
APPENDIX D: 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 binning 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 $L_{eff} = 0.5\mu m$ and $W_{eff} = 10\mu m$. 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,

$$vsat = 1e5 + 1e-2/0.5e6 + 2e-2/10e-6 + 3e-8/(0.5e-6 * 10e-6) = 1.28e5$$

D.1 Model Control Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
None	level	The model selector	NO
None	version	Model version selector	NO
None	binUnit	Bining unit selector	NO
None	param-Chk	Parameter value check	NO
mobMod	mobMod	Mobility model selector	NO
capMod	capMod	Flag for the short channel capacitance model	NO
nqsMod	nqsMod	Flag for NQS model	NO
noiMod	noiMod	Flag for Noise model	NO

D.2 DC Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Vth0	vth0	Threshold voltage @ $V_{bs}=0$ for Large L.	YES
VFB	vfb	Flat band voltage	YES
K1	k1	First order body effect coefficient	YES
K2	k2	Second order body effect coefficient	YES

DC Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
K3	k3	Narrow width coefficient	YES
K3b	k3b	Body effect coefficient of k3	YES
W0	w0	Narrow width parameter	YES
Nlx	nlx	Lateral non-uniform doping parameter	YES
Dvt0	dvt0	first coefficient of short-channel effect on Vth	YES
Dvt1	dvt1	Second coefficient of short-channel effect on Vth	YES
Dvt2	dvt2	Body-bias coefficient of short-channel effect on Vth	YES
Dvt0w	dvt0w	First coefficient of narrow width effect on Vth for small channel length	YES
Dvt1w	dvtw1	Second coefficient of narrow width effect on Vth for small channel length	YES
Dvt2w	dvt2w	Body-bias coefficient of narrow width effect for small channel length	YES
μ_0	u0	Mobility at Temp = Tnom NMOSFET PMOSFET	YES
Ua	ua	First-order mobility degradation coefficient	YES
Ub	ub	Second-order mobility degradation coefficient	YES

DC Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Uc	uc	Body-effect of mobility degradation coefficient	YES
vsat	vsat	Saturation velocity at Temp = Tnom	YES
A0	a0	Bulk charge effect coefficient for channel length	YES
Ags	ags	gate bias coefficient of Abulk	YES
B0	b0	Bulk charge effect coefficient for channel width	YES
B1	b1	Bulk charge effect width offset	YES
Keta	keta	Body-bias coefficient of bulk charge effect	YES
A1	a1	First non0saturation effect parameter	YES
A2	a2	Second non-saturation factor	YES
Rdsw	rdsw	Parasitic resistance per unit width	YES
Prwb	prwb	Body effect coefficient of Rdsw	YES
Prwg	prwg	Gate bias effect coefficient of Rdsw	YES
Wr	wr	Width Offset from Weff for Rds calculation	YES
Wint	wint	Width offset fitting parameter from I-V without bias	NO
Lint	lint	Length offset fitting parameter from I-V without bias	NO

DC Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
dWg	dwg	Coefficient of Weff's gate dependence	YES
dWb	dwb	Coefficient of Weff's substrate body bias dependence	YES
Voff	voff	Offset voltage in the subthreshold region for large W and L	YES
Nfactor	nfactor	Subthreshold swing factor	YES
Eta0	eta0	DIBL coefficient in subthreshold region	YES
Etab	etab	Body-bias coefficient for the subthreshold DIBL effect	YES
Dsub	dsub	DIBL coefficient exponent in subthreshold region	YES
Cit	cit	Interface trap capacitance	YES
Cdsc	cdsc	Drain/Source to channel coupling capacitance	YES
Cdscb	cdscb	Body-bias sensitivity of Cdsc	YES
Cdscd	cdscd	Drain-bias sensitivity of Cdsc	YES
Pclm	pclm	Channel length modulation parameter	YES
Pdiblc1	pdiblc1	First output resistance DIBL effect correction parameter	YES
Pdiblc2	pdiblc2	Second output resistance DIBL effect correction parameter	YES
Pdiblc b	pdiblc b	Body effect coefficient of DIBL correction parameters	YES

DC Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Drout	drou t	L dependence coefficient of the DIBL correction parameter in Rout	YES
Pscbe1	pscbe1	First substrate current body-effect parameter	YES
Pscbe2	pscbe2	Second substrate current body-effect parameter	YES
Pvag	pvag	Gate dependence of Early voltage	YES
δ	delta	Effective Vds parameter	YES
Ngate	ngate	poly gate doping concentration	YES
α_0	alpha0	The first parameter of impact ionization current	YES
α_1	alpha1	Isub parameter for length scaling	YES
β_0	beta0	The second parameter of impact ionization current	YES
Rsh	rsh	Source drain sheet resistance in ohm per square	NO
Js0	js	Source drain junction saturation current per unit area	NO
ijth	ijth	Diode limiting current	NO

