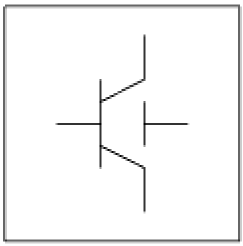
VBIC_Model (VBIC Model)

Symbol



Available in ADS and RFDE

Supported via model include file in RFDE

Parameters

Name	Definition	Units	Default
NPN	N-channel model type: yes, no	None	yes
PNP	P-channel model type: yes, no	None	no
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
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
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
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
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			

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* manual.

```
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" in the Using Circuit Simulators manual.
Example:

```
model  Npn2 VBIC \
  NPN=yes Gamm=8e-10  Cje=1e-13
```

Notes/Equations

> **Note**
> **For RFDE Users** Information about this model must be provided in a *model* file; refer to Netlist Format".

1. This model (version 1.1.4) supplies values for a VBIC device.
2. 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

3. More information about this model is available at: "http://www.designers-guide.com/VBIC/references.html"
4. 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).
5. 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.

6. 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.

References

1. 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*.
2. W. J. Kloosterman and H. C. de Graaff. "Avalanche Multiplication in a Compact Bipolar Transistor Model for Circuit Simulation," *IEEE 1988 BCTM*.
3. McAndrew and Nagel. "Spice Early Model," *IEEE 1994 BCTM*.
4. 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*.

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