2.2 for negative values of the narrow channel parameter PNCEW.
- Correction of a small undesired scaling of the flicker noise in the subthreshold regime as a function of gate length and back bias.

Accuracy improvements

- Simplification of the implementation of the self-heating.
- Introduction of a model for the excess noise.
- Global scale parameters **AXL2** and **AXLEXP2** added for more flexibility in **AX** scaling description.
- Global scale parameters **AGIDLO** and **DGIDLO** added for more scaling flexibility of the GIDL model.

Changes in model inputs and outputs

- Warnings about clipping of instance, global and local parameters, as well as channel temperature elevation, has been updated. Display is still controlled through **SWCLIPCHK** flag.

Model Parameters

The following table lists the model parameters.

Name	Description	Default	Min.	Max.	Unit
SWSCALE	Flag for scaling rules, 0=local parameter set, 1=global parameter set	0			
VERSION	Flag for model version	2.3			
SWCLIPCHK	Flag for warnings about parameter clipping	0			
SWSUBDEP	Flag for backplane depletion effect	0			
SWIGATE	Flag for gate current, 0=turn off	0			

Name	Description	Default	Min.	Max.	Unit
SWGIDL	Flag for gate induced source/drain leakage model, 0=turn off	0			
SWSHE	Flag for self heating effect, 0=turn off	0			
SWJUNASYM	Flag for source/drain junction asymmetry	0			
SWIGN	Flag for induced gate noise, 0=turn off	1	0	1	
QMC	Quantum confinement coefficient	1.0	0.0		
GENDER	Channel type: +1 = NMOS, -1 = PMOS	1			
TR	Reference temperature	21	-273		°C
TMAX	Maximum self-heating temperature elevation	150	0		°C

Instance Parameters

Name	Description	Default	Min.	Max.	Unit
L	Drawn channel length	10^{-6}	10^{-9}		m
W	Drawn channel width	10^{-6}	10^{-9} x NF		m
SA	Distance between active edge and poly at source side	0	0		m
SB	Distance between active edge and poly at drain side	0	0		m
SD	Distance between neighboring fingers	0	0		m
ASOURCE	Source region area	10^{-12}	0		m^2
ADRAIN	Drain region area	10^{-12}	0		m^2

Name	Description	Default	Min.	Max.	Unit
PSOURCE	Source region perimeter	10^{-6}	0		m
PDRAIN	Drain region perimeter	10^{-6}	0		m
NF	Number of fingers	1	1		
MULT	Number of device in parallel	1	1		
DELVTO	Threshold voltage shift parameter	0			V
FACTUO	Low field mobility pre-factor	1.0	0.0		

Scaling Parameters

Name	Description	Default	Min.	Max.	Unit
LVARO	Geometry-independent difference between physical and drawn gate lengths	0			m
LVARL	Length dependence of physical to drawn gate length difference	0			
LVARW	Width dependence of physical to drawn gate length difference	0			
LAP	Effective channel length reduction per side	0			m
WVARO	Geometry-independent difference between physical and drawn field-oxide opening	0			m
WVARL	Length dependence of physical to drawn active width difference	0			
WVARW	Width dependence of physical to drawn active width difference	0			
WOT	Effective reduction of channel width per side	0			m
DLQ	Effective channel length offset for CV	0			m

Name	Description	Default	Min.	Max.	Unit
DWQ	Effective channel width offset for CV	0			m

Stress Model Parameters

Name	Description	Default	Min.	Max.	Unit
SAREF	Reference distance between active edge to poly from one side	10^{-6}	10^{-9}		m
SBREF	Reference distance between active edge to poly from other side	10^{-6}	10^{-9}		m
WLOD	Width parameter	0			m
KUO	Mobility degradation/enhancement coefficient	0			m
KVSAT	Saturation velocity degradation/enhancement parameter	0	-1	1	m
TKUO	Temperature coefficient of KUO	0			
LKUO	Length dependence of KUO	0			
WKUO	Width dependence of KUO	0			
PKUO	Cross-term dependence of KUO	0			
LLODKUO	Length parameter for mobility stress effect	0	0		
WLODKUO	Width parameter for mobility stress effect	0	0		
KVTHO	Threshold voltage shift parameter	0			
LKVTHO	Length dependence of KVTHO	0			
WKVTHO	Width dependence of KVTHO	0			
PKVTHO	Cross-term dependence of KVTHO	0			

Name	Description	Default	Min.	Max.	Unit
LLODVTH	Length parameter for threshold voltage stress effect	0	0		
WLODVTH	Width parameter for threshold voltage stress effect	0	0		
STETAO	ETAO shift factor related to threshold voltage change	0			m
LODETAO	ETAO shift modification factor	1	0		

Local Level Parameters

Name	Description	Default	Min.	Max.	Unit
TOXE	Front gate equivalent oxide thickness (EOT)	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
TSI	Silicon or SiGe film thickness	10^{-8}	$3\ 10^{-9}$	$2\ 10^{-8}$	m
XGE	Fraction of germanium content in the channel	0.0	0.0	1.0	
TBOX	Back gate equivalent oxide thickness (EOT)	10^{-7}	$3\ 10^{-10}$	10^{-6}	m
NSUB	Backplane doping level: positive = p-type, negative = n-type	$3\ 10^{18}$	10^{16}	10^{21}	cm^{-3}
CT	Interface states factor	0.0	0.0		
TOXP	Front gate physical oxide thickness	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
NOV	Effective doping level of overlap-LDD regions	10^{20}	10^{15}	10^{21}	cm^{-3}
NOVD	Effective doping level of overlap-LDD regions at drain side	10^{20}	10^{15}	10^{21}	cm^{-3}
VFB	Front gate workfunction referenced to Si midgap at TR	0.0			V
VFBB	Back gate workfunction offset at TR	0.0			V

Name	Description	Default	Min.	Max.	Unit
STVFB	Temperature dependence of VFB and VFBB	0.0			V/K
CICF	Long channel front interface coupling coefficient	1.0	0.1	10.0	
CIC	Long channel back interface coupling coefficient	1.0	0.1	10.0	
PSCE	Short channel coupling attenuation parameter	0.0	-0.5	5.0	
PSCEB	Short channel back to front interface asymmetry factor	1.0	0.0		
PSCEDL	Short channel modulation due to Leff dependence on biases	0	0		
PNCE	Narrow channel effect on body factor	0	-1	1	
CF	Drain Induced Barrier Lowering (DIBL) parameter at TR	0.0	0.0		
CFB	DIBL back to front interface asymmetry factor	1.0	0.0		
STCF	Temperature dependence of CF	0.0			K^{-1}
CFD	Drain voltage dependence parameter of DIBL	0.2	0.05		V
CFDL	DIBL modulation due to Leff dependence on biases	0			
BETN	Front channel aspect ratio times low field mobility at TR	0.05	10^{-10}		m^2/Vs
BETNB	Back channel over front channel low field mobility ratio	1.0	0.1	10.0	
STBET	Temperature dependence exponent of BETN	1.5			
CS	Coulomb scattering parameter at TR	0.0	0.0		
STCS	Temperature dependence exponent of CS	0			
THECS	Coulomb scattering exponent at TR	1.5	0		

Name	Description	Default	Min.	Max.	Unit
STTHECS	Temperature dependence exponent of THECS	0			
CSTHR	Coulomb scattering threshold level	2	0.001		
MUE	High field mobility reduction coefficient at TR	0	0		cm/MV
STMUE	Temperature dependence exponent of MUE	0			
THEMU	High field mobility reduction exponent at TR	1.5	0		
STTHEMU	Temperature dependence exponent of THEMU	0			
XCOR	High field mobility non universality factor at TR	0			V^{-1}
STXCOR	Temperature dependence exponent of XCOR	0			
FETA	Transverse effective field parameter	1	0		
RS	Source/drain series resistance at TR	30	0		Ω
STRS	Temperature dependence exponent of RS	0			
RSG	Transverse electric field dependence of RS	0	-0.5		
THERSG	Transverse electric field exponent of RS	2			
THESAT	Velocity saturation parameter at TR	0	0		V^{-1}
STTHESAT	Temperature dependence exponent of THESAT	-0.1			
THESATG	Front gate bias dependence of velocity saturation	0	-0.5		
THESATB	Back gate bias dependence of velocity saturation	0	-0.5		
AX	Linear/saturation transition exponent	8	1	12	
ALP	Channel length modulation pre-factor	0	0		

Name	Description	Default	Min.	Max.	Unit
ALP1	Channel length modulation enhancement above threshold	0	0		V
VP	Channel length modulation logarithm dependence factor	0.05	10^{-10}		V
GCO	Gate tunneling energy adjustment in inversion mode	0	-10	10	
IGINV	Gate to channel current pre-factor	0	0		A
IGOVINV	Gate–overlap current pre-factor in inversion	0	0		A
IGOVINVD	Gate–overlap current pre-factor in inversion at drain side	0	0		A
IGOVACC	Gate–overlap current pre-factor in accumulation	0	0		A
IGOVACCD	Gate–overlap current pre-factor in accumulation at drain side	0	0		A
STIG	Temperature dependence of all gate current pre-factors	0			
GC2CH	Gate to channel current slope factor	0.375	0	10	
GC3CH	Gate to channel current curvature factor	0.063	-2	2	
GC2OVINV	Gate–overlap current slope factor in inversion	0.375	0	10	
GC3OVINV	Gate–overlap current curvature factor in inversion	0.063	-2	2	
GC2OVACC	Gate-overlap current slope factor in accumulation	0.375	0	10	
GS3OVACC	Gate-overlap current curvature factor in accumulation	0.063	-2	2	
CHIB	Tunneling barrier height	3.1	1		eV
NIGINV	Gate tunneling slope adjustment in subthreshold regime	0	0		

Name	Description	Default	Min.	Max.	Unit
AGIDL	GIDL/GISL current pre-factor	0	0		A/V^3
AGIDLD	GIDL current pre-factor at drain side	0	0		A/V^3
BGIDL	GIDL/GISL probability factor at TR	41	0		V
BGIDLD	GIDL probability factor at TR at drain side	41	0		V
STBGIDL	Temperature dependence of BGIDL	0			V/K
STBGIDLD	Temperature dependence of BGIDLD	0			V/K
CGIDL	Substrate bias dependence of GIDL/GISL	0			
CGIDLD	Substrate bias dependence of GIDL at drain side	0			
AREAQ	Effective channel area for intrinsic charge model	10_{-12}	10_{-18}		m^2
CGBOV	Oxide capacitance for gate to substrate overlap	0	0		F
COV	Overlap capacitance per side	0	0		F
COVD	Overlap capacitance at drain side	0	0		F
COVDL	Overlap capacitance modulation due to Leff bias-dependence	0	0		
CFR	Outer fringe capacitance per side	0	0		F
CFRD	Outer fringe capacitance at drain side	0	0		F
CSD	Drain to source direct capacitance	0	0		F
CSDBP	Drain/source to substrate perimeter capacitance	0	0		F/m
RTH	Thermal resistance	10^4	10_{-6}		K/W

Name	Description	Default	Min.	Max.	Unit
STRTH	Temperature dependence of RTH	0.0			
CTH	Thermal capacitance	10_{-11}	0.0		J/K
FNT	Thermal noise coefficient	1.0	0.0		
FNTEXC	Excess noise coefficient	0.0			
NFA	First coefficient of flicker noise	$8\ 10^{22}$	0.0		V_{-1} m_{-4}
NFB	Second coefficient of flicker noise	$3\ 10^{7}$	0.0		V_{-1} m_{-2}
NFC	Third coefficient of flicker noise	0.0	0.0		V^{-1}
NFE	Front interface transverse field effect coefficient	0.0	-1.0	1.0	
NFEB	Back interface transverse field effect coefficient	0.0	-1.0	1.0	
EF	Frequency dependence exponent of flicker noise	1.0	0.1		

Global Level Parameters

Name	Description	Default	Min.	Max.	Unit
TOXEO	Geometry independent global scale parameter for TOXE	$2\ 10^{-9}$	$3\ 10^{-10}$	10^{-6}	m
TSIO	Geometry independent global scale parameter for TSI	10^{-8}	$3\ 10^{-9}$	$2\ 10^{-8}$	m
TBOXO	Geometry independent global scale parameter for TBOX	10^{-7}	$3\ 10^{-10}$	10^{-6}	m
XGEO	Geometry independent global scale parameter for XGE	0.0	0.0	1.0	
NSUBO	Geometry independent global scale parameter for NSUB	$3\ 10^{18}$	10^{16}	10^{21}	cm^{-3}

Name	Description	Default	Min.	Max.	Unit
CTO	Geometry independent global scale parameter for CT	0.0	0.0		
TOXPO	Geometry independent global scale parameter for TOXP	2 10^{-9}	3 10^{-10}	10^{-6}	m
NOVO	Geometry independent global scale parameter for NOV	10^{20}	10^{15}	10^{21}	cm^{-3}
NOVDO	Geometry independent global scale parameter for NOVD	10^{20}	10^{15}	10^{21}	cm^{-3}
VFBO	Long and wide channel value of VFB	0.0			V
VFBL	Channel length scaling parameter of VFB	0.0			V
VFBLEXP	Channel length scaling exponent of VFB	2.0			
VFBW	Channel width scaling parameter of VFB	0.0			V
VFBLW	Channel area scaling parameter of VFB	0.0			
VFBBO	Long and wide channel value of VFBB	0.0			V
VFBLBO	Back to front interface asymmetry factor applied to VFBL	1.0	0.0		
STVFBO	Long and wide channel value of STVFB	0.0			V/K
STVFBL	Channel length scaling parameter of STVFB	0.0			
STVFBW	Channel width scaling parameter of STVFB	0.0			
STVFBLW	Channel area scaling parameter of STVFB	0.0			
CICFO	Geometry independent global scale parameter for CICF	1.0	0.1	10.0	
CICO	Geometry independent global scale parameter for CIC	1.0	0.1	10.0	
PSCEL	Channel length scaling parameter of PSCE	0.0			

Name	Description	Default	Min.	Max.	Unit
PSCELEXP	Channel length scaling exponent of PSCE	2.0			
PSCEW	Channel width scaling parameter of PSCE	0.0			
PSCEBO	Geometry independent global scale parameter for PSCEB	1.0	0.0		
PSCEDLL	Channel length scaling parameter of PSCEDL	0			
PSCEDLW	Channel width scaling parameter of PSCEDL	0			
PNCEW	Channel width scaling parameter of PNCE	0			
CFL	Channel length scaling parameter of CF	0. 0			
CFLEXP	Channel length scaling exponent of CF	2.0			
CFW	Channel width scaling parameter of CF	0.0			
CFBO	Geometry independent global scale parameter for CFB	1.0	0.0		
STCFO	Geometry independent global scale parameter for STCF	0.0			K^{-1}
CFDO	Geometry independent global scale parameter for CFD	0.2	0.05		V
CFDLL	Channel length scaling parameter of CFDL	0			
CFDLW	Channel length scaling parameter of CFDL	0			
UO	Front channel low field mobility at TR	0.05			m^2/Vs
BETNL	Second order channel length dependence of BETN	0.0			
BETNLEXP	Second order channel length exponent of BETN	1.0			
BETNW	Second order channel width dependence of BETN	0.0			
BETNBO	Geometry independent global scale parameter for BETNB	1.0	0.0		

