Basic SPICE Simulation Model Parameters

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1. Overview

The National Instrument **SPICE Simulation Fundamentals** series is your free resource on the internet for learning about circuit simulation. The series is a set of tutorials and information on SPICE simulation, OrCAD pSPICE compatibility, SPICE modeling, and other concepts in circuit simulation.

For more information, see the **SPICE Simulation Fundamentals** main page.

The series is divided among a number of in-depth detailed articles that will give you HOWTO information on the important concepts and details of SPICE simulation.

Circuit simulation is an important part of any design process. By simulating your circuits, you can detect errors early in the process, and avoid costly and time consuming prototype reworking. You can also easily swap components to evaluate designs with varying bills of materials (BOMs).

2. Basic SPICE Simulation Devices

SPICE includes several different types of electrical components that can be simulated. These range from simple resistors, to sophisticated MESFETs. The table below lists these components and their SPICE syntax.

3. SPICE Model Syntax

Parameters in angular parentheses <> are optional. If left unspecified, the default SPICE parameter values will be used.

Resistors	
Syntax	Rname n1 n2 value
Example	Rin 2 0 100
Notes	n1 and n2 are the two element nodes. Value is the resistance (in ohms) and may be positive or negative but not zero.

Semiconductor Resistors	
Syntax	Rname n1 n2 <value> <Mname> <L=Length> <W=Width> <Temp=T>
Example	Rload 3 7 RMODEL L=10u W=1u
Notes	This is the more general form of the resistor and allows the modeling of temperature effects and for the calculation of the actual resistance value from strictly geometric information and the specifications of the process.

Capacitors	
Syntax	Cname n+ n- value <IC=INCOND>
Example	Cout 13 0 1UF IC=3V
Notes	n+ and n- are the positive and negative element nodes, respectively. Value is the capacitance in Farads. The (optional) initial condition is the initial (time-zero) value of capacitor voltage (in Volts).

Semiconductor Capacitors	
Syntax	Cname n1 n2 <value> <Mname> <L=Length> <W=Width> <IC=VAL>
Example	Cfilter 3 7 CMODEL L=10u W=1u

Notes	This is the more general form of the Capacitor and allows for the calculation of the actual capacitance value from strictly geometric information and the specifications of the process.

Inductors

Syntax	Lname n+ n- value <IC=INCOND>
Example	LSHUNT 23 51 10U IC=15.7MA
Notes	n+ and n- are the positive and negative element nodes, respectively. Value is the inductance in Henries. The (optional) initial condition is the initial (time-zero) value of inductor current (in Amps) that flows from n+, through the inductor, to n-.

Coupled (Mutual) Inductors

Syntax	Kname Lname1 Lname2 value
Example	Kin L1 L2 0.87
Notes	Lname1 and Lname2 are the names of the two coupled inductors, and VALUE is the coefficient of coupling, K, which must be greater than 0 and less than or equal to 1.

Switches

Syntax	Sname n+ n- nc+ nc- Mname <ON><OFF> Wname n+ n- VNAM MnameL <ON><OFF>
Examples	Switch1 1 2 10 0 smodel1 W1 1 2 vclock switchmod1
Notes	Nodes n+ and n- are the nodes between which the switch terminals are connected. The model name is mandatory while the initial conditions are optional. For the voltage controlled switch, nodes nc+ and nc- are the positive and negative controlling nodes respectively. For the current controlled switch, the controlling current is that through the specified voltage source. The direction of positive controlling current flow is from the positive node, through the source, to the negative node.

Voltage Sources

Syntax	Vname n+ n- <DC<> DC/TRAN VALUE> <AC <ACMAG <ACPHASE>>> <DISTOF1 <F1MAG <F1PHASE>>> <DISTOF2 <F2MAG <F2PHASE>>>
Examples	VCC 10 0 DC 6 Vin 13 2 0.001 AC 1 SIN(0 1 1MEG)
Notes	n+ and n- are the positive and negative nodes, respectively. Note that voltage sources need not be grounded. Positive current is assumed to flow from the positive node, through the source, to the negative node. A current source of positive value forces current to flow out of the n+ node, through the source, and into the n- node. Voltage sources, in addition to being used for circuit excitation, are the 'ammeters' for SPICE, that is, zero valued voltage sources may be inserted into the circuit for the purpose of measuring current. They of course have no effect on circuit operation since they represent short-circuits. DC/TRAN is the dc and transient analysis value of the source. If the source value is zero both for dc and transient analyses, this value may be omitted. If the source value is time-invariant (e.g., a power supply), then the value may optionally be preceded by the letters DC.

Current Sources

Syntax	Iname n+ n- <<DC> DC/TRAN VALUE> <AC <ACMAG <ACPHASE>>> <DISTOF1 <F1MAG <F1PHASE>>> <DISTOF2 <F2MAG <F2PHASE>>>

Examples	Igain 12 15 DC 1 Irc 23 21 0.333 AC 5 SFFM(0 1 1K)
Notes	ACMAG is the ac magnitude and ACPHASE is the ac phase. The source is set to this value in the ac analysis. If ACMAG is omitted following the keyword AC, a value of unity is assumed. If ACPHASE is omitted, a value of zero is assumed. If the source is not an ac small-signal input, the keyword AC and the ac values are omitted. DISTOF1 and DISTOF2 are the keywords that specify that the independent source has distortion inputs at the frequencies F1 and F2 respectively (see the description of the .DISTO control line). The keywords may be followed by an optional magnitude and phase. The default values of the magnitude and phase are 1.0 and 0.0 respectively.