D.3 AC and Capacitance Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Xpart	xpart	Charge partitioning rate flag	NO
CGS0	cgso	Non LDD region source-gate overlap capacitance per channel length	NO
CGD0	cgdo	Non LDD region drain-gate overlap capacitance per channel length	NO
CGB0	cgbo	Gate bulk overlap capacitance per unit channel length	NO
Cj	cj	Bottom junction per unit area	NO
Mj	mj	Bottom junction capacitance grading coefficient	NO
Mjsw	mjsw	Source/Drain side junction capacitance grading coefficient	NO
Cjsw	cjsw	Source/Drain side junction capacitance per unit area	NO
Pb	pb	Bottom built-in potential	NO
Pbsw	pbsw	Source/Drain side junction built-in potential	NO
CGS1	cgs1	Light doped source-gate region overlap capacitance	YES
CGD1	cgd1	Light doped drain-gate region overlap capacitance	YES

AC and Capacitance Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
CKAPPA	ckappa	Coefficient for lightly doped region overlap capacitance Fringing field capacitance	YES
Cf	cf	fringing field capacitance	YES
CLC	clc	Constant term for the short channel model	YES
CLE	cle	Exponential term for the short channel model	YES
DLC	dlc	Length offset fitting parameter from C-V	YES
DWC	dwc	Width offset fitting parameter from C-V	YES
Vfbcv	vfbcv	Flat-band voltage parameter (for capMod = 0 only)	YES
noff	noff	CV parameter in Vgsteff,CV for weak to strong inversion	YES
voffcv	voffcv	CV parameter in Vgsteff,CV for weak to strong inversion	YES
acde	acde	Exponential coefficient for charge thickness in capMod=3 for accumulation and depletion regions	YES
moin	moin	Coefficient for the gate-bias dependent surface potential	YES

D.4 NQS Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Elm	elm	Elmore constant of the channel	YES

D.5 dW and dL Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Wl	wl	Coefficient of length dependence for width offset	NO
Wln	wln	Power of length dependence of width offset	NO
Ww	ww	Coefficient of width dependence for width offset	NO
Wwn	wn	Power of width dependence of width offset	NO
Wwl	wwl	Coefficient of length and width cross term for width offset	NO
Ll	ll	Coefficient of length dependence for length offset	NO
Lln	lln	Power of length dependence for length offset	NO

dW and dL Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Lw	lw	Coefficient of width dependence for length offset	NO
Lwn	lwn	Power of width dependence for length offset	NO
Lwl	lwl	Coefficient of length and width cross term for length offset	NO
Llc	Llc	Coefficient of length dependence for CV channel length offset	NO
Lwc	Lwc	Coefficient of width dependence for CV channel length offset	NO
Lwlc	Lwlc	Coefficient of length and width-dependence for CV channel length offset	NO
Wlc	Wlc	Coefficient of length dependence for CV channel width offset	NO
Wwc	Wwc	Coefficient of widthdependence for CV channel width offset	NO
Wwlc	Wwlc	Coefficient of length and width-dependence for CV channel width offset	NO

D.6 Temperature Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Tnom	tnom	Temperature at which parameters are extracted	NO
μ_{te}	ute	Mobility temperature exponent	YES
Kt1	kt1	Temperature coefficient for threshold voltage	YES
Kt1l	kt1l	Channel length dependence of the temperature coefficient for threshold voltage	YES
Kt2	kt2	Body-bias coefficient of Vth temperature effect	YES
Ua1	ua1	Temperature coefficient for Ua	YES
Ub1	ub1	Temperature coefficient for Ub	YES
Uc1	uc1	Temperature coefficient for Uc	YES
At	at	Temperature coefficient for saturation velocity	YES
Prt	prt	Temperature coefficient for Rds	YES
nj	nj	Emission coefficient	YES
XTI	xti	Junction current temperature exponent coefficient	YES

Flicker Noise Model Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
tpb	tpb	Temperature coefficient of Pb	NO
tpbsw	tpbsw	Temperature coefficient of Pbsw	NO
tpbswg	tpbswg	Temperature coefficient of Pbswg	NO
tcj	tcj	Temperature coefficient of Cj	NO
tcjsw	tcjsw	Temperature coefficient of Cjsw	NO
tcjswg	tcjswg	Temperature coefficient of Cjswg	NO

D.7 Flicker Noise Model Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Noia	noia	Noise parameter A	NO
Noib	noib	Noise parameter B	NO
Noic	noic	Noise parameter C	NO
Em	em	Saturation field	NO
Af	af	Flicker noise exponent	NO

Process Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Ef	ef	Flicker noise frequency exponent	NO
Kf	kf	Flicker noise parameter	NO

D.8 Process Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Tox	tox	Gate oxide thickness	NO
Toxm	toxm	Tox at which parameters are extracted	NO
Xj	xj	Junction Depth	YES
γ_1	gamma1	Body-effect coefficient near the surface	YES
γ_2	gamma2	Body-effect coefficient in the bulk	YES
Nch	nch	Channel doping concentration	YES
Nsub	nsub	Substrate doping concentration	YES
Vbx	vbx	Vbs at which the depletion region width equals xt	YES
Vbm	vbm	Maximum applied body bias in Vth calculation	YES
Xt	xt	Doping depth	YES

D.9 Geometry Range Parameters

Symbols used in equation	Symbols used in SPICE	Description	Can Be Binned?
Lmin	lmin	Minimum channel length	NO
Lmax	lmax	Maximum channel length	NO
Wmin	wmin	Minimum channel width	NO
Wmax	wmax	Maximum channel width	NO
binUnit	binUnit	Binning unit selector	NO