Appendix 5

Model card parameters for built-in components

In this Appendix, names and default values of model card parameters are given for built-in analogue components. These are SPICE models of diode, MOSFET, BJT, and JFET. In SPICE manuals more detailed explanations of these models and model card parameters can be found. Nevertheless, there are different versions of SPICE, and we hope this list of model card parameters can be useful to determine which version of SPICE model is implemented in Alecsis.

If you need some version of the model that is not built into Alecsis, you have to define new model in AleC++.

Note: In the parameter tables, some of the parameters are dummy, i.e. they have no meaning. They are given here for completeness, as memory is allocated for them (as in SPICE). Some of them are used for results of parameters preprocessing.

A5.1. Diode model card parameters

SPICE 2G6 diode model is built into Alecsis.

Physical units are not given in the following table. We will give these units in new versions of this Manual.

Table A5.1. Diode model card parameters in Alecsis.

name	**default**	**unit**	**meaning**
		-	dummy, not used
`is`	`1e-14`		saturation current
`rs`	`0.0`		parasitic resistance
`n`	`1.0`		emission coefficient
`tt`	`0.0`		transit time
`cjo`	`0.0`		zero-bias p-n capacitance
`vj`	`1.0`		p-n potential
`m`	`0.5`		p-n grading coefficient
`eg`	`1.11`		bandgap voltage
`xti`	`3.0`		IS temperature coefficient
`kf`	`0.0`		flicker noise coefficient
`af`	`1.0`		flicker noise exponent
`fc`	`0.5`		forward-bias depletion capacitance coefficient
`bv`	`0.0`		reverse breakdown "knee" voltage
`ibv`	`1e-3`		reverse breakdown "knee" current
Following parameters are read from the model card, but are not used in the current version of the model:			
`isr`	-		recombination current parameter
`nr`	-		emission coefficient for ISR
`ikf`	-		high-injection "knee" current
`nbv`	-		reverse breakdown ideality factor
`ibvl`	-		low-level reverse breakdown "knee" current
`nbvl`	-		low-level reverse breakdown ideality factor
`tikf`	-		IKF temperature coefficient (linear)
`tbv1`	-		BV temperature coefficient (linear)
`tbv2`	-		BV temperature coefficient (quadratic)
`trs1`	-		RS temperature coefficient (linear)
`trs2`	-		RS temperature coefficient (quadratic)

A5.2. MOSFET model card parameters

Alecsis has four versions (levels) of MOS models. These are level 1, level 2, level 3 and level 13 models. The first three are standard SPICE models. Fourth model is BSIM model (**B**erkeley **S**hort-Channel **I**GFET **M**odel), which is denoted as level 13 in HSPICE.

A5.2.1. MOSFET level 1, 2 and 3 parameters

SPICE 2G6 MOSFET level 1, 2, and 3 models are built into Alecsis.

Parameter explanations are not given in the following table. We will give these explanations in new versions of this Manual.

Table A5.2. MOSFET level 1, 2, and 3 model card parameters in Alecsis.

name	default	unit	meaning
level	1	-	
gamma	-	V$^{1/2}$	
nss	-	1/cm^2	
nsub	1.0e15	1/cm^3	
phi	-	V	
tpg	1.0	-	
vto	-	V	
af	1.0	-	
kf	-	-	
rd	-	Ω	
rs	-	Ω	
rsh	-	Ω/square	
cgso	-	F/m	
cgdo	-	F/m	
cgbo	-	F/m	
tox	1.0e-7	m	
cj	-	F/m^2	
cjsw	-	F/m	
mj	0.5	-	
mjsw	0.33	-	
pb	0.8	V	
fc	0.5	-	
ld	-	m	
kp	-	A/V^2	
lambda	-	1/V	
delta	-	-	
neff	1.0	-	
nfs	-	1/cm^2	
ucrit	1.0e4	V/cm	
uexp	-	-	
uo	600.0	cm^2/(Vs)	
vmax	-	m/s	
xj	-	m	
is	1.0e-14	A	
js	-	A/m^2	
kappa	0.2	-	
theta	-	1/V	
cox	-	F/m^2	
eta	-	-	
vbi	-	V	
xqc	-	-	
xd	-	-	For use of macromodels.
fnarrow	-	-	
vt	-	-	
xd2	-	-	

