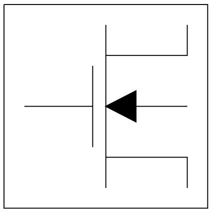
BSIM3_Model (BSIM3 MOSFET Model)

Symbol



Parameters

Model parameters must be specified in SI units.

Name	Description	Units	Default
NMOS	N-channel type model		yes
PMOS	P-channel type model		no
Idsmod	Ids model		8
Version	model version		3.22
Mobmod	mobility model selector		1
Capmod	capacitance model selector		1
Noimod	noise model selector		1
Paramchk	model parameter checking selector		0
Binunit	bin unit selector		1
Rg	gate resistance	ohms	0
Rsh	drain and source diffusion sheet resistance	ohms/sq	0.0
Nj	bulk P-N emission coefficient		1.0
Xti	junction current temp. exponent		3.0
Js	gate saturation current	A/m^2	10^{-4}
Jsw	sidewall junction reverse saturation current	A/m^2	0.0
Lint	length offset fitting parameter (binning parameter; see Note 4)	m	0.0
Ll	coefficient of length dependence for length offset	m^{Lln}	0.0
Lln	power of length dependence of length offset		1.0
Lw	coefficient of width dependence for length offset	m^{Lwn}	0.0

Name	Description	Units	Default
Lwn	power of width dependence of length offset		1.0
Lwl	coefficient of length and width cross term for length offset	$m^{(Lwn+Lln)}$	0.0
Wint	width offset fitting parameter (binning parameter; see Note 4)	m	0.0
Wl	coefficient of length dependence for width offset	m^{Wln}	0.0
Wln	power of length dependence of width offset		1.0
Ww	coefficient of width dependence for width offset	m^{Wwn}	0.0
Wwn	power of width dependence of width offset		1.0
Wwl	coefficient of length and width cross term for width offset	$m^{(Wwn+Wln)}$	0.0
Tnom	parameter measurement temp.	°C	25
Trise	temperature rise above ambient	°C	0
Tox	oxide thickness	m	1.5×10^{-8}
Cj	zero-bias bulk junction bottom capacitance	F/m^2	5.0×10^{-4}
Mj	bulk junction bottom grading coefficient		0.5
Cjsw	zero-bias bulk junction sidewall capacitance	F/m	5.0×10^{-10}
Mjsw	bulk junction sidewall grading coefficient		0.33
Pb	bulk junction potential	V	1.0
Pbsw	sidewall junction potential	V	1.0
Xt	doping depth	m	1.55×10^{-7}
Vbm	maximum applied body bias	V	–5.0
Vbx	Vth transition body voltage	V	calculated parameter
Xj	metallurgical junction depth	m	1.5×10^{-7}
Dwg	coefficient of Weff's gate dependence (binning parameter; see Note 4)	m/V	0.0
Dwb	coefficient of Weff's body dependence (binning parameter; see Note 4)	$m/V^{(1/2)}$	0.0
Nch	channel doping concentration	$1/cm^3$	1.7×10^{17}

Name	Description	Units	Default
Nsub	substrate doping concentration	$1/cm^3$	6.0×10^{16}
Ngate	poly-gate doping concentration	$1/cm^3$	†
Gamma1	body effect coefficient near interface	$V^{(1/2)}$	†
Gamma2	body effect coefficient in the bulk	$V^{(1/2)}$	†
Alpha0	1st parameter of impact ionization current (binning parameter; see Note 4)	m/V	0.0
Beta0	2nd parameter of impact ionization current (binning parameter; see Note 4)	V	30.0
Vth0	zero-bias threshold voltage (binning parameter; see Note 4)	V	†
K1	first order body effect coefficient (binning parameter; see Note 4)	$V^{(1/2)}$	†
K2	second order body effect coefficient (binning parameter; see Note 4)		†
K3	narrow width effect coefficient (binning parameter; see Note 4)		80.0
K3b	body effect coefficient of K3 (binning parameter; see Note 4)	1/V	0.0
W0	narrow width effect W offset (binning parameter; see Note 4)	m	2.5×10^{-6}
Nlx	lateral non-uniform doping effect (binning parameter; see Note 4)	m	1.74×10^{-7}
Dvt0	short channel effect coefficient 0 (binning parameter; see Note 4)		2.2
Dvt1	short channel effect coefficient 1 (binning parameter; see Note 4)		0.53
Dvt2	short channel effect coefficient 2 (binning parameter; see Note 4)	1/V	–0.032
Dvt0w	narrow width effect coefficient 0 (binning parameter; see Note 4)	1/m	0.0
Dvt1w	narrow width effect coefficient 1 (binning parameter; see Note 4)	1/m	5.3×10^{6}
Dvt2w	narrow width effect coefficient 2 (binning parameter; see Note 4)	1/V	–0.032

