1 Operating Point Information

Below is a list of those quantities that should be provided by the circuit simulator to the model user as “operating point information”. The voltages in the expressions are defined as follows:

$$V_{BEi} = V_{B'} - V_{E'}$$
$$V_{BEx} = V_{B*} - V_{E'}$$
$$V_{BCi} = V_{B'} - V_{C'}$$
$$V_{BCx} = V_{B*} - V_{C'}$$
$$V_{SCi} = V_{S'} - V_{C'}$$

Variable	Unit	Description	Definition
IB	A	Base terminal current	as calculated in the model
IC	A	Collector terminal current	as calculated in the model
IS	A	Substrate terminal current	as calculated in the model
IAVL	A	Avalanche current	as calculated in the model
VBE	V	External *BE* voltage	as calculated in the model
VBC	V	External *BC* voltage	as calculated in the model
VCE	V	External *CE* voltage	as calculated in the model
VSC	V	External *SC* voltage	as calculated in the model
BETADC		Common emitter forward current gain	$\beta_{dc} = \frac{I_C}{I_B}$
GMi	A/V	Internal transconductance (Same definition as for SGPM)	$g_{mi} = \left.\frac{\partial I_T}{\partial V_{BEi}}\right\|_{V_{CEi}} = \left.\frac{\partial I_T}{\partial V_{BEi}}\right\|_{V_{BCi}} + \left.\frac{\partial I_T}{\partial V_{BCi}}\right\|_{V_{BEi}}$
GMS	A/V	Transconductance of the parasitic substrate PNP	$g_{ms} = \left.\frac{\partial I_{TS}}{\partial V_{BCx}}\right\|_{V_{SCi}} - \left.\frac{\partial I_{TS}}{\partial V_{SCi}}\right\|_{V_{BCx}}$
RPIi	Ω	Internal base-emitter (input) resistance	$\frac{1}{r_{\pi i}} = \left.\frac{\partial I_{BEi}}{\partial V_{BEi}}\right\|_{V_{BCi}}$

Variable	Unit	Description	Definition
RPIx	Ω	External base-emitter (input) resistance	$\frac{1}{r_{\pi x}} = \left.\frac{\partial I_{BEp}}{\partial V_{BEx}}\right\|_{V_{BCx}} - \left.\frac{\partial I_{BEt}}{\partial V_{BEx}}\right\|_{V_{BCx}}$ (second term is due to tunnelling current)
RMUi	Ω	Internal feedback resistance	$\frac{1}{r_{\mu i}} = \left.\frac{\partial I_{BCi}}{\partial V_{BCi}}\right\|_{V_{BEx}} - \left.\frac{\partial I_{AVL}}{\partial V_{BCi}}\right\|_{V_{BEi}}$ (second term is due to avalanche current)
RMUx	Ω	External feedback resistance	$\frac{1}{r_{\mu x}} = \left.\frac{\partial I_{BCx}}{\partial V_{BCx}}\right\|_{V_{BEx}}$
ROi	Ω	Output resistance	$\frac{1}{r_o} = -\left.\frac{\partial I_T}{\partial V_{BCi}}\right\|_{V_{BEi}} + \left.\frac{\partial I_{AVL}}{\partial V_{BCi}}\right\|_{V_{BEi}}$
CPIi	F	Total internal *BE* capacitance	$C_{\pi i} = C_{jEi} + C_{dE}$
CPIx	F	Total external *BE* capacitance	$C_{\pi x} = C_{jEp} + C_{BEpar}$
CMUi	F	Total internal *BC* capacitance	$C_{\mu i} = C_{jCi} + C_{dC}$
CMUx	F	Total external *BC* capacitance	$C_{\mu x} = C_{jCx} + C_{BCpar} + C_{dS}$
CCS	F	*CS* junction capacitance	C_{jS}
RBI	Ω	Internal base resistance	as calculated in the model
RB	Ω	Total base resistance	as calculated in the model $R_{BI} + R_{BX}$
RCX	Ω	External (saturated) collector series resistance	Model parameter R_{CX}
RE	Ω	Emitter series resistance	Model parameter R_E
BETAAC		Small signal current gain	$\beta_{ac} = g_{mi} \cdot (r_{\pi i} + r_{\pi x})$
CRBI	F	Shunt capacitance across R_{BI}	as calculated in the model
TF	s	Forward transit time	as calculated in the model

Variable	Unit	Description	Definition
FT	Hz	Transit frequency (Note this is an approximation)	$f_T = \frac{g_{mi}}{2\pi \cdot (C_{BE} + C_{BC} + r \cdot C_{BC} \cdot g_{mi})}$, $C_{BE} = C_{\pi i} + C_{\pi x}$, $C_{BC} = C_{\mu i} + C_{\mu x}$, $r = R_{Cx} + R_E + \frac{R_B + R_E}{\beta_{ac}}$, $R_B = R_{BI} + R_{BX}$