Name	Description	Default	Min.	Max.	Unit
STBETO	Long and wide channel value of STBET	1.5			
STBETL	Channel length scaling parameter of STBET	0.0			
STBETW	Channel width scaling parameter of STBET	0.0			
STBETLW	Channel area scaling parameter of STBET	0.0			
CSO	Long and wide channel value of CS	0.0			
CSL	Channel length scaling parameter of CS	0.0			
CSLEXP	Geometry independent global scale parameter for CS	1.0			
CSW	Channel width scaling parameter of CS	0.0			
CSLW	Channel area scaling parameter of CS	0.0			
STCSO	Geometry independent global scale parameter for STCS	0			
THECSO	Geometry independent global scale parameter for THECS	1.5	0		
STTHECSO	Geometry independent global scale parameter for STTHECS	0			
CSTHRO	Geometry independent global scale parameter for CSTHR	2	0.001		
MUEO	Geometry independent global scale parameter for MUE	0	0		cm/MV
STMUEO	Geometry independent global scale parameter for STMUE	0			
THEMUO	Geometry independent global scale parameter for THEMU	1.5	0		
STTHEMUO	Geometry independent global scale parameter for STTHEMU	0			
XCORO	Long and wide channel value of XCOR	0			V^{-1}

Name	Description	Default	Min.	Max.	Unit
XCORL	Channel length scaling parameter of XCOR	0			
XCORLEXP	Channel length scaling exponent of XCOR	1			
XCORW	Channel width scaling parameter of XCOR	0			
XCORLW	Channel area scaling parameter of XCOR	0			
STXCORO	Geometry independent global scale parameter for STXCOR	0			
FETAO	Geometry independent global scale parameter for FETA	1	0		
RSW1	Source/drain series resistance for a WEN width at TR	30			Ω
RSW2	Second order width scaling parameter of RS	0			
STRSO	Geometry independent global scale parameter for STRS	0			
RSGO	Geometry independent global scale parameter for RSG	0	-0.5		
THERSGO	Geometry independent global scale parameter for THERSG	2			
THESATO	Long and wide channel parameter for THESAT	0	0		V^{-1}
THESATL	Channel length scaling parameter of THESAT	0			
THESATLEXP	Channel length scaling exponent of THESAT	1			
THESATW	Channel width scaling parameter of THESAT	0			
THESATLW	Channel area scaling parameter of THESAT	0			
STTHESATO	Long and wide channel value of STTHESAT	-0.1			
STTHESATL	Channel length scaling parameter of STTHESAT	0			

Name	Description	Default	Min.	Max.	Unit
STTHESATW	Channel width scaling parameter of STTHESAT	0			
STTHESATLW	Channel area scaling parameter of STTHESAT	0			
THESATGO	Geometry independent global scale parameter for THESATG	0	-0.5		
THESATBO	Geometry independent global scale parameter for THESATB	0	-0.5		
AXO	Long and wide channel value of AX	8			
AXL	Channel length scaling parameter of AX	0	0		
AXLEXP	Channel length scaling exponent of AX	1			
ALPL1	Channel length scaling parameter of ALP	0			
AXL2	Second order length dependence of AX	0			
AXLEXP2	Exponent for second order length dependence of AX	1.5			
ALPLEXP	Channel length scaling exponent of ALP	1			
ALPL2	Second order channel length dependence of ALP	0	0		
ALPW	Channel width scaling parameter of ALP	0			
ALP1L1	Channel length scaling parameter of ALP1	0			
ALP1LEXP	Channel length scaling exponent of ALP1	0.5			
ALP1L2	Second order channel length dependence of ALP1	0	0		
ALP1W	Channel width scaling parameter of ALP1	0			
VPO	Geometry independent global scale parameter for VP	0.05	10^{-10}		V
GCOO	Geometry independent global scale parameter for GCO	0	-10	10	

Name	Description	Default	Min.	Max.	Unit
IGINVLW	IGINV value for a LEN.WEN area	0	0		A
IGOVINVW	IGOVINV value for a WEN width	0	0		A
IGOVINVDW	IGOVINVD for a WEN width	0	0		A
IGOVACCW	IGOVACC value for a WEN width	0	0		A
IGOVACCDW	IGOVACCD value for a WEN width	0	0		A
STIGO	Geometry independent global scale parameter for STIG	0			
GC2CHO	Geometry independent global scale parameter for GC2CH	0.375	0	10	
GC3CHO	Geometry independent global scale parameter for GC3CH	0.063	-2	2	
GC2OVINVO	Geometry independent global scale parameter for GC2OVINV	0.375	0	10	
GC3OVINVO	Geometry independent global scale parameter for GC3OVINV	0.063	-2	2	
GC2OVACCO	Geometry independent global scale parameter for GC2OVACC	0.375	0	10	
GC3OVACCO	Geometry independent global scale parameter for GC3OVACC	0.063	-2	2	
CHIBO	Geometry independent global scale parameter for CHIB	3.1	1		eV
NIGINVO	Geometry independent global scale parameter for NIGINV	0	0		
AGIDL0	GIDL geometry independent pre-factor	0			A/V^3
AGIDLD0	GIDL geometry independent pre-factor at drain side	0			A/V^3
AGIDLW	AGIDL value for a WEN width	0	0		A/V^3
AGIDLDW	AGIDLD value for a WEN width	0	0		A/V^3

Name	Description	Default	Min.	Max.	Unit
BGIDLO	Geometry independent global scale parameter for BGIDL	41	0		V
BGIDLDO	Geometry independent global scale parameter for BGIDLD	41	0		V
STBGIDLO	Geometry independent global scale parameter for STBGIDL	0			V/K
STBGIDLDO	Geometry independent global scale parameter for STBGIDLDV^-1	0			V/K
CGIDLO	Geometry independent global scale parameter for CGIDL	0			
CGIDLDO	Geometry independent global scale parameter for CGIDLD	0			
DGIDL0	High field geometry independent parameter of GIDL	0			V^-1
DGIDLD0	High field geometry independent parameter of GIDL at drain side	0			V^-1
CGBOVL	CGBOV value for a LEN length	0	0		F
LOVO	Overlap length for gate/source-drain overlap capacitance	0	0		m
LOVDO	Overlap length for gate/drain overlap capacitance	0	0		m
COVDLO	Wide channel parameter for COVDL	0			
COVDLW	Channel width scaling parameter of COVDL	0			
CFRO	Corner related outer fringe capacitance	0			F
CFRW	Outer fringe capacitance per side for a WEN width	0			F
CFRDO	Corner related outer fringe capacitance at drain side	0			F
CFRDW	Outer fringe capacitance at drain side for a WEN width	0			F
CSDO	Drain to source direct capacitance correction factor	1	0		
CSDBPO	Geometry independent global scale parameter for CSDBP	0	0		F/m

Name	Description	Default	Min.	Max.	Unit
RTHO	Geometry independent global scale parameter for RTH	10^5			K/W
RTHL	Channel length scaling parameter of RTH and CTH	0.0			
RTHW	Channel width scaling parameter of RTH and CTH	0.0			
RTHLW	Channel area scaling parameter of RTH and CTH	9.0			
STRTHO	Geometry independent global scale parameter for STRTH	0.0			
CTHO	Geometry independent global scale parameter for CTH	10_{-12}			J/K
FNTO	Geometry independent global scale parameter for FNT	1.0	0.0		
FNTEXCL	Length dependence coefficient of excess noise	0			
FNTEXCLEXP	Length dependence exponent of excess noise	2			
NFALW	NFA value for a LEN.WEN area	$8\ 10^{22}$	0.0		V_{-1} m_{-4}
NFBLW	NFB value for a LEN.WEN area	$3\ 10^7$	0.0		V_{-1} m_{-2}
NFCLW	NFC value for a LEN.WEN area	0.0	0.0		V^{-1}
NFEO	Geometry independent global scale parameter for NFE	0.0	-1.0	1.0	
NFEBO	Geometry independent global scale parameter for NFEB	0.0	-1.0	1.0	
EFO	Geometry independent global scale parameter for EF	1.0	0.1		

Model Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

```
model modelName utsoi211 [param=value]
```

Example: model utsoi2model utsoi211 GENDER=1

Instance Netlist Format

```
modelName [:Name] d g s b
```

where, d is the drain node, g is the gate node, s is the source node, and b is the body (substrate) node.

Example: utsoi2model:M1 d g s b MULT=1

Keysight Si or SiC PowerMOS Model

Description

Keysight SiC PowerMOS Model

SiC PowerMOS Model

SiC Power metal–oxide–semiconductor field-effect transistor (MOSFET) model which is used to model discrete power electronic devices.

NOTE The PowerMOS_SiC model is developed based on the Angelov/Chalmers GaN model.

NOTE PowerMOS_SiC power devices operate under a very wide range of voltage and current slew rates and it is a challenge to create a model that converges under all conditions – especially conditions that depend upon what components are connected externally to the power device in the circuit schematic. Please contact technical support if you encounter such an issue when attempting to use this model.

Parameter Table

PowerMOS Model Parameter

Parameter Name	Parameter Description	Unit	Minimum	Default	Maximum
PFET	Only NFET supported		0	0	0
W	Unused: gate width		0	1u	inf
Ng	Unused: gate fingers		0	1	inf
Mode	Unused		0	1	1
Noise	Globally disable noise		0	1	2
Noimod	Noise model (0=def, 1=PRC, 2= not supported)		0	0	2
Selft	Flag for self-heating		0	0	1
Trise	Difference sim. temp and device temp,	C	-inf	0.0	inf
Temp	Device temp (only used if Trise is zero)	C	273.15	25.0	inf

Idsmod	Ids Current Model (0 or 1)		0	1.000	1
Igmod	Select gate diode model		0	1.000	1
Capmod	Select cap model		0	2.000	2
Tempmod	Select Temp model		0	1.000	1
Ipk0	Current for max. transconductance Ipk	A		35.72	
Vpks	Gate voltage Vpk for max transconductance	V		14.73	
Dvpks	Delta gate voltage at peak gm	V		0.000	
P1	Polynomial coeff P1 for channel current	1/V		167.1m	
P2	Polynomial coeff P2 for channel current	$1/V^2$		-23.26m	
P3	Polynomial coeff P3 for channel current	$1/V^3$		661.8u	
Alphar	Saturation parameter alpha_r	1/V		156.3m	
Alphas	Saturation parameter alpha	1/V		1.112	
Vkn	Knee voltage	V		800.0m	
Lambda	Channel length modulation parameter			1.000	
Lambda1	Channel length modulation parameter			7.936m	
Lambda2	Channel length modulation parameter			882.3m	
Lvg	Coeff for channel length modulation parameter			0.000	
B1	Unsaturated coeff B1 for P1			7.681m	
B2	Saturated coeff B2 for P1	1/V		44.41a	
Lsb0	Soft breakdown model parameter			0.000	

Vtr	Soft breakdown model parameter	V		20.00	
Vsb2	Surface breakdown model parameter	V		0.000	
Ebd	Surface breakdown model parameter	1/V		0.000	
Cds	Zero-bias D-S junction capacitance	F	0	0.000	inf
Cgspi	Gate-source pinch-off capacitance	F		0.0	
Cgs0	Gate-source capacitance parameter	F		0.0	
Cgs0i	Gate-source capacitance parameter	F		0.0	
Cgdpi	Gate-drain pinch-off capacitance	F		0.0	
Cgdpe	External G-D Capacitor	F	0	0.000	inf
Cgd0	Gate-drain capacitance parameter Cgdo	F		0.0	
Cgdfunc	Gate-drain capacitance parameter			0.5	
Cgdpi2	Gate-drain pinch-off capacitance	F		0.0	
Cgd02	Gate-drain capacitance parameter	F		424.7p	
P10	Polynomial coeff P10 for capacitance		-10	0.000	100
P11	Polynomial coeff P11 for capacitance		-10	1.000	100
P20	Polynomial coeff P20 for capacitance		-10	-2.071	100
P21	Polynomial coeff P21 for capacitance		-10	217.7m	100
P10i	Polynomial coeff P10i for capacitance		-10	-4.270	100

P11i	Polynomial coeff P11i for capacitance		-10	-1.155	10
P20i	Polynomial coeff P20i for capacitance		-2	0.0	5
P21i	Polynomial coeff P21i for capacitance		-5	0.2	5
P30	Polynomial coeff P30 for capacitance		-10	0.0	100
P31	Polynomial coeff P31 for capacitance		-10	0.2	100
P302	Polynomial coeff P302 for capacitance		-10	0.0	100
P312	Polynomial coeff P312 for capacitance		-10	0.2	100
P40	Polynomial coeff P40 for capacitance		-10	-2.770	100
P41	Polynomial coeff P41 for capacitance		-10	803.3m	100
P402	Polynomial coeff P402 for capacitance		-10	0.000	100
P412	Polynomial coeff P412 for capacitance		-10	1.000	100
P111	Polynomial coeff P111 for capacitance		0	0.000	1
P222	Polynomial coeff P222 for capacitance		0	0.000	5
m	Coefficient for capacitance			1.000	
Ij	Gate fwd saturation current	A	0	0.000	inf
Pg	Gate current parameter		0	15.0	inf
Ne	Gate p-n emission coeff		0	1.400	inf exclude 0
Vjg	Gate current parm	V	0	700.0m	inf exclude 0
Rg	Gate ohmic resistance	Ohm	0	0.000	inf
Rd	Drain ohmic resistance	Ohm	0	41.06m	inf