Linear Voltage-Controlled Current Sources

Syntax	Gname n+ n- nc+ nc- value
Example	G1 2 0 5 0 0.1MMHO
Notes	n+ andn- are the positive and negative nodes, respectively. Current flow is from the positive node, through the source, to the negative node. nc+ and nc- are the positive and negative controlling nodes, respectively. VALUE is the transconductance (in mhos).

Linear Voltage-Controlled Voltage Sources

Syntax	Ename n+ n- nc+ nc- value
Example	E1 2 3 14 1 2.0
Notes	n+ is the positive node, and n- is the negative node. nc+ and nc- are the positive and negative controlling nodes, respectively. Value is the voltage gain.

Linear Current-Controlled Current Sources

Syntax	Fname n+ n- Vname value
Example	F1 13 5 Vsen 5
Notes	n+ andn- are the positive and negative nodes, respectively. Current flow is from the positive node, through the source, to the negative node. Vname is the name of a voltage source through which the controlling current flows. The direction of positive controlling current flow is from the positive node, through the source, to the negative node of Vname. Value is the current gain.

Linear Current-Controlled Voltage Sources

Syntax	Hname n+ n- Vname value
Example	Hx1 5 17 Vz 0.5K
Notes	n+ and n- are the positive and negative nodes, respectively. Vnameis the name of a voltage source through which the controlling current flows. The direction of positive controlling current flow is from the positive node, through the source, to the negative node of Vname. Value is the transresistance (in ohms).

Non-linear Dependent Sources

Syntax	Bname n+ n- <I=EXPR> <V=EXPR>
Example	B1 0 1 I=cos(v(1))+sin(v(2))
Notes	n+ is the positive node, and n- is the negative node. The values of the V and I parameters determine the voltages and currents across and through the device, respectively. If I is given then the device is a current

source, and if V is given the device is a voltage source. One and only one of these parameters must be given. The small-signal AC behavior of the nonlinear source is a linear dependent source (or sources) with a proportionality constant equal to the derivative (or derivatives) of the source at the DC operating point.

Lossless Transmission Lines

Syntax	Oname n1 n2 n3 n4 Mname
Example	O23 1 0 2 0 LOSSYMOD
Notes	This is a two-port convolution model for single-conductor lossy transmission lines. n1 and n2 are the nodes at port 1; n3 and n4 are the nodes at port 2. Note that a lossy transmission line with zero loss may be more accurate than than the lossless transmission line due to implementation details.

Uniform Distributed RC Lines (lossy)

Syntax	Uname n1 n2 n3 Mname L=LEN <N=LUMPS>
Example	U1 1 2 0 URCMOD L=50U
Notes	n1 and n2 are the two element nodes the RC line connects, while n3 is the node to which the capacitances are connected. Mname is the model name, LEN is the length of the RC line in meters. Lumps, if specified, is the number of lumped segments to use in modeling the RC line (see the model description for the action taken if this parameter is omitted).

Junction Diodes

Syntax	Dname n+ n- Mname <Area> <OFF> <IC=VD> <TEMP=T>
Example	Dfwd 3 7 DMOD 3.0 IC=0.2
Notes	n+ and n- are the positive and negative nodes, respectively. Mname is the model name, Area is the area factor, and OFF indicates an (optional) starting condition on the device for dc analysis.

Bipolar Junction Transistors (BJT)

Syntax	Qname nC nB nE <nS> Mname <AREA> <OFF> <IC=VBE, VCE> <TEMP=T>
Example	Q23 10 24 13 QMOD IC=0.6, 5.0
Notes	nC, nB, andnE are the collector, base, and emitter nodes, respectively. nS is the (optional) substrate node. If unspecified, ground is used. Mname is the model name, Area is the area factor, and OFF indicates an (optional) initial condition on the device for the dc analysis.

Junction Field-Effect Transistors (JFET)

Syntax	Jname nD nG nS Mname <Area> <OFF> <IC=VDS, VGS> <TEMP=T>
Example	J1 7 2 3 JM1 OFF
Notes	nD, nG, and nS are the drain, gate, and source nodes, respectively. Mname is the model name, Area is the area factor, and OFF indicates an (optional) initial condition on the device for dc analysis.

MOSFETs

Syntax	Mname ND NG NS NB MNAME <L=VAL> <W=VAL> <AD=VAL> <AS=VAL> <PD=VAL> <PS=VAL> <NRD=VAL> <NRS=VAL> <OFF> <IC=VDS, VGS, VBS> <TEMP=T>
Example	M31 2 17 6 10 Mname L=5U W=2U

Notes	nD, nG, nS, and nB are the drain, gate, source, and bulk (substrate) nodes, respectively. Mname is the model name. L and W are the channel length and width, in meters. AD and AS are the areas of the drain and source diffusions, in 2 meters . Note that the suffix U specifies microns (1e-6 m) 2 and P sq-microns (1e-12 m). If any of L, W, AD, or AS are not specified, default values are used.

MESFETs

Syntax	Zname nD nG nS Mname <Area> <OFF> <IC=VDS, VGS>
Example	Z1 7 2 3 ZM1 OFF
Notes	nD, nG, andnS are the drain, gate, and source nodes, respectively. Mname is the model name, Area is the area factor, and OFF indicates an (optional) initial condition on the device for dc analysis.