Following parameters are read from the model card, but are not used in the current version of the model:			
rg	-	Ω	
rb	-	Ω	
rds	-	Ω	
jssw	-	A/m	
n	-	–	
pbsw	-	V	
cbd	-	F	
cbs	-	F	
tt	-	s	
wd	-	m	
utra	-	-	
The following two parameters are used, if they are not given when MOS transistor is invoked (connected):			
l	0.0	m	channel length
w	0.0	m	channel width

A5.2.2. BSIM parameters (level 13)

HSPICE MOSFET level 13 model is built into Alecsis.

Table A5.3. MOSFET level 13 model card parameters in Alecsis.

name	default	unit	meaning
level		-	mosfet model level selector, 13 for HSPICE BSIM
vfb0	-1.0641	V	flatband voltage and its length and width sensitivities
lvfb	1.71979e-1	V µm	
wvfb	1.11454e-1	V µm	
phi0	7.95392e-1	V	two times the Fermi potential, its length and width sensitivities
lphi	0.0	V µm	
wphi	0.0	V µm	
k1	1.10425	$V^{1/2}$	root-vbs threshold coefficient, its length and width sensitivities
lk1	-4.3371e-1	$V^{1/2}$ µm	
wk1	-9.8518e-2	$V^{1/2}$ µm	
k2	1.93126e-1	-	linear vbs threshold coefficient, its length and width sensitivities
lk2	4.14269e-4	µm	
wk2	-6.0274e-2	µm	
eta0	-4.7124e-3	-	linear vds threshold coefficient, its length and width sensitivities
leta	-1.0565e-2	µm	
weta	1.08645e-2	µm	
muz	6.00853e2	$cm^2/(Vs)$	low drain field first order mobility
dl0	6.2438e-1	µm	difference between drawn poly and electrical
dw0	1.0384	µm	difference between drawn diffusion and electrical
u00	5.11222e-2	1/V	gate field mobility reduction factor, its length and width sensitivities
lu0	1.73108e-1	(1/V) µm	
wu0	-5.9804e-2	(1/V) µm	
u1	-2.3954e-1	µm/V	drain field mobility reduction factor, its length and width sensitivities
lu1	2.91101	(µm/V) µm	
wu1	-5.3638e-2	(µm/V) µm	
x2m	4.66158	$(cm/V)^2 / s$	vbs correction to low field first order mobility, its length and width sensitivities
lx2m	-8.0305	$((cm/V)^2 / s)$ µm	
wx2m	5.54267	$((cm/V)^2 / s)$ µm	