Rd2	Variable Drain ohmic resistance	Ohm	0	0.000	inf
Ri	Input resistance	Ohm	0	1.000u	inf
Rs	Source ohmic resistance	Ohm	0	37.15m	inf
Rgd	Gate resistance	Ohm	0	1.000u	inf
Ld	Drain ohmic inductance	H	0	0.000	inf
Ls	Source ohmic inductance	H	0	0.000	inf
Lg	Gate ohmic inductance	H	0	0.000	inf
Tau	Device delay	s	0	0.000	inf
Rcmin	Min value of Rc	Ohm	0	1.000k	inf
Rc	R for freq dep output cond	Ohm	0	10.00k	inf
Crf	C for freq dep output cond	F		0.000	
Rcin	R for freq dep input cond	Ohm	0	100.0k	inf
Crfin	C for freq dep input cond	F	0	0.000	inf
Rdel	R for freq dep input cond	Ohm	0	0.000	inf
Cdel	C for freq dep input cond	F	0	0.000	inf
Kbgate	Polynomial coeff Kbgate for freq dep input cond	1/V		0.000	
Rth	Thermal resistance	K/W	0.001	1.000m	inf
Cth	Thermal capacitance	Ws/K	0.00001	1.000m	inf
Tcipk0	Linear temp coef TIpk for Ipk0	1/K		10.39m	
Tcipk01	Linear temp coef TIpk for Ipk0	1/K		0.000	
Tcipk02	Linear temp coef TIpk for Ipk0	1/K		0.000	
Tcvpks	Linear temp coef TVpks for Vpks	1/K		-40.30m	

Tcvpks1	Linear temp coef TVpks for Vpks	1/K		0.000	
Tcvpks2	Linear temp coef TVpks for Vpks	1/K		0.000	
Tcp1	Linear temp coef TP1 for P1	1/K		-500.0u	
Tccgs0	Linear temp coef for Cgs0	1/K		0.000	
Tccgd0	Linear temp coef for Cgd0	1/K		0.000	
Tclsb0	Linear temp coef for Lsb0	1/K		0.000	
Tcrc	Linear temp coef for Rc	1/K		0.000	
Tccrf	Linear temp coef for Crf	1/K		0.000	
Tcrd	Linear temp coef for Rd	1/K		2.989m	
Tcrs	Linear temp coef for Rs	1/K		0.000	
TcRtherm	Linear temp coef for Rth	1/K		2.000m	
Kbdgate	Gate breakdown parm	V	0	0.000	inf
Vbdgs	Gate source breakdown voltage	V	0	0.000	inf
Vbdgd	Gate drain breakdown voltage	V	0	0.000	inf
Pbdg	Gate breakdown exponent	1/V	0	500.0m	inf exclude 0
Vj	Junction potential	V		128.8m	
Mm	Grading coef		0	564.7m	inf
Fc	Forward bias junct parm		0	500.0m	1
NoiseR	Gate noise coeff		0	500.0m	inf
NoiseP	Gate noise coeff		0	1.000	inf
NoiseC	Gate-drain noise coeff		0	900.0m	inf
Fnc	Noise corner freq	Hz	0	0.000	inf
Kf	Flicker noise coeff		0	0.000	inf

Af	Flicker noise exponent		0	1.000	inf
Ffe	Flicker noise parameter		0	1.000	inf
Tg	Equiv temp	C	273.15	25.0	inf
Td	Equiv temp	C	273.15	25.0	inf
Td1	Equiv temp	C	-inf	100.0m	inf
Tmn	noise fitting coeff		-inf	1.000	inf
Klf	Flicker noise exponent		-inf	0.000	inf
Fgr	G-R freq corner	Hz	-inf	0.000	inf
Np	flicker noise freq exp		-inf	1.000	inf
Lw	effective gate noise width	mm	-inf	0.1	inf
Tnom	param meas T	C	273.15	25.0	inf

Diode Model Parameter

Parameter Name	Parameter Description	Units	Default
IS	Saturation current (diode equation)	A	85.12n
RS	Parsitic resistance (series resistance)	Ohm	100.0m
N	Emission coefficient, 1 to 2	-	4.867
TT	Transit time	s	0
CJO	Zero-bias junction capacitance	F	2.793n
VJ	Junction potential	V	892.9m
M	Junction grading coefficient: 0.33 for linearly graded junction / 0.5 for abrupt junction	-	469.4m
EG	Activation energy: Si: 1.11 / Ge: 0.67 / Schottky: 0.69	eV	1.100
XTI	IS temperature exponent: P-N junction: 3.0 / Schottky: 2.0	-	10.00
KF	Flicker noise coefficient	-	0
AF	Flicker noise exponent	-	1
FC	Forward bias depletion capacitance coefficient	-	0.5

BV	Reverse breakdown voltage	V	inf
IBV	Reverse breakdown current	A	1.000p

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

For PowerMOS_SiC, we need to define two model cards (MOS, Diode) and pass these model names to the PowerMOS_SiC_Keysight instance.

```
model modelname sic_mos_va [parm=value]\*
```

```
model modelname Diode [parm=value]\*
```

```
#uselib "pelib","PowerMOS_SiC_Keysight"
```

```
PowerMOS_SiC_Keysight:PowerMOS1 D G S _PowerMOS_SiC_Model=modelname
_Diode_DS_Model=modelname
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by the instance to refer to the model. The third parameter indicates the type of model. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example

```
model PowerMOS_SiC_M1_MOS sic_mos_va Noimod=0 Selft=0 Idsmod=1 Igmod=1 Capmod=2
Tempmod=1 Ipk0=35.72
```

```
model PowerMOS_SiC_M1_DIODE Diode Tlevc=1.000  Is=85.12n N=4.867  Ikf=1.000
Rs=100.0m Bv=1.000MEG Ibv=1.000p
```

```
#uselib "pelib","PowerMOS_SiC_Keysight"
```

```
PowerMOS_SiC_Keysight:PowerMOS1 D G 0 _PowerMOS_SiC_Model=PowerMOS_SiC_M1_MOS
_Diode_DS_Model=PowerMOS_SiC_M1_DIODE
```

Keysight IGBT Model

Keysight IGBT Model

This page is summarizing the Insulated-Gate Bipolar Transistor (IGBT) model which is used to model discrete power electronic devices.

NOTE You can refer to the example located in **$HPEESOF_DIR/examples/PE/IGBT_Example_wrk**. Refer Simulation of Keysight IGBT Model for an example of how to use this model.

IGBT MOS Model Parameter

NOTE The parameter values populated on the model card for BJTs and Diode are not the default values. The default values are as listed in this section.

Parameter Name	Parameter Description	Unit	Minimum	Default	Maximum
Idsmod	Ids Current Model (0 or 1)		0	1.000	1
Capmod	Capacitance Model (0 or 1)		0	1.000	1
Tempmod	Select Temp model		0	1.000	1
Ipk0	Current for max. transconductance Ipk	A		2.354	
Vpks	Gate voltage Vpk for max transconductance	V		13.30	
Dvpks	Delta gate voltage at peak gm	V		442.8m	
P1	Polynomial coeff P1 for channel current	1/V		169.2m	
P2	Polynomial coeff P2 for channel current	$1/V^2$		11.02m	

Parameter Name	Parameter Description	Unit	Minimum	Default	Maximum
P3	Polynomial coeff P3 for channel current	$1/V^3$		6.475m	
P4	Polynomial coeff P4 for channel current	$1/V^4$		-266.4u	
P5	Polynomial coeff P5 for channel current	$1/V^5$		-8.626u	
Alphar	Saturation parameter alpha_r	1/V		566.8m	
Alphas	Saturation parameter alpha	1/V		503.8m	
Lambda	Channel length modulation parameter			634.8u	
Lvg	Coeff for channel length modulation parameter			0.000	
B1	Unsaturated coeff B1 for P1			85.06m	
B2	Saturated coeff B2 for P1	1/V		36.03m	
Cdspi	Zero-bias D-S junction capacitance	F		1.000p	
Cds0	Zero-bias D-S junction capacitance	F		0.0	
Cgspi	Gate-source pinch-off capacitance	F		293.6p	
Cgs0	Gate-source capacitance parameter	F		10.02p	
Cgdpi	Gate-drain pinch-off capacitance	F		5.867p	
Cgd0	Gate-drain capacitance parameter Cgdo	F		1.000p	

Parameter Name	Parameter Description	Unit	Minimum	Default	Maximum
Cgs02	Gate-source capacitance parameter	F		1.000f	
Cgd02	Gate-drain capacitance parameter Cgdo	F		428.4p	
Cgs0a	Gate-source capacitance parameter	F		1.283n	
P10a	Polynomial coeff P10 for capacitance		-100	-4.308	100
P11a	Polynomial coeff P11 for capacitance		-10	-5.012	10
P10	Polynomial coeff P10 for capacitance		-100	-9.900	100
P11	Polynomial coeff P11 for capacitance		-10	3.594	10
P20	Polynomial coeff P20 for capacitance		-100	6.933m	100
P21	Polynomial coeff P21 for capacitance		-10	1.395	10
P30	Polynomial coeff P30 for capacitance		-100	0.000	100
P31	Polynomial coeff P31 for capacitance		-10	200.0m	10
P40	Polynomial coeff P40 for capacitance		-100	-736.1m	100
P41	Polynomial coeff P41 for capacitance		-10	1.492	10
P50	Polynomial coeff P10 for capacitance		-100	0.000	100

Parameter Name	Parameter Description	Unit	Minimum	Default	Maximum
P51	Polynomial coeff P11 for capacitance		-10	-200.0m	10
P111	Polynomial coeff P111 for capacitance		-1	0.000	1
M	Coefficient for capacitance			1.000	
P202	Polynomial coeff P20 for capacitance		-100	0.000	100
P212	Polynomial coeff P21 for capacitance		-10	200.0m	10
P302	Polynomial coeff P30 for capacitance		-100	833.0m	100
P312	Polynomial coeff P31 for capacitance		-10	5.430	10
Vj	Junction potential	V		142.6m	
Mm	Grading coef		0	544.2m	inf
Fc	Forward bias junct parm		0	500.0m	1
Rgd	Gate-Drain resistance	Ohm	0	19.62	inf
Rgs	Gate-Source resistance	Ohm	0	332.4m	inf
Rds	Drain-Source resistance	Ohm	0	50.00m	inf
Rgi	Gate ohmic resistance	Ohm	0	0.000	inf
Rdi	Drain ohmic resistance	Ohm	0	180.7m	inf
Rd0	Drain ohmic resistance	Ohm	0	0.000	inf
P10rd	Polynomial coeff P10 for capacitance		-100	0.000	100

Parameter Name	Parameter Description	Unit	Minimum	Default	Maximum
P11rd	Polynomial coeff P11 for capacitance		-10	1.000	10
P20rd	Polynomial coeff P20 for capacitance		-100	0.000	100
P21rd	Polynomial coeff P21 for capacitance		-10	-200.0m	10
Rsi	Source ohmic resistance	Ohm	0	1.171	inf
Rs0	Source ohmic resistance	Ohm	0	0.000	inf
P10rs	Polynomial coeff P10 for capacitance		-100	0.000	100
P11rs	Polynomial coeff P11 for capacitance		-10	1.000	10
P20rs	Polynomial coeff P20 for capacitance		-100	0.000	100
P21rs	Polynomial coeff P21 for capacitance		-10	-200.0m	10
Rth	Thermal resistance	K/W	0.001	3.476	inf
Cth	Thermal capacitance	Ws/K	0.00001	100.0u	inf
Tcipk0	Linear temp coef TIpk for Ipk0	1/K		-1.709m	
Tcipk01	Linear temp coef TIpk for Ipk0	1/K		0.000	
Tcipk02	Linear temp coef TIpk for Ipk0	1/K		0.000	
Tcvpks	Linear temp coef TVpks for Vpks	1/K		15.57m	

Parameter Name	Parameter Description	Unit	Minimum	Default	Maximum
Tcvpks1	Linear temp coef TVpks for Vpks	1/K		0.000	
Tcvpks2	Linear temp coef TVpks for Vpks	1/K		0.000	
Tcp1	Linear temp coef TP1 for P1	1/K		-428.5u	
Tccgs0	Linear temp coef for Cgs0	1/K		-500.0u	
Tccgd0	Linear temp coef for Cgd0	1/K		-500.0u	
Tcrd	Linear temp coef for Rd	1/K		50.00m	
Tcrs	Linear temp coef for Rs	1/K		0.003	
TcRtherm	Linear temp coef for Rth	1/K		2.000m	
Tnom	param meas T	C	-273.15	25.0	inf
Selft	Flag for self-heating		0	1.000	1
Trise	Difference sim. temp and device temp,	C	-inf	0.0	inf
Temp	Device temp (only used if Trise is zero)	C	-273.15	25.0	inf

IGBT Diode Model Parameter

Parameter Name	Parameter Description	Unit	Minimum	Default	Maximum
Icmod	Current Model (0 or 1)		0	0	1
Ct1	Cap at steady time		0	0	inf
Ct2	Cap at initial time		0	0	inf

Parameter Name	Parameter Description	Unit	Minimum	Default	Maximum
Ipk0	Current for max. transconductance Ipk	A		0.05	
Vpks	Gate voltage Vpk for max transconductance	V		-0.2	
Rs	Ohmic res	Ohm	0	0.1	inf
P1	Polynomial coeff P1 for channel current	1/V		0.8	
P2	Polynomial coeff P2 for channel current	$1/V^2$		0.0	
P3	Polynomial coeff P3 for channel current	$1/V^3$		0.0	
Tt	Device delay	s	0	1p	inf
Tirr	Device delay	s	0	1	inf
Ij	Gate fwd saturation current	A	0	0.00005	inf
Pg	Gate current parameter		0	15.0	inf
Ne	Gate p-n emission coeff		0	1.0	inf exclude 0
Vjg	Gate current parm	V	0	0.7	inf exclude 0
Kbdac	Gate breakdown parm	V	0	1.0	inf
Vbdac	Gate source breakdown voltage	V	0	5.0	inf
Pbdac	Gate breakdown exponent	1/V	0	0.5	inf exclude 0
Cjo	Junction Vapacitance at Vd=0		0	1p	inf

Parameter Name	Parameter Description	Unit	Minimum	Default	Maximum
Cjoi	Junction Vapacitance		0	1f	inf
Vj	Junction potential	v		1.0	
Mm	Grading coef		0	0.5	inf
Mm2	Grading coef		0	0.5	inf
Fc	Forward bias junct parm		0	0.5	1
Tccjo	Current for max. transconductance Ipk	A		0	
Rrev	ReverseRecovery resistance	K/W	0.001	0.001	inf
Crev	ReverseRecovery capacitance	Ws/K	1e-15	0.0001	inf

BJT Model Parameter

Parameter Name	Parameter Description	Units	Default
IS	transport saturation current	A	1.00E-16
BF	ideal max forward beta	-	100
NF	forward current emission coefficient	-	1
VAF	forward Early voltage	V	inf
IKF	corner for forward beta high current roll-off	A	inf
ISE	B-E leakage saturation current	A	0
NE	B-E leakage emission coefficient	-	1.5
BR	ideal max reverse beta	-	1

Parameter Name	Parameter Description	Units	Default
NR	reverse current emission coefficient	-	1
VAR	reverse Early voltage	V	inf
IKR	corner for reverse beta high current roll-off	A	inf
ISC	B-C leakage saturation current	A	0
NC	B-C leakage emission coefficient	-	2
RB	zero-bias base resistance	Ohm	0
IRB	current where base resistance falls half-way to its minimum	A	inf
RBM	minimum base resistance at high currents	Ohm	RB
RE	emitter resistance	Ohm	0
RC	collector resistance	Ohm	0
CJE	B-E zero-bias depletion capacitance	F	0
VJE	B-E built-in potential	V	0.75
MJE	B-E junction exponential factor	-	0.33
TF	ideal forward transit time	s	0
XTF	coefficient for bias dependence of TF	-	0
VTF	voltage describing VBC dependence of TF	V	inf
ITF	high-current parameter for effect on TF	A	0
PTF	excess phase at freq=1.0/(TF*2PI) Hz	deg	0
CJC	B-C zero-bias depletion capacitance	F	0

Parameter Name	Parameter Description	Units	Default
VJC	B-C built-in potential	V	0.75
MJC	B-C junction exponential factor	-	0.33
XCJC	fraction of B-C depletion capacitance connected to internal base node	-	1
TR	ideal reverse transit time	s	0
CJS	zero-bias collector-substrate capacitance	F	0
VJS	substrate junction built-in potential	V	0.75
MJS	substrate junction exponential factor	-	0
XTB	forward and reverse beta temperature exponent	-	0
EG	energy gap for temperature effect of IS	eV	1.1
XTI	temperature exponent for effect of IS	-	3
KF	flicker-noise coefficient	-	0
AF	flicker-noise exponent	-	1
FC	coefficient for forward-bias depletion capacitance formula	-	0.5
TNOM	parameter measurement temperature	C	27

NOTE The l,w,and nf parameters are not yet supported.

Netlist Format

Model statements for the ADS circuit simulator may be stored in an external file. This is typically done with foundry model kits. For more information on how to set up and use foundry model kits, refer to Design Kit Development.

For IGBT, we need to define four model cards (MOS, Diode, BJT1, BJT2) and pass these model names to the IGBT instance.

