4. Comparing the VBIC and Gummel-Poon Parameters

The following table gives a comparison between the VBIC and the G-P model parameters.

VBIC	G-P	Remarks
Parasitic Capacitors		
CBE0	-	External capacitors, not included in the G-P model
CBC0	-	External capacitors, not included in the G-P model
Space Charge Capacitors		
AJE	-	AJE selects one of the space charge models (-0.5 for G-P version)
CJE	CJE	
PE	VJE	
ME	MJE	
AJC	-	AJC selects one of the space charge models (-0.5 for G-P version)
CJC	CJC * XCJC	
PC	VJC	
MC	MJC	
CJEP	CJC*(1-XCJC)	
CJCP	CJS	GP only includes the CV path from C->S, however not the DC C->S diode
PS	VJS	
MS	MJS	
AJS	-	AJS selects one of the space charge models (-0.5 for G-P version)
FC	FC	Default for VBIC: 0.9; at G-P: 0.5
WBE	-	WBE distributes the Base-Emitter current space charge capacitor between inner and outer Base
Early Modeling		
VEF	VAF	The Early effect is modeled differently
VER	VAR	With the VBIC model !!
DC Forward Main Transistor		
IS	IS	
NF	NF	
Forward Base:		
IBEI	IS / BF	With the VBIC, the forward Base current is not coupled to the
NEI	NF	Collector current. Instead, two parallel diodes, one to model
IBEN	ISE	the ideal (I) Base current and another to cover the non-ideal
NEN	NE	or recombination (N) effect, are used.
IKF	IKF	

VBIC	G-P	Remarks
DC reverse Main Transistor		
		Note: IS from the forward Collector current model is used.
NR	NR	
IBCI	IS / BF	With the VBIC model, the reverse Base current is not coupled to the
NCI	NR	Emitter current. Instead, two parallel diodes, one to model
IBCN	ISC	the ideal (I) Base current and another to cover the non-ideal
NCN	NC	or recombination effect (N) effect, are used.
IKR	IKR	
Parasitic Transistor		
ISP	-	G-P does not cover a parasitic transistor
NFP	-	
WSP	-	Distributes parasitic collector current control to vbci of the main transistor and vbep of the parasitic transistor
Forward Base:		
BEIP	-	For the exponential coefficient, NCI of the main transistor is used
IBENP	-	For the exponential coefficient, NCN of the main transistor is used
Reverse Base		
IBCIP	-	With the VBIC model, the reverse Base current is not coupled to the
NCIP	-	Collector current. Instead, two parallel diodes, one to model
IBCNP	-	the ideal (I) Base current and another to cover the non-ideal
NCNP	-	or recombination effect (N), are used.
IKP	-	
Avalanche Effect		
AVC1	-	
AVC2	-	
Resistances		
RE	RE	
RBX	RBM	The bias-dependent Base resistance is modeled differently
RBI	RB - RBM	in both models.
-	RB	
-	IRB	
RS	-	
RBP	-	
RCX	RC	Constant, external Collector resistance

VBIC	G-P	Remarks
Quasi-Saturation		
CI	-	VBIC has a modified Kull model implemented
GAMM	-	
VO	-	
HRCF	-	
QCO	-	
Transit Time Modeling		
TF	TF	
QTF	-	Describes the additional dependency of the transit time from qb.
XTF	XTF	
ITF	ITF	
VTF	VTF	
TR	TR	
Excess Phase		
TD	Π*TF*PTF/180	The VBIC implementation is consistent between small signal and transient analysis
Temperature Dependence		
CTH	-	VBIC includes self-heating effects
RTH	-	
TAMB	-	Environmental temperature
TNOM	TNOM	Measurement temperature for parameter extraction
EA	EG	The G-P model only contains one energy gap
EAIE	-	
EAIC	-	
EAIS	-	
EANE	-	
EANC	-	
EANS	-	
XRE	-	Temperature coefficients of the resistors are not covered with G-P
XRB	-	
XRC	-	
XRS	-	
XVO	-	
XIS	XTI	
XII	XTB	
XIN	XTB	
TNF	-	
TAVC	-	

Since the VBIC model is based essentially upon the G-P model, most of the G-P parameters can be converted to VBIC. However, the following details have to be kept in mind strictly:

- **Space Charge Capacitances**
  For all space charge capacitances, the parameter Ajx with x = E, C and S must be set to a value less than or equal zero, in order to obtain the same formulation in both models. In this case, the values of the Base-Emitter capacitance can be transferred. With the CJC parameter of the Base-Collector capacitance, it must be reflected that
  $CJC^{VBIC} = XCJC \cdot CJC^{GP}$ and $CJEP^{VBIC} = (1 - XCJC) \cdot CJC^{GP}$
  If the actual SPICE implementation of the G-P model only contains a constant value for the Substrate capacitance, CJCP will hold that value and MS is set to 0. Finally, FC, modeling the transition between the hyperbolic formulation and the linear continuation, has different default values in both models.

- **Diode Currents**
  The forward and reverse parameters IS, NF and NR can be transferred directly. The ideal Base current sections are not coupled to the transport currents. For VBIC, there is *IBEI = IS/BF* and *IBCI = IS/BR* . The G-P parameters of the non-ideal or recombination section of the Base current can, however, be transferred directly to VBIC. Finally, setting *WBE =1* , the Base current distribution (inner and outer Base) is switched off.

- **Early Modeling**
  The implementation of the Early effect in the Gummel-Poon and the VBIC model is so different, that the parameters cannot be converted (different modeling of the normalized Base charge qb). Especially with small G-P Early voltages, the resulting error can be considerably big. Yet, as a general rule, the G-P Early parameters are usually bigger than those of the VBIC model. For rather big values of the G-P Early voltage, only slight modifications should be required.

- **Parasitic Transistor and Avalanche effect**
  Using the mentioned default values in VBIC, the parasitic transistor and the Avalanche effects are switched off. Exception: Base-Collector space charge capacitance.

- **Resistances**
  The constant resistors of Emitter and Collector can be overtaken. From the parameters *RBM*, *RB* and *IRB* of the G-P model, suitable values have to be generated for the VBIC parameters *RBI* and *RBX*, since the models differ here.

- **Quasi-Saturation**
  Using suitable parameter values, no quasi-saturation effects are taken into account with the VBIC. Setting *GAMM* = 0, Rc is reduced to an ohmic resistance. QC0 = 0 eliminates the influence of the additional capacitances Cbcx and Cbcq.

- **Transit Time Parameters**
  Setting *QTF* = 0, the G-P parameters of the transit time TFF as well as the excess phase can be transferred without any change.

- **Temperature Modeling**
  Setting Rth = 0, the VBIC temperature model including self-heating is reduced to G-P, which only covers a constant ambient temperature.