Appendix E: Model Parameter Binning

Below is the information on parameter binning regarding which model parameters can or cannot be binned. All those parameters which can be binned 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: P_0 = k1, P_L = lk1, P_W = wk1, P_P = pk1. binUnit is a bining unit selector. If binUnit = 1, the units of L_{eff} and W_{eff} used in the binning equation above 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 1e5, 1e4, 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, 1e-2, 2e-2, 3e-8, respectively. Thus,

vsat = 1e5 + 1e-2/0.5e-6 + 2e-2/10e-6 + 3e-8/(0.5e-6 * 10e-6) = 1.28e5

Model parameters that have been binned in B4SOI are listed as follows:

E.1. DC Parameters

Symbol used in equation	Symbol used in SPICE	Description
V_{th0}	vth0	Threshold voltage @V_{bs}=0 for long and wide device
K_1	k1	First order body effect coefficient
$\boldsymbol{K_{1w1}}$	**k1w1**	**First body effect width dependent parameter**
$\boldsymbol{K_{1w2}}$	**k1w2**	**Second body effect width dependent parameter**
K_2	k2	Second order body effect coefficient
K_3	k3	Narrow width coefficient
K_{3b}	k3b	Body effect coefficient of k3
K_{b1}	Kb1	Backgate body charge coefficient
W_0	w0	Narrow width parameter
N_{LX}	nlx	Lateral non-uniform doping parameter
D_{vt0}	Dvt0	first coefficient of short-channel effect on Vth
D_{vt1}	dvt1	Second coefficient of short-channel effect on Vth
D_{vt2}	dvt2	Body-bias coefficient of short-channel effect on Vth
D_{vt0w}	dvt0w	first coefficient of narrow width effect on Vth for small channel length
D_{vt1w}	dvt1w	Second coefficient of narrow width effect on Vth for small channel length
D_{vt2w}	dvt2w	Body-bias coefficient of narrow width effect on Vth for small channel length
μ_0	u0	Mobility at Temp = Tnom
U_a	ua	First-order mobility degradation coefficient
U_b	ub	Second-order mobility degradation coefficient
U_c	uc	Body-effect of mobility degradation coefficient
v_{sat}	vsat	Saturation velocity at Temp=Tnom
$A0$	a0	Bulk charge effect coefficient for channel length

A_{gs}	ags	Gate bias coefficient of A_{bulk}
B0	b0	Bulk charge effect coefficient for channel width
B1	b1	Bulk charge effect width offset
Keta	keta	Body-bias coefficient of bulk charge effect
Ketas	**Ketas**	**Surface potential adjustment for bulk charge effect**
A_1	A1	First non-saturation effect parameter
A_2	A2	Second non-saturation effect parameter
R_{dsw}	rdsw	Parasitic resistance per unit width
Prwb	prwb	Body effect coefficient of Rdsw
Prwg	prwg	Gate bias effect coefficient of Rdsw
Wr	wr	Width offset from Weff for Rds calculation
Nfactor	nfactor	Subthreshold swing factor
Wint	wint	Width offset fitting parameter from I-V without bias
Lint	lint	Length offset fitting parameter from I-V without bias
DWg	dwg	Coefficient of W_{eff}'s gate dependence
DWb	dwb	Coefficient of W_{eff}'s substrate body bias dependence
V_{off}	voff	Offset voltage in the subthreshold region for large W and L
Eta0	eta0	DIBL coefficient in subthreshold region
Etab	etab	Body-bias coefficient for the subthreshold DIBL effect
D_{sub}	dsub	DIBL coefficient exponent
C_{it}	cit	Interface trap capacitance
C_{dsc}	cdsc	Drain/Source to channel coupling capacitance
C_{dscb}	cdscb	Body-bias sensitivty of C_{dsc}
C_{dscd}	cdscd	Drain-bias sensitivty of C_{dsc}
P_{clm}	pclm	Channel length modulation parameter
P_{dibl1}	pdibl1	First output resistance DIBL effect correction parameter
P_{dibl2}	pdibl2	Second output resistance DIBL effect correction parameter
D_{rout}	drout	L dependence coefficient of the DIBL correction parameter in Rout
Pvag	pvag	Gate dependence of Early voltage

δ	delta	Effective V_{ds} parameter
α_0	alpha0	The first parameter of impact ionization current
F_{bjtii}	**fbjtii**	**Fraction of bipolar current affecting the impact ionization**
β_0	**beta0**	**First V_{ds} dependent parameter of impact ionization current**
β_1	**beta1**	**Second V_{ds} dependent parameter of impact ionization current**
β_2	**beta2**	**Third V_{ds} dependent parameter of impact ionization current**
$V_{dsatii0}$	**vdsatii0**	**Nominal drain saturation voltage at threshold for impact ionization current**
T_{ii}	**tii**	**Temperature dependent parameter for impact ionization current**
L_{ii}	**lii**	**Channel length dependent parameter at threshold for impact ionization current**
E_{satii}	**esatii**	**Saturation channel electric field for impact ionization current**
S_{ii0}	**sii0**	**First V_{gs} dependent parameter for impact ionization current**
S_{ii1}	**sii1**	**Second V_{gs} dependent parameter for impact ionization current**
S_{ii2}	**sii2**	**Third V_{gs} dependent parameter for impact ionization current**
S_{iid}	**siid**	**V_{ds} dependent parameter of drain saturation voltage for impact ionization current**
α_{gidl}	**Agidl**	**GIDL constant**
β_{gidl}	**Bgidl**	**GIDL exponential coefficient**
χ	**Ngidl**	**GIDL V_{ds} enhancement coefficient**
n_{tun}	**Ntun**	**Reverse tunneling non-ideality factor**
n_{diode}	**Ndiode**	**Diode non-ideality factor**
n_{recf0}	**Nrecf0**	**Recombination non-ideality factor at forward bias**
n_{recr0}	**Nrecr0**	**Recombination non-ideality factor at reversed bias**
i_{sbjt}	**Isbjt**	**BJT injection saturation current**
i_{sdif}	**Isdif**	**Body to source/drain injection saturation current**
i_{srec}	**Isrec**	**Recombination in depletion saturation current**
i_{stun}	**Istun**	**Reverse tunneling saturation current**
V_{rec0}	**Vrec0**	**Voltage dependent parameter for recombination current**

V_{tun0}	**Vtun0**	**Voltage dependent parameter for tunneling current**
N_{bjt}	**Nbjt**	**Power coefficient of channel length dependency for bipolar current**
L_{bjt0}	**Lbjt0**	**Reference channel length for bipolar current**
V_{abjt}	**Vabjt**	**Early voltage for bipolar current**
A_{ely}	**Aely**	**Channel length dependency of early voltage for bipolar current**
A_{hli}	**Ahli**	**High level injection parameter for bipolar current**

E.2. AC and Capacitance Parameters

Symbol used in equation	Symbol used in SPICE	Description
V_{sdfb}	**vsdfb**	**Source/drain bottom diffusion capacitance flatband voltage**
V_{sdth}	**vsdth**	**Source/drain bottom diffusion capacitance threshold voltage**
DelVt	**delvt**	**Threshold voltage adjust for C-V**
acde	**acde**	**Exponential coefficient for charge thickness in capMod=3 for accumulation and depletion regions.**
moin	**moin**	**Coefficient for the gate-bias dependent surface potential.**