Name	Description	Units	Default
Cgso	gate-source overlap capacitance, per channel width	F/m	†
Cgdo	gate-drain overlap capacitance, per channel width	F/m	†
Cgbo	gate-bulk overlap capacitance, per channel length	F/m	0.0
Xpart	flag for channel charge partition		0.0
Drout	DIBL effect on Rout coefficient binning parameter; see Note 4)		0.56
Dsub	DIBL effect coefficient in subthreshold region binning parameter; see Note 4)		(fixed by Drout)
Ua	linear Vgs dependence of mobility (binning parameter; see Note 4)	m/V	2.25×10^{-9}
Ua1	temperature coefficient of Ua	m/V	4.31×10^{-9}
Ub	quadratic Vgs dependence of mobility (binning parameter; see Note 4)	$(m/V)^2$	5.87×10^{-19}
Ub1	temperature coefficient of Ub	$(m/V)^2$	-7.61×10^{-18}
Uc	body-bias dependence of mobility (binning parameter; see Note 4)	m/V^2 1/V	-4.65×10^{-11} Mobmod=1, 2 –0.0465 Mobmod=3
Uc1	temperature coefficient of Uc	m/V^2 1/V	-5.6×10^{-11} Mobmod=1,2 –0.056 Mobmod=3
U0	low-field mobility at T=Tnom (binning parameter; see Note 4)	$cm^{2/Vs}$	670.0 NMOS 250.0 PMOS
Ute	temperature coefficient of mobility		–1.5
Rdsw	source drain resistance per width (binning parameter; see Note 4)	$ohms \times \mu m^{Wr}$	0.0
Prwg	gate bias effect coefficient of Rdsw (binning parameter; see Note 4)	1/V	0.0
Prwb	body effect coefficient of Rdsw (binning parameter; see Note 4)	1/V	0.0
Wr	width dependence of Rds (binning parameter; see Note 4)		1.0
Prt	temperature coefficient of Rdsw	$ohms \times \mu m$	0.0

Name	Description	Units	Default
Vsat	saturation velocity at T=Tnom (binning parameter; see Note 4)	m/s	8.0×10^4
At	temperature coefficient of Vsat	m/s	3.3×10^4
A0	bulk charge effect coefficient for channel length (binning parameter; see Note 4)		1.0
Keta	body-bias coefficient of bulk charge (binning parameter; see Note 4)	1/V	–0.047
Ags	gate bias coefficient of Abulk (binning parameter; see Note 4)	1/V	0.0
A1	first non-saturation factor for PMOS (binning parameter; see Note 4)	1/V	0.0
A2	second non-saturation factor for PMOS (binning parameter; see Note 4)		1.0
B0	bulk charge effect coefficient for channel width (binning parameter; see Note 4)	m	0.0
B1	bulk charge effect width offset (binning parameter; see Note 4)	m	0.0
Voff	threshold voltage offset (binning parameter; see Note 4)	V	-0.08
Nfactor	subthreshold swing factor (binning parameter; see Note 4)		1.0
Cdsc	D/S and channel coupling capacitance (binning parameter; see Note 4)	F/m^2	2.4×10^{-4}
Cdscb	body-bias dependence of Cdsc (binning parameter; see Note 4)	$F/V/m^2$	0.0
Cdscd	drain-bias dependence of Cdsc (binning parameter; see Note 4)	$F/V/m^2$	0.0
Cit	interface state capacitance (binning parameter; see Note 4)	F/m^2	0.0
Eta0	subthreshold region DIBL coefficient (binning parameter; see Note 4)		0.08
Etab	body-bias coefficient for DIBL effect (binning parameter; see Note 4)	1/V	–0.07
Pclm	channel-length modulation coefficient (binning parameter; see Note 4)		1.3
Pdiblc1	first Rout DIBL effect coefficient		0.39