```
model modelname IGBT_MOS_va [parm=value]\*
model modelname IGBT_Diode_va [parm=value]\*
model modelname BJT [parm=value]\*
model modelname BJT [parm=value]\*
#uselib "pelib","IGBT_Keysight"
IGBT_Keysight:IGBT1 C G E _IGBT_MOS_Model=modelname _Diode_DS_Model=modelname
_BJT1_Model=modelname _BJT2_Model=modelname
```

The model statement starts with the required keyword *model*. It is followed by the *modelname* that will be used by the instance to refer to the model. The third parameter indicates the type of model. The rest of the model contains pairs of model parameters and values, separated by an equal sign. The name of the model parameter must appear exactly as shown in the parameters table-these names are case sensitive. Model parameters may appear in any order in the model statement. Model parameters that are not specified take the default value indicated in the parameters table. For more information about the ADS circuit simulator netlist format, including scale factors, subcircuits, variables and equations, refer to ADS Simulator Input Syntax.

Example

```
#uselib "pelib","IGBT_Keysight"
model IGBT_M1_MOS IGBT_MOS_va Idsmod=1 Capmod=1 Tempmod=1 Selft=1 Ipk0=2.354
model IGBT_M1_DIODE IGBT_DIODE_va Icmod=1.000 Ipk0=0.000 A Vpks=200.0m Rs=36.31m
model IGBT_M1_BJT1 BJT PNP=yes Is=903.7f Bf=27.95 Nf=1.194 Vaf=420.7 V Ikf=426.6
A
model IGBT_M1_BJT2 BJT PNP=yes Is=4.266p Bf=100.0 Nf=1.000 Vaf=1.000K Ikf=10.00
A

IGBT_Keysight:IGBT1 C G E _IGBT_MOS_Model=IGBT_M1_MOS
_Diode_DS_Model=IGBT_M1_DIODE _BJT1_Model=IGBT_M1_BJT1 _BJT2_Model=IGBT_M1_BJT2
```

Devices and Models, NXP SiMKit

EESOF VIEWABLE Warning : Auto Generated Page - be careful editing this version.
Much of this page is automatically generated. Be careful changing the information here. Only the text immediately below the headers, "Devices and Models, NXP SiMKit", "SiMKit Models in ADS" , " Versioned Models", and "List of all SiMKit Model Names" can be edited. Everything else is updated via confluence markup generated by scripts maintained by Darryl Okahata.
The script, "simkit/older-versions/utils/list-models", is used to create all of the tables and text after the initial text in "Versioned Models". This script creates confluence markup which is used to replace the tables and text.
The script, "simkit/older-versions/utils/create-columnized-devices", is used to generate the big table in "List of all SiMKit Model Names". This script creates confluence markup that replaces the entire table.
NOTE: this page uses macros that are specific to ADS releases. These macros are used in multiple places, which makes it easy to update this information.

Devices and Models, NXP SiMKit

The ADS circuit simulator supports the transistor models developed by NXP Semiconductors, called SiMKit. SiMKit Release 5.0 (April 2018) is currently the default release. With the exception of SiMKit 4.8, older versions of SiMKit, up to and including release 3.2 can now be accessed from ADS (see the next section). SiMKit 4.8 is not supported, because it was a short-lived release with an issue. The complete list of supported SiMKit releases is:

3.2 (Dec. 2008)	3.8 (Feb. 2012)	4.4 (Jan. 2015)	4.9 (May 2017)
3.3 (June 2009)	4.0 (July 2012)	4.5 (June 2015)	5.0 (April 2018)
3.4 (Dec. 2009)	4.0.1 (Jan. 2013)	4.6 (Dec. 2015)	
3.5.2 (Oct. 2010)	4.1 (July 2013)	4.7 (July 2016)	
3.6 (Jan. 2011)	4.2 (Jan. 2014)	~~4.8 (Dec. 2016)~~	
3.7 (Aug. 2011)	4.3 (Aug. 2014)	4.8.1 (Feb. 2017)	

The simulator will recognize these models and instances at the netlist level. Schematic level support for ADS is available by downloading the SiMKit design kit from the NXP website. However, this only supports recent SiMKit releases, and does not support accessing multiple SiMKit releases in ADS.
For more information, refer to the following *NXP SiMKit* website:

http://www.nxp.com/models

SiMKit Models in ADS

The current default SiMKit release is release 5.0 (April 2018). If a specific version is not specified for a device, the model in this release will be used. However, this is for models that are still supported in that release. There are model families that are no longer supported in SiMKit: mos1100, and bjt3500. If these are used, the last SiMKit release that supported these models will be used.

SiMKit models in older releases can be accessed by specifying a version number for the device model.

Versioned Models

A specific version of a device model can be specified via the "`version`" parameter on the device model card. Example:

```
model my_psp_model psp103  version=103.0  Gender=-1 Cfw=-0.07 Dlq=-1e-7 ...
```

See the tables below for supported version numbers for each device model. For entries where the version is "(unspecified)", that describes which release will be used if an explicit version is not specified.

Note: the value given for "`version`" can only be a floating-point number or an integer. It cannot be an expression or variable name that evaluates to a floating-point number or integer. If an expression or variable is used, this is either an error or warning, depending upon the value of the variable, "`SIM_IGNORE_NON_NUMERIC_VERSION_VALUES`", in the `hpeesofsim.cfg` config file:

- If enabled ("`y`" or "`1`"), the simulator will ignore model version values that are variables or expressions, which is what older versions of the simulator did; for this case, the latest model version will instead be used, but a warning will be displayed.
- If disabled ("`n`" or "`0`"), the simulator will give an error message and abort, if model versions are specified via a variable or expression (only numeric values are allowed).

Device model versioning is done by remapping model names/version numbers to a version-specific model name. For example, the psp103 model, version 103.0, gets renamed from "`psp103`" to "`psp103_simkit_release_3_2a`". These model names will appear in warnings, errors, and circuit censuses. (In ADS, SiMKit release 3.2 appears with an "`a`" suffix, such as "`3_2a`"; this is simply an historical naming artifact, and does not represent model changes from the official SiMKit release. This is also the only release for which an "`a`" suffix is used.)

Note that ADS still supports older models not present in the latest SiMKit releases:

- mos1100 family (last supported in SiMKit release 3.8)
- bjt3500 family (last supported in SiMKit release 4.7)

The "mos40" and "mos4000" model families are the same. These are different names for the same model.

As a special case, the use of a device in a specific SiMKit release, instead of a specific device version, can be forced through the use of special version numbers:

Version	SiMKit release to use
-3020000	SiMKit Release 3.2 (Dec. 2008)
-3030000	SiMKit Release 3.3 (June 2009)
-3040000	SiMKit Release 3.4 (Dec. 2009)
-3050200	SiMKit Release 3.5.2 (Oct. 2010)
-3060000	SiMKit Release 3.6 (Jan. 2011)
-3070000	SiMKit Release 3.7 (Aug. 2011)
-3080000	SiMKit Release 3.8 (Feb. 2012)
-4000000	SiMKit Release 4.0 (July 2012)
-4000100	SiMKit Release 4.0.1 (Jan. 2013)
-4010000	SiMKit Release 4.1 (July 2013)
-4020000	SiMKit Release 4.2 (Jan. 2014)
-4030000	SiMKit Release 4.3 (Aug. 2014)
-4040000	SiMKit Release 4.4 (Jan. 2015)
-4050000	SiMKit Release 4.5 (June 2015)
-4060000	SiMKit Release 4.6 (Dec. 2015)
-4070000	SiMKit Release 4.7 (July 2016)
-4080100	SiMKit Release 4.8.1 (Feb. 2017)
-5000000	SiMKit Release 5.0 (April 2018)

bjt3500

Note that the `bjt3500` model family is no longer supported in the latest SiMKit. They were last supported in release 4.7. If these models are used in ADS, the default will be the models in SiMKit release 4.7.

Version	SiMKit Release
(unspecified)	`bjt3500_simkit_release_4_7`
`2.71`	`bjt3500_simkit_release_4_0_1`
`2.72`	`bjt3500_simkit_release_4_7`

bjt3500t

Note that the `bjt3500` model family is no longer supported in the latest SiMKit. They were last supported in release 4.7. If these models are used in ADS, the default will be the models in SiMKit release 4.7.

Version	SiMKit Release
(unspecified)	`bjt3500t_simkit_release_4_7`
`2.71`	`bjt3500t_simkit_release_4_0_1`
`2.72`	`bjt3500t_simkit_release_4_7`

bjtd3500

Note that the `bjt3500` model family is no longer supported in the latest SiMKit. They were last supported in release 4.7. If these models are used in ADS, the default will be the models in SiMKit release 4.7.

Version	SiMKit Release
(unspecified)	`bjtd3500_simkit_release_4_7`
`2.71`	`bjtd3500_simkit_release_4_0_1`
`2.72`	`bjtd3500_simkit_release_4_7`

bjtd3500t

Note that the `bjt3500` model family is no longer supported in the latest SiMKit. They were last supported in release 4.7. If these models are used in ADS, the default will be the models in SiMKit release 4.7.

Version	SiMKit Release
(unspecified)	`bjtd3500t_simkit_release_4_7`
`2.71`	`bjtd3500t_simkit_release_4_0_1`
`2.72`	`bjtd3500t_simkit_release_4_7`

bjt500

Version	SiMKit Release
(unspecified)	(default simkit release)
`0.9`	`bjt500_simkit_release_3_3`
`0.1`	`bjt500_simkit_release_3_4`
`0.11`	`bjt500_simkit_release_3_5_2`
`0.12`	`bjt500_simkit_release_3_6`
`0.13`	`bjt500_simkit_release_3_7`
`0.14`	`bjt500_simkit_release_3_8`
`0.15`	`bjt500_simkit_release_4_0_1`
`0.16`	(default simkit release)

bjt500t

Version	SiMKit Release
(unspecified)	(default simkit release)
0.9	bjt500t_simkit_release_3_3
0.1	bjt500t_simkit_release_3_4
0.11	bjt500t_simkit_release_3_5_2
0.12	bjt500t_simkit_release_3_6
0.13	bjt500t_simkit_release_3_7
0.14	bjt500t_simkit_release_3_8
0.15	bjt500t_simkit_release_4_0_1
0.16	(default simkit release)

bjt504

Version	SiMKit Release
(unspecified)	(default simkit release)
504.71	bjt504_simkit_release_3_2a
504.8	bjt504_simkit_release_3_3
504.81	bjt504_simkit_release_3_4
504.9	bjt504_simkit_release_3_5_2
504.91	bjt504_simkit_release_3_7
504.1	bjt504_simkit_release_3_8

Version	SiMKit Release
504.101	bjt504_simkit_release_4_0_1
504.11	bjt504_simkit_release_4_3
504.111	bjt504_simkit_release_4_5
504.112	bjt504_simkit_release_4_7
504.121	(default simkit release)

bjt504t

Version	SiMKit Release
(unspecified)	(default simkit release)
504.71	bjt504t_simkit_release_3_2a
504.8	bjt504t_simkit_release_3_3
504.81	bjt504t_simkit_release_3_4
504.9	bjt504t_simkit_release_3_5_2
504.91	bjt504t_simkit_release_3_7
504.1	bjt504t_simkit_release_3_8
504.101	bjt504t_simkit_release_4_0_1
504.11	bjt504t_simkit_release_4_6
504.111	bjt504t_simkit_release_4_5
504.112	bjt504t_simkit_release_4_7
504.121	(default simkit release)

bjtd504

Version	SiMKit Release
(unspecified)	(default simkit release)
504.71	bjtd504_simkit_release_3_2a
504.8	bjtd504_simkit_release_3_3
504.81	bjtd504_simkit_release_3_4
504.9	bjtd504_simkit_release_3_5_2
504.91	bjtd504_simkit_release_3_7
504.1	bjtd504_simkit_release_3_8
504.101	bjtd504_simkit_release_4_0_1
504.11	bjtd504_simkit_release_4_6
504.111	bjtd504_simkit_release_4_5
504.112	bjtd504_simkit_release_4_7
504.121	(default simkit release)

bjtd504t

Version	SiMKit Release
(unspecified)	(default simkit release)
504.71	bjtd504t_simkit_release_3_2a
504.8	bjtd504t_simkit_release_3_3

Version	SiMKit Release
504.81	bjtd504t_simkit_release_3_4
504.9	bjtd504t_simkit_release_3_5_2
504.91	bjtd504t_simkit_release_3_7
504.1	bjtd504t_simkit_release_3_8
504.101	bjtd504t_simkit_release_4_0_1
504.11	bjtd504t_simkit_release_4_6
504.111	bjtd504t_simkit_release_4_5
504.112	bjtd504t_simkit_release_4_7
504.121	(default simkit release)

bjt505

Version	SiMKit Release
(unspecified)	(default simkit release)
505.00	(default simkit release)

bjt505t

Version	SiMKit Release
(unspecified)	(default simkit release)
505.00	(default simkit release)

bjtd505

Version	SiMKit Release
(unspecified)	(default simkit release)
`505.00`	(default simkit release)

bjtd505t

Version	SiMKit Release
(unspecified)	(default simkit release)
`505.00`	(default simkit release)

jfetidg

Version	SiMKit Release
`1.03`	(default simkit release)
(unspecified)	(default simkit release)

jfetidgt

Version	SiMKit Release
`1.03`	(default simkit release)
(unspecified)	(default simkit release)

juncap

Version	SiMKit Release
(unspecified)	(default simkit release)
`1.13`	`juncap_simkit_release_3_2a`

Version	SiMKit Release
`1.14`	`juncap_simkit_release_3_3`
`1.15`	`juncap_simkit_release_3_4`
`1.16`	`juncap_simkit_release_3_5_2`
`1.17`	`juncap_simkit_release_3_8`
`1.18`	(default simkit release)

juncap200

Version	SiMKit Release
(unspecified)	(default simkit release)
`200.33`	`juncap200_simkit_release_3_3`
`200.34`	`juncap200_simkit_release_3_8`
`200.35`	`juncap200_simkit_release_4_0`
`200.40`	`juncap200_simkit_release_4_7`
`200.50`	(default simkit release)

mos1100

Note that the `mos1100` model family is no longer supported in the latest SiMKit. They were last supported in release 3.8. If these models are used in ADS, the default will be the models in SiMKit release 3.8.

Version	SiMKit Release
(unspecified)	`mos1100_simkit_release_3_8`

mos1100e

Note that the `mos1100` model family is no longer supported in the latest SiMKit. They were last supported in release 3.8. If these models are used in ADS, the default will be the models in SiMKit release 3.8.

Version	SiMKit Release
(unspecified)	`mos1100e_simkit_release_3_8`

mos11010

Version	SiMKit Release
(unspecified)	(default simkit release)
`9.3`	`mos11010_simkit_release_3_2a`
`9.4`	`mos11010_simkit_release_3_3`
`10.0`	`mos11010_simkit_release_3_4`
`10.1`	`mos11010_simkit_release_3_5_2`
`11.0`	`mos11010_simkit_release_3_8`
`11.1`	`mos11010_simkit_release_4_0_1`
`11.2`	(default simkit release)

mos11010t

Version	SiMKit Release
(unspecified)	(default simkit release)
`9.3`	`mos11010t_simkit_release_3_2a`

Version	SiMKit Release
9.4	mos11010t_simkit_release_3_3
10.0	mos11010t_simkit_release_3_4
10.1	mos11010t_simkit_release_3_5_2
11.0	mos11010t_simkit_release_3_8
11.1	mos11010t_simkit_release_4_0_1
11.2	(default simkit release)

mos11011

Version	SiMKit Release
(unspecified)	(default simkit release)
9.3	mos11011_simkit_release_3_2a
9.4	mos11011_simkit_release_3_3
10.0	mos11011_simkit_release_3_4
10.1	mos11011_simkit_release_3_5_2
11.0	mos11011_simkit_release_3_8
11.1	mos11011_simkit_release_4_0_1
11.2	(default simkit release)

mos11011t

Version	SiMKit Release
(unspecified)	(default simkit release)
9.3	mos11011t_simkit_release_3_2a
9.4	mos11011t_simkit_release_3_3
10.0	mos11011t_simkit_release_3_4
10.1	mos11011t_simkit_release_3_5_2
11.0	mos11011t_simkit_release_3_8
11.1	mos11011t_simkit_release_4_0_1
11.2	(default simkit release)

mos1101e

Version	SiMKit Release
(unspecified)	(default simkit release)
9.3	mos1101e_simkit_release_3_2a
9.4	mos1101e_simkit_release_3_3
10.0	mos1101e_simkit_release_3_4
10.1	mos1101e_simkit_release_3_5_2
11.0	mos1101e_simkit_release_3_8
11.1	mos1101e_simkit_release_4_0_1
11.2	(default simkit release)

mos1101et

Version	SiMKit Release
(unspecified)	(default simkit release)
9.3	mos1101et_simkit_release_3_2a
9.4	mos1101et_simkit_release_3_3
10.0	mos1101et_simkit_release_3_4
10.1	mos1101et_simkit_release_3_5_2
11.0	mos1101et_simkit_release_3_8
11.1	mos1101et_simkit_release_4_0_1
11.2	(default simkit release)

mos11020

Version	SiMKit Release
(unspecified)	(default simkit release)
5.4	mos11020_simkit_release_3_2a
6.0	mos11020_simkit_release_3_3
6.1	mos11020_simkit_release_3_4
6.2	mos11020_simkit_release_3_5_2
7.0	mos11020_simkit_release_3_8
7.1	mos11020_simkit_release_4_0_1

Version	SiMKit Release
7.2	(default simkit release)

mos11020t

Version	SiMKit Release
(unspecified)	(default simkit release)
5.4	mos11020t_simkit_release_3_2a
6.0	mos11020t_simkit_release_3_3
6.1	mos11020t_simkit_release_3_4
6.2	mos11020t_simkit_release_3_5_2
7.0	mos11020t_simkit_release_3_8
7.1	mos11020t_simkit_release_4_0_1
7.2	(default simkit release)

mos11021

Version	SiMKit Release
(unspecified)	(default simkit release)
5.4	mos11021_simkit_release_3_2a
6.0	mos11021_simkit_release_3_3
6.1	mos11021_simkit_release_3_4
6.2	mos11021_simkit_release_3_5_2

Version	SiMKit Release
7.0	mos11021_simkit_release_3_8
7.1	mos11021_simkit_release_4_0_1
7.2	(default simkit release)

mos11021t

Version	SiMKit Release
(unspecified)	(default simkit release)
5.4	mos11021t_simkit_release_3_2a
6.0	mos11021t_simkit_release_3_3
6.1	mos11021t_simkit_release_3_4
6.2	mos11021t_simkit_release_3_5_2
7.0	mos11021t_simkit_release_3_8
7.1	mos11021t_simkit_release_4_0_1
7.2	(default simkit release)

mos1102e

Version	SiMKit Release
(unspecified)	(default simkit release)
5.4	mos1102e_simkit_release_3_2a
6.0	mos1102e_simkit_release_3_3

Version	SiMKit Release
6.1	mos1102e_simkit_release_3_4
6.2	mos1102e_simkit_release_3_5_2
7.0	mos1102e_simkit_release_3_8
7.1	mos1102e_simkit_release_4_0_1
7.2	(default simkit release)

mos1102et

Version	SiMKit Release
(unspecified)	(default simkit release)
5.4	mos1102et_simkit_release_3_2a
6.0	mos1102et_simkit_release_3_3
6.1	mos1102et_simkit_release_3_4
6.2	mos1102et_simkit_release_3_5_2
7.0	mos1102et_simkit_release_3_8
7.1	mos1102et_simkit_release_4_0_1
7.2	(default simkit release)

mos3100

Version	SiMKit Release
(unspecified)	(default simkit release)

Version	SiMKit Release
3.6	mos3100_simkit_release_3_3
3.7	mos3100_simkit_release_3_4
3.8	mos3100_simkit_release_3_5_2
3.9	mos3100_simkit_release_3_6
3.10	mos3100_simkit_release_3_8
3.11	mos3100_simkit_release_4_0_1
3.12	(default simkit release)

mos3100t

Version	SiMKit Release
(unspecified)	(default simkit release)
3.6	mos3100t_simkit_release_3_3
3.7	mos3100t_simkit_release_3_4
3.8	mos3100t_simkit_release_3_5_2
3.9	mos3100t_simkit_release_3_6
3.10	mos3100t_simkit_release_3_8
3.11	mos3100t_simkit_release_4_0_1
3.12	(default simkit release)

mos40

Note that the `mos40` and `mos4000` model families are the same. These are different names for the same model.

Version	SiMKit Release
(unspecified)	(default simkit release)
`2.6`	`mos40_simkit_release_3_3`
`2.7`	`mos40_simkit_release_3_4`
`2.8`	`mos40_simkit_release_3_5_2`
`2.9`	`mos40_simkit_release_3_6`
`2.10`	`mos40_simkit_release_3_8`
`2.11`	`mos40_simkit_release_4_0_1`
`2.12`	(default simkit release)

mos40t

Note that the `mos40` and `mos4000` model families are the same. These are different names for the same model.

Version	SiMKit Release
(unspecified)	(default simkit release)
`2.6`	`mos40t_simkit_release_3_3`
`2.7`	`mos40t_simkit_release_3_4`
`2.8`	`mos40t_simkit_release_3_5_2`
`2.9`	`mos40t_simkit_release_3_6`
`2.10`	`mos40t_simkit_release_3_8`

Version	SiMKit Release
`2.11`	`mos40t_simkit_release_4_0_1`
`2.12`	(default simkit release)

mos4000

Note that the `mos40` and `mos4000` model families are the same. These are different names for the same model.

Version	SiMKit Release
(unspecified)	(default simkit release)
`2.6`	`mos4000_simkit_release_3_3`
`2.7`	`mos4000_simkit_release_3_4`
`2.8`	`mos4000_simkit_release_3_5_2`
`2.9`	`mos4000_simkit_release_3_6`
`2.10`	`mos4000_simkit_release_3_8`
`2.11`	`mos4000_simkit_release_4_0_1`
`2.12`	(default simkit release)

mos4000t

Note that the `mos40` and `mos4000` model families are the same. These are different names for the same model.

Version	SiMKit Release
(unspecified)	(default simkit release)
`2.6`	`mos4000t_simkit_release_3_3`

Version	SiMKit Release
2.7	mos4000t_simkit_release_3_4
2.8	mos4000t_simkit_release_3_5_2
2.9	mos4000t_simkit_release_3_6
2.10	mos4000t_simkit_release_3_8
2.11	mos4000t_simkit_release_4_0_1
2.12	(default simkit release)

mos903

Version	SiMKit Release
(unspecified)	(default simkit release)
1.0	mos903_simkit_release_3_4
1.1	mos903_simkit_release_3_5_2
1.2	mos903_simkit_release_4_0_1
1.3	(default simkit release)

mos903e

Version	SiMKit Release
(unspecified)	(default simkit release)
1.0	mos903e_simkit_release_3_4
1.1	mos903e_simkit_release_3_5_2

Version	SiMKit Release
1.2	mos903e_simkit_release_4_0_1
1.3	(default simkit release)

mos903t

Version	SiMKit Release
(unspecified)	(default simkit release)
1.0	mos903t_simkit_release_3_4
1.1	mos903t_simkit_release_3_5_2
1.2	mos903t_simkit_release_4_0_1
1.3	(default simkit release)

ovcheck

Version	SiMKit Release
(unspecified)	(default simkit release)

ovcheck6

Version	SiMKit Release
(unspecified)	(default simkit release)

psp1020

Version	SiMKit Release
(unspecified)	(default simkit release)

Version	SiMKit Release
102.34	psp1020_simkit_release_4_0
102.4	psp1020_simkit_release_4_6
102.5	(default simkit release)

pspnqs1020

Version	SiMKit Release
(unspecified)	(default simkit release)
102.34	pspnqs1020_simkit_release_4_0
102.4	pspnqs1020_simkit_release_4_6
102.5	(default simkit release)

pspnqs1021

Version	SiMKit Release
(unspecified)	(default simkit release)
102.34	pspnqs1021_simkit_release_4_0
102.4	pspnqs1021_simkit_release_4_6
102.5	(default simkit release)

pspnqs102e

Version	SiMKit Release
(unspecified)	(default simkit release)

Version	SiMKit Release
102.34	pspnqs102e_simkit_release_4_0
102.4	pspnqs102e_simkit_release_4_6
102.5	(default simkit release)

psp1021

Version	SiMKit Release
(unspecified)	(default simkit release)
102.34	psp1021_simkit_release_4_0
102.4	psp1021_simkit_release_4_6
102.5	(default simkit release)

psp102e

Version	SiMKit Release
(unspecified)	(default simkit release)
102.34	psp102e_simkit_release_4_0
102.4	psp102e_simkit_release_4_6
102.5	(default simkit release)

psp103

Version	SiMKit Release
(unspecified)	(default simkit release)

Version	SiMKit Release
103.0	psp103_simkit_release_3_2a
103.1	psp103_simkit_release_3_3
103.11	psp103_simkit_release_4_0
103.2	psp103_simkit_release_4_1
103.3	psp103_simkit_release_4_7
103.4	psp103_simkit_release_4_8_1
103.5	psp103_simkit_release_4_9
103.6	(default simkit release)

psp103t

Version	SiMKit Release
(unspecified)	(default simkit release)
103.0	psp103t_simkit_release_3_2a
103.1	psp103t_simkit_release_3_3
103.11	psp103t_simkit_release_4_0_1
103.2	psp103t_simkit_release_4_1
103.3	psp103t_simkit_release_4_7
103.4	psp103t_simkit_release_4_8_1
103.5	psp103t_simkit_release_4_9
103.6	(default simkit release)

pspnqs103

Version	SiMKit Release
(unspecified)	(default simkit release)
103.0	pspnqs103_simkit_release_3_2a
103.1	pspnqs103_simkit_release_3_3
103.11	pspnqs103_simkit_release_4_0
103.2	pspnqs103_simkit_release_4_1
103.3	pspnqs103_simkit_release_4_7
103.4	pspnqs103_simkit_release_4_8_1
103.5	pspnqs103_simkit_release_4_9
103.6	(default simkit release)

List of all SiMKit Model Names

This is a list of all supported SiMKit-related model names recognized by the circuit simulator. They are only recognized in ADS or spectre netlist syntax, and are listed here only for reference.

bjt3500	mos11010t_simkit_release_4_7	mos4000t_simkit_release_3_7
bjt3500_simkit_release_3_2a	mos11010t_simkit_release_4_8_1	mos4000t_simkit_release_3_8
bjt3500_simkit_release_3_3	mos11010t_simkit_release_4_9	mos4000t_simkit_release_4_0
bjt3500_simkit_release_3_4	mos11011	mos4000t_simkit_release_4_0_1
bjt3500_simkit_release_3_5_2	mos11011_simkit_release_3_2a	mos4000t_simkit_release_4_1
bjt3500_simkit_release_3_6	mos11011_simkit_release_3_3	mos4000t_simkit_release_4_2

bjt3500_simkit_release_3_7	mos11011_simkit_release_3_4	mos4000t_simkit_release_4_3
bjt3500_simkit_release_3_8	mos11011_simkit_release_3_5_2	mos4000t_simkit_release_4_4
bjt3500_simkit_release_4_0	mos11011_simkit_release_3_6	mos4000t_simkit_release_4_5
bjt3500_simkit_release_4_0_1	mos11011_simkit_release_3_7	mos4000t_simkit_release_4_6
bjt3500_simkit_release_4_1	mos11011_simkit_release_3_8	mos4000t_simkit_release_4_7
bjt3500_simkit_release_4_2	mos11011_simkit_release_4_0	mos4000t_simkit_release_4_8_1
bjt3500_simkit_release_4_3	mos11011_simkit_release_4_0_1	mos4000t_simkit_release_4_9
bjt3500_simkit_release_4_4	mos11011_simkit_release_4_1	mos40t
bjt3500_simkit_release_4_5	mos11011_simkit_release_4_2	mos40t_simkit_release_3_2a
bjt3500_simkit_release_4_6	mos11011_simkit_release_4_3	mos40t_simkit_release_3_3
bjt3500_simkit_release_4_7	mos11011_simkit_release_4_4	mos40t_simkit_release_3_4
bjt3500t	mos11011_simkit_release_4_5	mos40t_simkit_release_3_5_2
bjt3500t_simkit_release_3_2a	mos11011_simkit_release_4_6	mos40t_simkit_release_3_6
bjt3500t_simkit_release_3_3	mos11011_simkit_release_4_7	mos40t_simkit_release_3_7
bjt3500t_simkit_release_3_4	mos11011_simkit_release_4_8_1	mos40t_simkit_release_3_8
bjt3500t_simkit_release_3_5_2	mos11011_simkit_release_4_9	mos40t_simkit_release_4_0
bjt3500t_simkit_release_3_6	mos11011t	mos40t_simkit_release_4_0_1
bjt3500t_simkit_release_3_7	mos11011t_simkit_release_3_2a	mos40t_simkit_release_4_1
bjt3500t_simkit_release_3_8	mos11011t_simkit_release_3_3	mos40t_simkit_release_4_2
bjt3500t_simkit_release_4_0	mos11011t_simkit_release_3_4	mos40t_simkit_release_4_3

bjt3500t_simkit_release_4_0_1	mos11011t_simkit_release_3_5_2	mos40t_simkit_release_4_4
bjt3500t_simkit_release_4_1	mos11011t_simkit_release_3_6	mos40t_simkit_release_4_5
bjt3500t_simkit_release_4_2	mos11011t_simkit_release_3_7	mos40t_simkit_release_4_6
bjt3500t_simkit_release_4_3	mos11011t_simkit_release_3_8	mos40t_simkit_release_4_7
bjt3500t_simkit_release_4_4	mos11011t_simkit_release_4_0	mos40t_simkit_release_4_8_1
bjt3500t_simkit_release_4_5	mos11011t_simkit_release_4_0_1	mos40t_simkit_release_4_9
bjt3500t_simkit_release_4_6	mos11011t_simkit_release_4_1	mos903
bjt3500t_simkit_release_4_7	mos11011t_simkit_release_4_2	mos903_simkit_release_3_2a
bjt500	mos11011t_simkit_release_4_3	mos903_simkit_release_3_3
bjt500_simkit_release_3_2a	mos11011t_simkit_release_4_4	mos903_simkit_release_3_4
bjt500_simkit_release_3_3	mos11011t_simkit_release_4_5	mos903_simkit_release_3_5_2
bjt500_simkit_release_3_4	mos11011t_simkit_release_4_6	mos903_simkit_release_3_6
bjt500_simkit_release_3_5_2	mos11011t_simkit_release_4_7	mos903_simkit_release_3_7
bjt500_simkit_release_3_6	mos11011t_simkit_release_4_8_1	mos903_simkit_release_3_8
bjt500_simkit_release_3_7	mos11011t_simkit_release_4_9	mos903_simkit_release_4_0
bjt500_simkit_release_3_8	mos1101e	mos903_simkit_release_4_0_1
bjt500_simkit_release_4_0	mos1101e_simkit_release_3_2a	mos903_simkit_release_4_1
bjt500_simkit_release_4_0_1	mos1101e_simkit_release_3_3	mos903_simkit_release_4_2
bjt500_simkit_release_4_1	mos1101e_simkit_release_3_4	mos903_simkit_release_4_3

bjt500_simkit_release_4_2	mos1101e_simkit_release_3_5_2	mos903_simkit_release_4_4
bjt500_simkit_release_4_3	mos1101e_simkit_release_3_6	mos903_simkit_release_4_5
bjt500_simkit_release_4_4	mos1101e_simkit_release_3_7	mos903_simkit_release_4_6
bjt500_simkit_release_4_5	mos1101e_simkit_release_3_8	mos903_simkit_release_4_7
bjt500_simkit_release_4_6	mos1101e_simkit_release_4_0	mos903_simkit_release_4_8_1
bjt500_simkit_release_4_7	mos1101e_simkit_release_4_0_1	mos903_simkit_release_4_9
bjt500_simkit_release_4_8_1	mos1101e_simkit_release_4_1	mos903e
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bjt500t_simkit_release_3_2a	mos1101e_simkit_release_4_4	mos903e_simkit_release_3_4
bjt500t_simkit_release_3_3	mos1101e_simkit_release_4_5	mos903e_simkit_release_3_5_2
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bjt500t_simkit_release_3_5_2	mos1101e_simkit_release_4_7	mos903e_simkit_release_3_7
bjt500t_simkit_release_3_6	mos1101e_simkit_release_4_8_1	mos903e_simkit_release_3_8
bjt500t_simkit_release_3_7	mos1101e_simkit_release_4_9	mos903e_simkit_release_4_0
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bjt500t_simkit_release_4_2	mos1101et_simkit_release_3_5_2	mos903e_simkit_release_4_4

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bjt500t_simkit_release_4_8_1	mos1101et_simkit_release_4_1	mos903t
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bjt504_simkit_release_3_5_2	mos1101et_simkit_release_4_7	mos903t_simkit_release_3_7
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bjt504_simkit_release_3_7	mos1101et_simkit_release_4_9	mos903t_simkit_release_4_0
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bjtd3500t_simkit_release_4_0	mos11021t_simkit_release_3_2a	psp1021_simkit_release_4_7
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bjtd504_simkit_release_3_2a	mos11021t_simkit_release_4_2	psp102e_simkit_release_3_8
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bjtd504_simkit_release_3_4	mos11021t_simkit_release_4_4	psp102e_simkit_release_4_0_1
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bjtd504_simkit_release_3_6	mos11021t_simkit_release_4_6	psp102e_simkit_release_4_2
bjtd504_simkit_release_3_7	mos11021t_simkit_release_4_7	psp102e_simkit_release_4_3