Name	Description	Units	Default
Pdiblc2	second Rout DIBL effect coefficient		0.0086
Pdiblcb	body effect coefficient of DIBL correction parameters	1/V	0
Pscbe1	first substrate current body effect	V/m	4.24×10^{8}
Pscbe2	second substrate current body effect	m/V	10^{-5}
Pvag	Vg dependence of Rout coefficient (binning parameter; see Note 4)		0.0
Delta	effective Vds parameter (binning parameter; see Note 4)	V	0.01
Kt1	temperature coefficient of Vth	V	–0.11
Kt1l	channel length sensitivity of Kt1	$V \times m$	0.0
Kt2	body bias coefficient of Kt1		0.022
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 lightly doped region overlap capacitance	F/m	0.6
Cf	fringing field capacitance	F/m	
Clc	constant term for short channel model	m	0.1×10^{-6}
Cle	exponential term for short channel		0.6
Dlc	length offset fitting parameter from C-V	m	Lint
Dwc	width offset fitting parameter from C-V	m	Wint
Nlev	Noise model level		-1
Gdwnoi	Drain noise parameters for Nlev=3		1
Kf	flicker (1/f) noise coefficient		0.0
Af	flicker (1/f) noise exponent		1.0
Ef	flicker (1/f) noise frequency exponent		1.0
Em	flicker (1/f) noise parameter	V/m	4.1×10^{7}
Noia	noise parameter A		1.0×10^{20} NMOS 9.9×10^{18} PMOS

Name	Description	Units	Default
Noib	noise parameter B		5.0×10^{4} NMOS 2.4×10^{3} PMOS
Noic	noise parameter C		-1.4×10^{-12} NMOS 1.4×10^{12} PMOS
Imax	explosion current	A	10.0
wVsubfwd	substrate junction forward bias (warning)	V	infinite
wBvsub	substrate junction reverse breakdown voltage (warning)	V	infinite
wBvg	gate oxide breakdown voltage (warning)	V	infinite
wBvds	drain-source breakdown voltage (warning)	V	infinite
wIdsmax	maximum drain-source current (warning)	A	infinite
Toxm	gate oxide thickness tox value at which parameters are extracted	m	
Vfb	DC flat-band voltage	V	†
Noff	CV parameter in VgsteffCV for weak-to-strong inversion region		1.0
Voffcv	CV parameter in VgsteffCV for weak-to-strong inversion region		1.0
Ijth	diode limiting current	A	†
Alpha1	substrate current parameter	1/V	0.0
Acde	exponential coefficient for charge thickness in the accumulation and depletion regions (binning parameter; see Note 4)	m/V	1.0
Moin	coefficient for the gate-bias dependent surface potential (binning parameter; see Note 4)	$V^{(1/2)}$	15.0
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

Name	Description	Units	Default
Llc	coefficient of length dependence for CV channel length offset	m^{Lln}	DC Ll
Lwc	coefficient of width dependence for CV channel length offset	m^{Lwn}	DC Lw
Lwlc	coefficient of length and width cross-term for CV channel length offset	$m^{Lwn + LLn}$	DC Lwl
Wlc	coefficient of length dependence for CV channel width offset	m^{Wln}	DC Wl
Wwc	coefficient of width dependence for CV channel width offset	m^{Wwn}	DC Ww
Wwlc	coefficient of length and width cross-term for CV channel width offset	$m^{Wln + Wwn}$	DC Wwl
wPmax	maximum power dissipation (warning)	W	infinite
Acm	area calculation method		-1
Calcacm	flag to use Acm when Acm=12		0
Hdif	length of heavily doped diffusion (ACM=2,3 only)	m	0
Ldif	length of lightly doped diffusion adjacent to gate (ACM=1,2)	m	0
Wmlt	width diffusion layer shrink reduction factor		1
Xw	accounts for masking and etching effects	m	0
Xl	accounts for masking and etching effects	m	0
Rdc	additional drain resistance due to contact resistance	Ohms	0
Rsc	additional source resistance due to contact resistance	Ohms	0
Vfbcv	flat-band voltage parameter for capmod=0 only	F/m	-1.0
B3qmod	BSIM3 charge model (0 for Berkeley, 1 for Hspice Capmod = 0)		0
Cjswg	S/D (gate side) sidewall junction capacitance	F/m	Cjsw
Pbswg	S/D (gate side) sidewall junction built in potential	V	Mjsw
Mjswg	S/D (gate side) sidewall junction grading coefficient		Pbsw