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bjtd504_simkit_release_4_0	mos11021t_simkit_release_4_9	psp102e_simkit_release_4_5
bjtd504_simkit_release_4_0_1	mos1102e	psp102e_simkit_release_4_6
bjtd504_simkit_release_4_1	mos1102e_simkit_release_3_2a	psp102e_simkit_release_4_7
bjtd504_simkit_release_4_2	mos1102e_simkit_release_3_3	psp102e_simkit_release_4_8_1
bjtd504_simkit_release_4_3	mos1102e_simkit_release_3_4	psp102e_simkit_release_4_9
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bjtd504_simkit_release_4_5	mos1102e_simkit_release_3_6	psp103_simkit_release_3_2a

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bjtd504_simkit_release_4_9	mos1102e_simkit_release_4_0_1	psp103_simkit_release_3_6
bjtd504t	mos1102e_simkit_release_4_1	psp103_simkit_release_3_7
bjtd504t_simkit_release_3_2a	mos1102e_simkit_release_4_2	psp103_simkit_release_3_8
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bjtd505	mos1102et_simkit_release_4_1	psp103t_simkit_release_3_7
bjtd505t	mos1102et_simkit_release_4_2	psp103t_simkit_release_3_8
juncap	mos1102et_simkit_release_4_3	psp103t_simkit_release_4_0
juncap_simkit_release_3_2a	mos1102et_simkit_release_4_4	psp103t_simkit_release_4_0_1
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juncap_simkit_release_3_5_2	mos1102et_simkit_release_4_7	psp103t_simkit_release_4_3
juncap_simkit_release_3_6	mos1102et_simkit_release_4_8_1	psp103t_simkit_release_4_4
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juncap_simkit_release_3_8	mos3100	psp103t_simkit_release_4_6
juncap_simkit_release_4_0	mos3100_simkit_release_3_2a	psp103t_simkit_release_4_7
juncap_simkit_release_4_0_1	mos3100_simkit_release_3_3	psp103t_simkit_release_4_8_1
juncap_simkit_release_4_1	mos3100_simkit_release_3_4	psp103t_simkit_release_4_9
juncap_simkit_release_4_2	mos3100_simkit_release_3_5_2	pspnqs1020
juncap_simkit_release_4_3	mos3100_simkit_release_3_6	pspnqs1020_simkit_release_3_2a
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juncap_simkit_release_4_8_1	mos3100_simkit_release_4_1	pspnqs1020_simkit_release_3_7
juncap_simkit_release_4_9	mos3100_simkit_release_4_2	pspnqs1020_simkit_release_3_8
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juncap200_simkit_release_3_8	mos3100t	pspnqs1020_simkit_release_4_6
juncap200_simkit_release_4_0	mos3100t_simkit_release_3_2a	pspnqs1020_simkit_release_4_7
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juncap200_simkit_release_4_2	mos3100t_simkit_release_3_5_2	pspnqs1021
juncap200_simkit_release_4_3	mos3100t_simkit_release_3_6	pspnqs1021_simkit_release_3_2a
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mos1100	mos3100t_simkit_release_4_3	pspnqs1021_simkit_release_4_0
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mos1100_simkit_release_3_8	mos40	pspnqs1021_simkit_release_4_6
mos1100e	mos40_simkit_release_3_2a	pspnqs1021_simkit_release_4_7
mos1100e_simkit_release_3_2a	mos40_simkit_release_3_3	pspnqs1021_simkit_release_4_8_1
mos1100e_simkit_release_3_3	mos40_simkit_release_3_4	pspnqs1021_simkit_release_4_9
mos1100e_simkit_release_3_4	mos40_simkit_release_3_5_2	pspnqs102e
mos1100e_simkit_release_3_5_2	mos40_simkit_release_3_6	pspnqs102e_simkit_release_3_2a
mos1100e_simkit_release_3_6	mos40_simkit_release_3_7	pspnqs102e_simkit_release_3_3
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mos11010	mos40_simkit_release_4_0_1	pspnqs102e_simkit_release_3_6
mos11010_simkit_release_3_2a	mos40_simkit_release_4_1	pspnqs102e_simkit_release_3_7
mos11010_simkit_release_3_3	mos40_simkit_release_4_2	pspnqs102e_simkit_release_3_8
mos11010_simkit_release_3_4	mos40_simkit_release_4_3	pspnqs102e_simkit_release_4_0
mos11010_simkit_release_3_5_2	mos40_simkit_release_4_4	pspnqs102e_simkit_release_4_0_1
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mos11010_simkit_release_3_8	mos40_simkit_release_4_7	pspnqs102e_simkit_release_4_3
mos11010_simkit_release_4_0	mos40_simkit_release_4_8_1	pspnqs102e_simkit_release_4_4
mos11010_simkit_release_4_0_1	mos40_simkit_release_4_9	pspnqs102e_simkit_release_4_5
mos11010_simkit_release_4_1	mos4000	pspnqs102e_simkit_release_4_6
mos11010_simkit_release_4_2	mos4000_simkit_release_3_2a	pspnqs102e_simkit_release_4_7
mos11010_simkit_release_4_3	mos4000_simkit_release_3_3	pspnqs102e_simkit_release_4_8_1
mos11010_simkit_release_4_4	mos4000_simkit_release_3_4	pspnqs102e_simkit_release_4_9
mos11010_simkit_release_4_5	mos4000_simkit_release_3_5_2	pspnqs103
mos11010_simkit_release_4_6	mos4000_simkit_release_3_6	pspnqs103_simkit_release_3_2a
mos11010_simkit_release_4_7	mos4000_simkit_release_3_7	pspnqs103_simkit_release_3_3
mos11010_simkit_release_4_8_1	mos4000_simkit_release_3_8	pspnqs103_simkit_release_3_4
mos11010_simkit_release_4_9	mos4000_simkit_release_4_0	pspnqs103_simkit_release_3_5_2

mos11010t	mos4000_simkit_release_4_0_1	pspnqs103_simkit_release_3_6
mos11010t_simkit_release_3_2a	mos4000_simkit_release_4_1	pspnqs103_simkit_release_3_7
mos11010t_simkit_release_3_3	mos4000_simkit_release_4_2	pspnqs103_simkit_release_3_8
mos11010t_simkit_release_3_4	mos4000_simkit_release_4_3	pspnqs103_simkit_release_4_0
mos11010t_simkit_release_3_5_2	mos4000_simkit_release_4_4	pspnqs103_simkit_release_4_0_1
mos11010t_simkit_release_3_6	mos4000_simkit_release_4_5	pspnqs103_simkit_release_4_1
mos11010t_simkit_release_3_7	mos4000_simkit_release_4_6	pspnqs103_simkit_release_4_2
mos11010t_simkit_release_3_8	mos4000_simkit_release_4_7	pspnqs103_simkit_release_4_3
mos11010t_simkit_release_4_0	mos4000_simkit_release_4_8_1	pspnqs103_simkit_release_4_4
mos11010t_simkit_release_4_0_1	mos4000_simkit_release_4_9	pspnqs103_simkit_release_4_5
mos11010t_simkit_release_4_1	mos4000t	pspnqs103_simkit_release_4_6
mos11010t_simkit_release_4_2	mos4000t_simkit_release_3_2a	pspnqs103_simkit_release_4_7
mos11010t_simkit_release_4_3	mos4000t_simkit_release_3_3	pspnqs103_simkit_release_4_8_1
mos11010t_simkit_release_4_4	mos4000t_simkit_release_3_4	pspnqs103_simkit_release_4_9
mos11010t_simkit_release_4_5	mos4000t_simkit_release_3_5_2	
mos11010t_simkit_release_4_6	mos4000t_simkit_release_3_6	

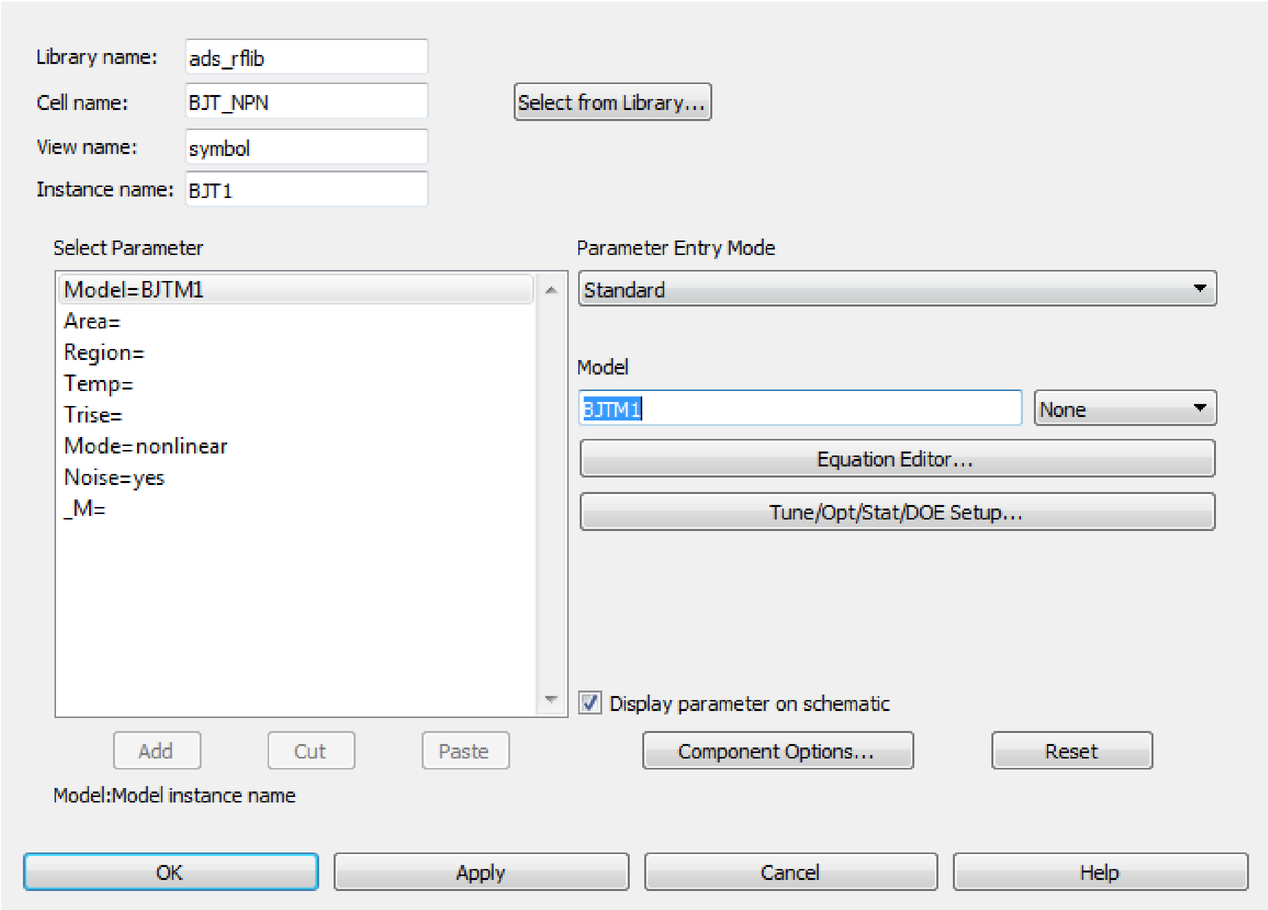
Equation-Based Nonlinear Components

Equation-Based Nonlinear Components

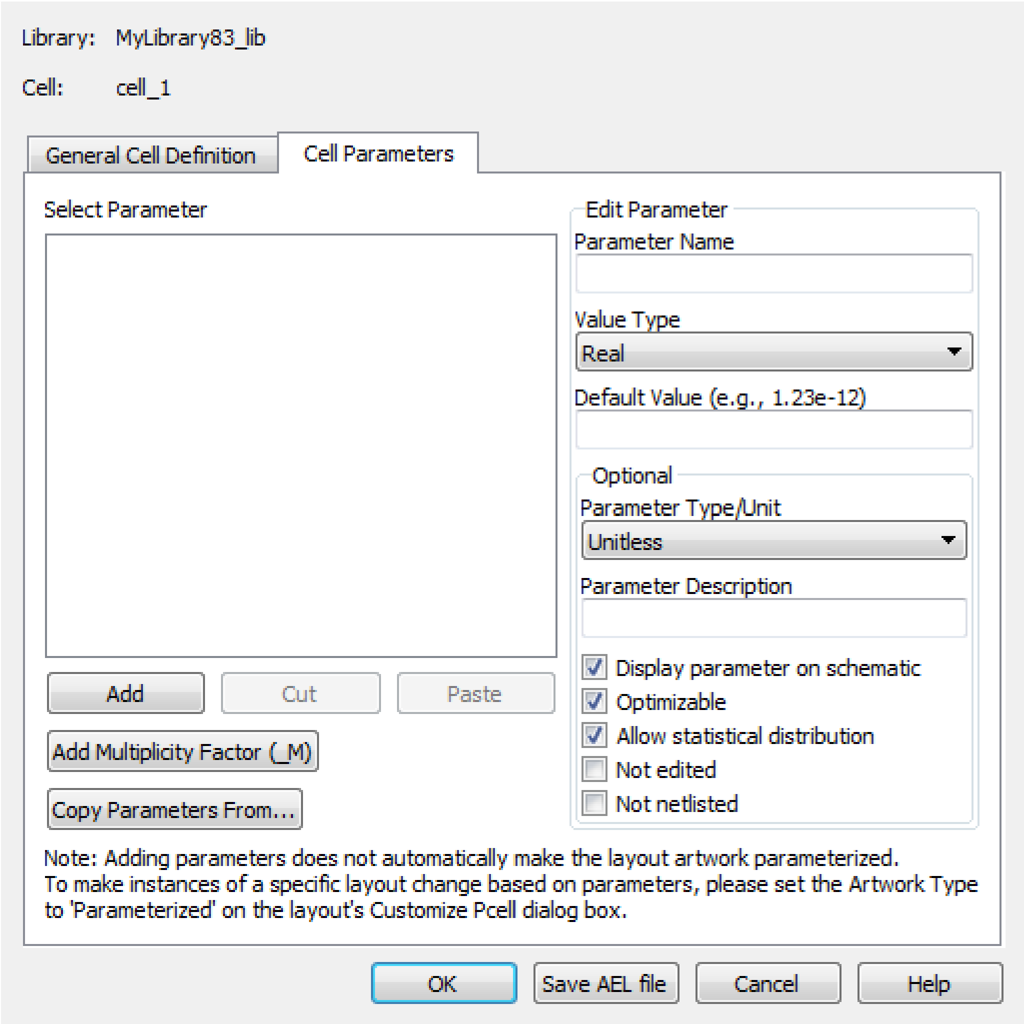
Multiplicity Parameter _M

The multiplicity feature provides a way to scale components or entire sub-circuits containing many components and sub-circuits. Given a component with a multiplicity value *M* , the simulator treats this component as if there were *M* such components all connected in parallel. Sub-circuits within sub-circuits will be appropriately scaled.

The _M parameter is available at the component level as shown here. (For components that do not explicitly have a Multiplicity parameter, the same functionality can be achieved by placing the component in a sub-circuit and using the sub-circuit's Multiplicity parameter, as described next.)



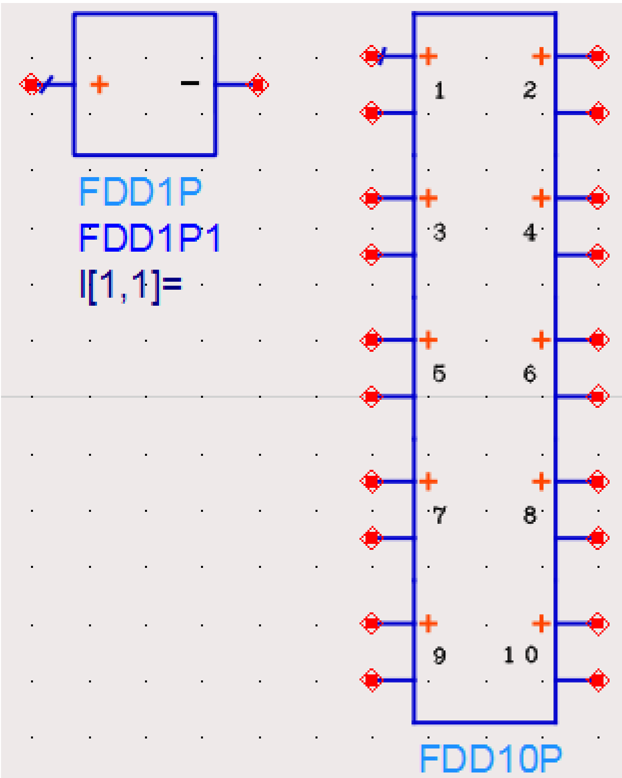
For sub-circuits, the parameter is enabled by selecting **File** > **Design Parameters** from the Schematic window. In the dialog box, select the **Parameters** tab. To add the Multiplicity parameter, choose **Add Multiplicity Factor_M**.


Library: MyLibrary83_lib
Cell: cell_1
General Cell Definition
Cell Parameters
Select Parameter
Edit Parameter
Parameter Name
Value Type
Real
Default Value (e.g., 1.23e-12)
Optional
Parameter Type/Unit
Unitless
Parameter Description
Display parameter on schematic
Optimizable
Allow statistical distribution
Not edited
Not netlisted
Add
Cut
Paste
Add Multiplicity Factor (_M)
Copy Parameters From...
Note: Adding parameters does not automatically make the layout artwork parameterized.
To make instances of a specific layout change based on parameters, please set the Artwork Type
to 'Parameterized' on the layout's Customize Pcell dialog box.
OK
Save AEL file
Cancel
Help

FDD1P to FDD10P (1- to 10-Port Frequency-Domain Defined Devices)

FDD1P to FDD10P (1- to 10-Port Frequency-Domain Defined Devices)

Symbol



The frequency-domain defined (FDD) device enables you to create equation-based, user-defined, nonlinear components. The FDD is a multi-port device that describes current and voltage spectral values in terms of algebraic relationships of other voltage and current spectral values. It is for developing nonlinear, behavioral models that are more easily defined in the frequency domain. For more information on how to use these devices and application examples, refer to "Custom Modeling with Frequency-Domain Defined Devices" in *User-Defined Models*.

Range of Usage

$0 \leq i \leq 10$

Parameters

Name	Description	Units	Default
I[i, j]	current equation that describes spectral current. *i* refers to the port number. *j* refers to a frequency index	None	None
V[i, j]	voltage equation that describes spectral voltage. *i* refers to the port number. *j* refers to a frequency index		
Freq[k]	carrier frequency	F	Hz
Trig[k]	trigger event		
Ce[k]	clock enable definiiton		

- Equations that relate to port spectral voltages and currents are described in the frequency domain. The two basic types of equations are current equations and voltage equations. Their format is:

  > *I[port, findex] = f(_sv(),_sv_d(),_si(),_si_d())*
  > *V[port, findex] = f(_sv(),_sv_d(),_si(),_si_d())*

  where *port* is the port number and *findex* is a frequency index.
  The equations can be listed in any order; more than one equation can be used for a single port, but each port must have at least one equation.
  The variables of interest at a given port are the port spectral voltages and currents. Spectral voltages and currents can be obtained using the functions:

  > *_sv(), _si(), _sv_d(), and _si_d().*

- The Freq parameter enables you to define one or more carrier frequencies.
- The FDD device enables you to define up to 31 trigger events. Any time the value of the trigger expression is equal to a number other than 0, a trigger event is declared for the corresponding trigger.
- Clock enables specify that the output of a given port can change only when a specified trigger, or a set of specified triggers, occurs.

NonlinC (Nonlinear Capacitor)

NonlinC (Nonlinear Capacitor)

Symbol

Parameters

Name	Description	Units	Default
Coeff	list of coefficients that describe a polynomial that defines capacitance as a function of voltage v across the capacitor where: cap = Coeff[0] + Coeff[1] × v + Coeff[2] × v^2 +, ... , + Coeff[n] × v^n and coefficients are entered using the list function: Coeff = list (Coeff[0], Coeff[1],Coeff[2], ... , Coeff[n])	None	list(1,1)

- The coefficients of the polynomial are specified in the dialog box for this component. Enter the values for each coefficient in a single line.

> *units of Coeff[0] = farads*
> *units of Coeff[1] = farads/volt*
> *units of Coeff[2] = farads/volt^2*

Coefficients are entered using the list function. For example, if

> $C = 5V^2 + 4V^4$

the parameter entry is:

> *Coeff = list(0,0,5,0,4)*

- The controlling voltage V is the voltage across the capacitor, with pin 1 being positive and pin 2 being negative.
- For linear analyses DC, AC and S_Param, the behavior of this component is linearized around its DC operating point, so the effective value of cap=Coeff[0].

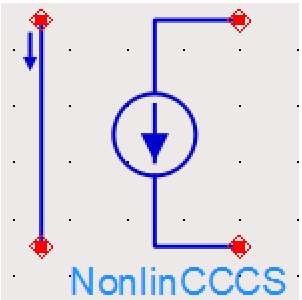
Additional Information

- This component has no default artwork associated with it.

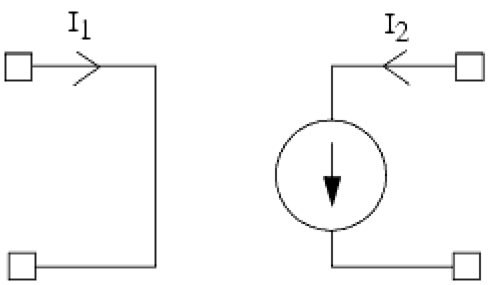
NonlinCCCS (Nonlinear Current-Controlled Current Source)

NonlinCCCS (Nonlinear Current-Controlled Current Source)

Symbol



Illustration



Parameters

Name	Description	Units	Default
Coeff	list of coefficients that describe a polynomial that defines output current I_2 as a function of input current I_1:if only one coefficient is specified: I_2 = Coeff[0] × I_1^2 the coefficient is entered using the list function: Coeff = list(Coeff[0]) Otherwise: I_2 Coeff[0] + Coeff[1] × I_1 + Coeff[2] × I_1^2 +, ... , + Coeff[n] × I_1^n and coefficients are entered as: Coeff = list (Coeff[0], Coeff[1],Coeff[2], ... , Coeff[n])	None	list(1,1)