Name	Description	Units	Default
Is	bulk junction saturation current	A	1e-14
Nqsmod	non-quasi-static model selector		0
Elm	non-quasi-static Elmore constant parameter		5.0
Rd	drain resistance	Ohms	0
Rs	source resistance	Ohms	0
Flkmod	flicker noise model selector		0
Tlev	temperature equation selector (0/1/2/3)		0
Tlevc	temperature equation selector for capacitance (0/1/2/3)		0
Eg	band gap	eV	1.16
Gap1	energy gap temperature coefficient alpha	$V/^oC$	7.02e-4
Gap2	energy gap temperature coefficient beta	K	1108
Cta	Cj linear temperature coefficient	$1/^oC$	0
Ctp	Cjsw linear temperature coefficient	$1/^oC$	0
Pta	Vj linear temperature coefficnet	$1/^oC$	0
Ptp	Vjsw linear temperature coefficient	$1/^oC$	0
Trd	Rd linear temperature coefficient	$1/^oC$	0
Trs	Rs linear temperature coefficient	$1/^oC$	0
Wmin	binning minimum width (not used for binning; use BinModel)	m	0
Wmax	binning maximum width (not used for binning; use BinModel)	m	1
Lmin	binning minimum length (not used for binning; use BinModel)	m	0
Lmax	binning maximum length (not used for binning; use BinModel)	m	1
AllParams	DataAccessComponent-based parameters		

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 book*.

```
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 is used to tell 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, refer to *RFIC Dynamic Link Appendix E: ADS Simulator Input Syntax*.

Example:

```
model  Nch6  MOSFET Idsmod=8 \
 Vtho=0.7 Cj=3e-4 NMOS=yes
```

Notes/Equations/References

1. This model supplies values for a MOSFET device. The default Version is 3.22. The previous version can be used by setting the Version parameter to 3.0, 3.1, 3.2, or 3.21.
2. BSIM1, BSIM2, and BSIM3 MOSFET models use the same parameters and parameter definitions as the BSIM models in SPICE3 (University of California-Berkeley).
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 = lkl, P_W = wkl, P_P=pkl. The Binunit parameter is a binning unit selector. If Binunit = 1, the units of 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} = 0.5µm and W_{eff} = 10µm, if Binunit = 1, the parameter values for vsat 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, the 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
4. The nonquasi-static (NQS) charge model is supported in versions 3.2 and later.
5. Model parameter U0 can be entered in meters or centimeters. U0 is converted to m^2/V sec as follows: if U0 > 1, it is multiplied by 10^{-4}.
6. 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.
7. 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 specified via AllParams. Set AllParams to thehp DataAccessComponent instance name.

8. 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 doing this is described in the *Circuit Simulation* manual. The device operating point information that is 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

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:

$$E_G(T) = 1.16 - \frac{7.02 \times 10^{-4} T^2}{T + 1108} \quad Tlev = 0,\ 1,\ 3$$

$$E_G(T) = Eg - \frac{Gap1T^2}{T + Gap2} \quad Tlev = 2$$

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 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 $\geq$ 3.2 and ACM $\geq$ 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

$$dPbdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (Eg - E_G(Tnom))\frac{Tnom + 2Gap2}{Tnom + Gap2} - Pb\right)\frac{1}{Tnom}$$

$$dPbswdT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (Eg - E_G(Tnom))\frac{Tnom + 2Gap2}{Tnom + Gap2} - Pbsw\right)\frac{1}{Tnom}$$

$$dPbswdgT = -\left(E_G(Tnom) + \frac{3kTnom}{q} + (Eg - E_G(Tnom))\frac{Tnom + 2Gap2}{Tnom + Gap2} - Pbswg\right)\frac{1}{Tnom}$$

$$Pb^{NEW} = Pb + dPbdT(Temp - Tnom)$$

$$Pbsw^{NEW} = Pbsw + dPbswdT(Temp - Tnom)$$

$$Pbswg^{NEW} = Pbswg + dPbswgT(Temp - Tnom)$$

$$Cj^{NEW} = Ce\left(1 - \frac{dPbdT(Temp - Tnom)}{2Pb}\right)$$

$$Cjsw^{NEW} = Cjsw\left(1 - \frac{dPbswdT(Temp - Tnom)}{2Pbsw}\right)$$

$$Cjswg^{NEW} = Cjswg\left(1 - \frac{dPbswgdT(Temp - Tnom)}{2Pbswg}\right)$$