- The coefficients of polynomial are specified in the dialog box for this component. Enter values for each coefficient in a single line using the list function. For example, if:

$$I_2 = 3 - 2I_1^2 + 5I_1^6$$

the parameter entry is:

Coeff = list(3,0,-2,0,0,0,5)

If $I_2 = 5I_1$, then Coeff = list(5)

If $I_2 = 5$, then Coeff = list(5,0)

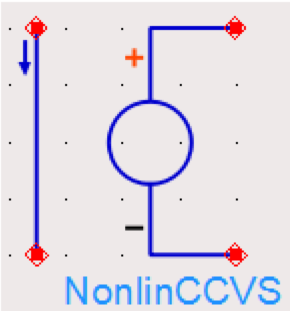
Additional Information

- This component has no default artwork associated with it.
- Output current is in Amperes.

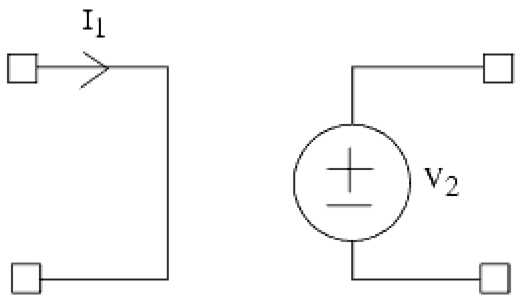
NonlinCCVS (Nonlinear Current-Controlled Voltage Source)

NonlinCCVS (Nonlinear Current-Controlled Voltage Source)

Symbol



Illustration



Parameters

Name	Description	Units	Default
Coeff	a list of coefficients that describe a polynomial that defines output voltage V_2 as a function of input current I_1: if only one coefficient is specified V_2 = Coeff[0] × I_1 the coefficient is entered using the list function: Coeff = list(Coeff[0]) otherwise: V_2 = Coeff[0] + Coeff[1] × I_1 + Coeff[2] × I_1^2 +, ... , + Coeff[n] × I_1^n and coefficients are entered as: Coeff = list (Coeff[0], Coeff[1],Coeff[2], ... , Coeff[n])	None	list(1,1)

- The coefficients of polynomial are specified in the dialog box for this component. Enter values for each coefficient in a single line. Enter values for each coefficient in a single line using the list function. For example, if:
  $V_2 = 3 - 2I_1^2 + 5I_1^6$
  the parameter entry is:
  Coeff = list(3,0,-2,0,0,0,5)
  If $V_2 = 5I_1$, then Coeff = list(5)
  If $V_2 = 5$, then Coeff = list(5,0)

Additional Information

- This component has no default artwork associated with it.
- Output voltage is in volts.

NonlinL (Nonlinear Inductor)

NonlinL (Nonlinear Inductor)

Symbol

Parameters

Name	Description	Units	Default
Coeff	a list of coefficients that describe a polynomial that defines inductance as a function of current through the inductor: L= Coeff[0] + Coeff[1] × I + Coeff[2] × I^2 +, ... , +Coeff[n] × I^n and coefficients are entered using the list function: Coeff = list(Coeff[0],Coeff[1],Coeff[2] , ... , Coeff[n])	None	list(1,1)

- The coefficients of the polynomial are specified in the dialog box for this component. Enter the values for each coefficient in a single line.

  > *units of Coeff[0] = henries*
  > *units of Coeff[1] = henries/amp*
  > *units of Coeff[2] = henries/amp*^{2}

  Coefficients are entered using the list function. For example, if:

  > $L = 5I^2 + 4I^4$

  the parameter entry is:

  > *Coeff = list(0,0,5,0,4)*

- The controlling current I is the current flowing from pin 1 to pin 2.
- For linear analyses DC, AC and S_Param, the behavior of this component is linearized around its DC operating point, so the effective value of L=Coeff[0].

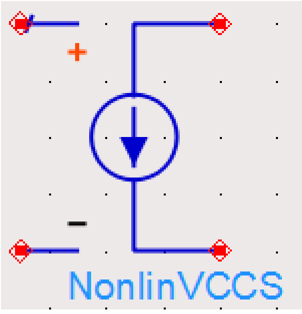
Additional Information

- This component has no default artwork associated with it.

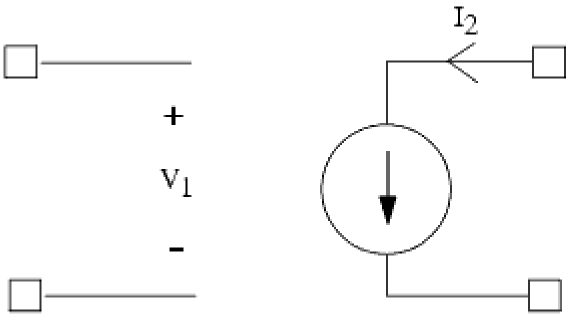
NonlinVCCS (Nonlinear Voltage-Controlled Current Source)

NonlinVCCS (Nonlinear Voltage-Controlled Current Source)

Symbol



Illustration



Parameters

Name	Description	Units	Default
Coeff	a list of coefficients that describe a polynomial that defines output current I_2 as a function of input voltage V_1: if only one coefficient is specified: I_2 = Coeff[0] × V_1 the coefficient is entered using the list function: Coeff = list(Coeff[0]) otherwise: I_2 = Coeff[0] + Coeff[1] × V1 + Coeff[2] × V_1^2 +, ... , +Coeff[n] × V_1^n and coefficients are entered as: Coeff = list (Coeff[0], Coeff[1],Coeff[2], ... , Coeff[n])	None	list(1,1)

- The coefficients of polynomial are specified in the dialog box for this component. Enter values for each coefficient in a single line. Enter values for each coefficient in a single line using the list function. For example, if:

  > $I_2 = 3 - 2V_1^2 + 5V_1^6$

  the parameter entry is:

  > *Coeff = list(3,0,-2,0,0,0,5)*

  If $I_2 = 5V_1$, then Coeff = list(5)

  If $I_2 = 5$, then Coeff = list(5,0)

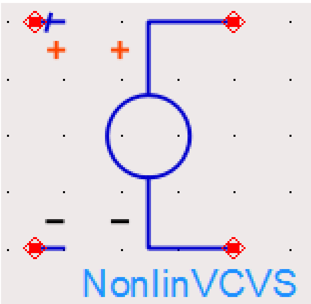
Additional Information

- This component has no default artwork associated with it.
- Output current is in amperes.

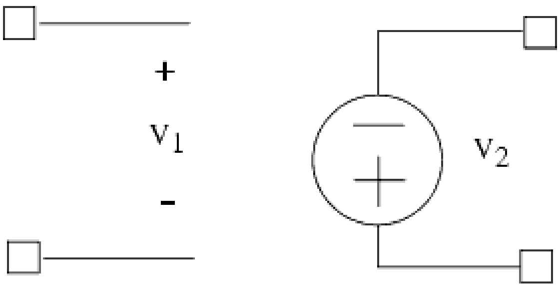
NonlinVCVS (Nonlinear Voltage-Controlled Voltage Source)

NonlinVCVS (Nonlinear Voltage-Controlled Voltage Source)

Symbol



Illustration



Parameters

Name	Description	Units	Default
Coeff	a list of coefficients that describe a polynomial that defines output voltage V_2 as a function of input voltage V_1: If only one coefficient is specified: V_2 = Coeff [0] × V_1 the coefficient is entered using the list function: Coeff = list(Coeff[0]) otherwise, V_2 = Coeff[0] + Coeff[1] × V1 + Coeff[2] × V12 +, ... , +Coeff[n] × V_1^n and coefficients are entered as: Coeff = list (Coeff[0], Coeff[1],Coeff[2], ... , Coeff[n])	None	list(1,1)

- The coefficients of polynomial are specified in the dialog box for this component. Enter values for each coefficient in a single line. Enter values for each coefficient in a single line using the list function. For example, if:

  $V_2 = 3 - 2V_1^2 + 5V_1^6$

  the parameter entry is:

  Coeff = list(3,0,-2,0,0,0,5)

  If $V_2 = 5V_1$, then Coeff = list(5)
  If $V_2 = 5$, then Coeff = list(5,0)

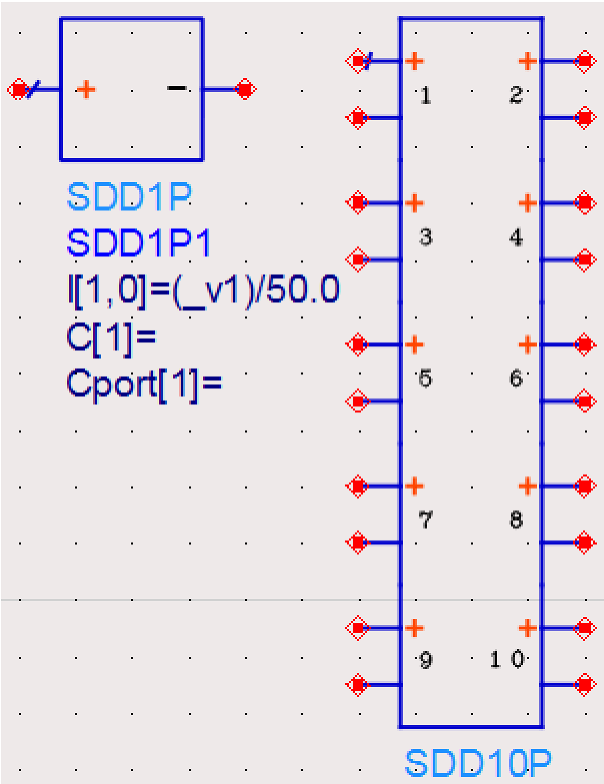
Additional Information

- This component has no default artwork associated with it.
- Output voltage is in volts.

SDD14P (Symbolically Defined Devices, 1-12 and 14 Ports)

SDD1P to SDD12P, SDD14P (Symbolically Defined Devices, 1-12 and 14 Ports)

Symbol



The symbolically-defined device (SDD) enables you to create equation based, user-defined, nonlinear components. The SDD is a multi-port device which is defined by specifying algebraic relationships that relate the port voltages, currents, and their derivatives, plus currents from certain other devices. Devices SDD1P through SDD10P are available from the component palette and library browser. Two additional devices, SDD12P and SDD14P are only available by typing their exact names into the Component History box, pressing Enter, and moving the cursor to the drawing area to place the components.

Range of Usage

$1 \leq p \leq 60$
$1 \leq q \leq 60$

$1 \le n$

$0 \le w$, but H[w] is internally pre-defined for *w*={0,1}, use only $2 \le w$ for H[].

Parameters

Name	Description	Units	Default
I[p,w]	explicit equation that describes port current in terms of voltage. *p* refers to the port number. *w* refers to the weighting function (0,1, or user defined).	None	I[1,0]=(_v1)/50.0
C[n]	controlling current device name (repeatable). *n* is index of list of controlling currents	None	None
Cport[n]	port number on controlling current device to use (repeatable). *n* is index of port number associated with current source C[n]	None	1
_M	number of devices in parallel	None	1
F[p,w]	implicit equation defining a nonlinear relationship of port voltages and port currents (or the currents of certain other devices) that is equal to 0. *p* refers to the port number. *w* refers to the weighting function (0, 1, or user defined).		
H[w]	user-defined weighting function		
In[p,w]	equation that specifies the noise current squared. *p* refers to the port number. *w* refers to the weighting function (0, 1, or user defined).		
Nc[p,q]	complex noise correlation coefficient between ports *p* and *q*.		

- The port index*p* starts at 1 and should go no higher than the number of ports on the SDD. SDD1P through SDD10P are available from the *Devices - Nonlinear Equation* palette; SDD12P and SDD14P are available for direct placement.
- Port variables, *_in* and *_vn* , contain the current and voltage values of a port, respectively. The suffix *n* specifies the port number, for example, the current and voltage variables for port 1 are *_i1* and *_v1* , respectively.
- Equations that relate port currents and voltages are specified in the time domain. These constitutive relationships may be specified in either *explicit* or *implicit* representations.
  With the *explicit* representation, the current at port *k*is specified as a function of port voltages:
  $$i_k = func(v_1, v_2, \cdots, v_n)$$

The *implicit* representation uses an implicit relationship between any of the port currents and any of the port voltages:

$$f_k(v_1, v_2, \cdots, v_n, i_1, i_2, \cdots, i_n) = 0$$

Using the implicit representation, you can also reference current flowing in another device by using controlling currents.
Different types of expressions cannot be mixed-that is, a single port must be described by either implicit or explicit expressions. Every port must have at least one equation.
By convention, a positive port current flows into the terminal marked + .

- A *weighting function* H[w] is a frequency-dependent expression used to scale the spectrum of a port current. Weighting functions are evaluated in the frequency domain. There are two predefined weighting functions. Weighting function 0 is defined to be identically one; it is used when no weighting is desired. Weighting function 1 is defined as jω and is used when a time derivative is desired. Other weighting functions can be defined, starting with 2. H[w] can be made dependent on frequency by using the global variable *freq*.
- An SDD can also be set up to reference the current flowing in another device. The devices that can be referenced are limited to:
    - independent voltage sources
    - current probes and shorts
    - inductors (L and L_Model)
    - hybrid (primary current only)
    - SnP S-parameter devices
    - ZnP Z-parameter devices
    - SDD (implicit voltage ports only)
      To specify a current as a control current, you enter the instance name of the device in the C[n] parameter of the SDD. For devices with more than one port (SnP, ZnP, SDD), the port number whose current is to be measured must be specified with Cport[n]. These currents can then be referred to using the variable *_cn* for the n^{th} referenced current. The variables *_cn* can be used in the SDD equations along with the SDD port voltages *_vn* and port currents *_in* .
- In[*p*,*w*] specifies the short-circuit noise current squared, in units of amperes squared at port *p* , with weighting function *w*. This expression should not have a negative value:

  $$< i_p, i_p^* >$$

  When user-defined weighting function H[*w*] are used with noise, they should be real and non-negative. Only one In[*p*,*w*] can be defined for each port *p*. If there is a need to define two noise currents at one port with different weighting factors, introduce one of them through an additional SDD port that is used only for noise. For example, on a two port SDD the expressions on the left-hand are not legal. Instead, creating a new third port and using the expressions on the right-hand solves the problem:

Incorrect	Correct
$SDD2P:$ $In[1,0] = funcA(\_v1);$ $In[1,2] = funcB(\_v1);$ $H[2] = freq**2$	$SDD3P:$ $In[1,0] = funcA(\_v1);$ $I[3,0] = 0;$ $In[3,2] = funcB(\_v1);$ $H[2] = freq**2$

- Nc[*p*,*q*] specifies the complex noise correlation coefficient between ports *p* and *q*. It should be a complex number with a magnitude ≤ 1, Nc[*p*,*q)] and Nc[_q*,*p*] should be complex conjugates of each other. If only one is specified, the other term is assumed since the noise correlation matrix is assumed to be Hermitian. Nc[*p*,*q*] should be a constant for harmonic balance noise analysis. This parameter is not used during Transient Circuit Envelope noise analysis.

$$Nc[p,q] = \frac{< i_p, i_q^* >}{\sqrt{< i_p, i_p^* > * < i_q, i_q^* >}}$$

Additional Information

- For more information on how to use these devices and application examples, refer to "Custom Modeling with Symbolically-Defined Devices" in *User-Defined Models*.