x2e	-9.142e-4	1/V	vbs correction to linear vds threshold coefficient, its length and width sensitivities
lx2e	1.23113e-2	(1/V) µm	
wx2e	2.4326e-3	(1/V) µm	
x3e	1.05704e-4	1/V	vds correction to linear vds threshold coefficient, its length and width sensitivities
lx3e	1.04115e-2	(1/V) µm	
wx3e	-2.5834e-3	(1/V) µm	
x2u0	2.68363e-4	1/V^2	vbs reduction to gate field mobil. reduction factor, its length and width sensitivities
lx2u0	-1.5668e-3	(1/V^2) µm	
wx2u0	-8.5052e-4	(1/V^2) µm	
x2u1	-7.2567e-2	µm/V^2	vbs reduction to drain field mobil. reduction factor, its length and width sensitivities
lx2u1	1.10182e-1	(µm/V^2) µm	
wx2u1	5.66859e-2	(µm/V^2) µm	
mus	5.49834e2	cm^2/(Vs)	high drain field mobility, its length and width sensitivities
lms	1.77273e3	cm^2/(Vs) µm	
wms	-9.0196e1	cm^2/(Vs) µm	
x2ms	-1.6724e1	(cm/V)^2 / s	vbs reduction to high drain field mobility, its length and width sensitivities
lx2ms	8.98504	((cm/V)^2 / s) µm	
wx2ms	2.8234e1	((cm/V)^2 / s) µm	
x3ms	4.86164	(cm/V)^2 / s	vds reduction to high drain field mobility, its length and width sensitivities
lx3ms	1.56629e1	((cm/V)^2 / s) µm	
wx3ms	-6.57	((cm/V)^2 / s) µm	
x3u1	7.76925e-3	µm/V^2	vds reduction to drain field mobility reduction factor, its length and width sensitivities
lx3u1	-1.094e-1	(µm/V^2) µm	
wx3u1	-8.3353e-3	(µm/V^2) µm	
toxm	2.5e-2	µm	gate oxide thickness
tempm	25.0	ºC	reference temperature of model
vddm	5.0	V	critical voltage for high drain field mobility reduction
cgdom	1.5e-9	F/m	gate to drain parasitic capacitance; f/m of width
cgsom	1.5e-9	F/m	gate to source parasitic capacitance; f/m of width
cgbom	2.0e-10	F/m	gate to bulk parasitic capacitance; f/m of length
xpart	1.0	-	selector for gate capacitance charge sharing coefficient
dum1	0.0	-	dummy, not used
dum2	0.0	-	dummy, not used
n0	1.5	-	low field weak inversion gate drive coefficient, -||-, value of 200 for n0 disables weak inversion calculation
ln0	0.0	µm	
wn0	0.0	µm	
nb0	0.1	1/V	vbs reduction to low field weak inversion gate drive coefficient., its length and width sensitivities
lnb	0.0	(1/V) µm	
wnb	0.0	(1/V) µm	
nd0	0.0	1/V	vds reduction to low field weak inversion gate drive coefficient., its length and width sensitivities
lnd	0.0	(1/V) µm	
wnd	0.0	(1/V) µm	
rshm	50.0	Ω/square	sheet resistance / square
cjm	4.5e-5	F/m^2	zero-bias bulk junction bottom capacitance
cjw	0.0	F/m	zero-bias bulk junction sidewall capacitance
ijs	1.0e-4	A/m^2	bulk junction saturation current
pj	0.8	V	bulk junction bottom potential
pjw	0.6	V	bulk junction sidewall potential
mj0	0.5	-	bulk junction bottom grading coefficient
mjw	0.33	-	bulk junction sidewall grading coefficient
wdf	2.0e-6	m	default width of the layer
ds	0.5	m	average variation of size due to side etching or mask compensation

A5.3. BJT model card parameters

SPICE 2G6 bipolar junction transistor (BJT) model is built into Alecsis.

Table A5.4. BJT model card parameters in Alecsis.

name	**default**	**unit**	**meaning**
		-	dummy, not used
`is`	`1.0e-16`	A	saturation current
`bf`	`100.`	-	ideal maximum forward current gain
`nf`	`1.`	-	forward current emission coefficient
`vaf`	`0.` (means ∝)	V	forward early voltage
`ikf`	`0.` (means ∝)	A	corner for forward beta high-current roll-off
`ise`	`0.`	A	base-emitter leakage saturation current
`ne`	`1.5`	-	base-emitter leakage emission coefficient
`br`	`1.`	-	ideal maximum reverse current gain
`nr`	`1.`	-	reverse current emission coefficient
`var`	`0.` (means ∝)	V	reverse early voltage
`ikr`	`0.` (means ∝)	A	corner for reverse beta high-current roll-off
`isc`	`0.`	A	base-collector leakage saturation current
`nc`	`2.`	-	base-collector leakage emission coefficient
		-	dummy, not used
		-	dummy, not used
`rb`	`0.`	Ω	zero bias base resistance
`irb`	`0.` (means ∝)	A	current where base resistance falls halfway to its minimum value
`rbm`	`0.` (means rb)	Ω	minimum base resistance at high currents
`re`	`0.`	Ω	emitter resistance
`rc`	`0.`	Ω	collector resistance
`cje`	`0.`	F	zero-bias base-emitter depletion capacitance
`vje`	`0.75`	V	base-emitter built-in potential
`mje`	`0.33`	-	base-emitter junction grading coefficient
`tf`	`0.`	s	ideal forward transit time
`xtf`	`0.`	-	coefficient for bias dependence of tf
`vtf`	`0.` (means ∝)	V	voltage describing vbc depencence of tf
`itf`	`0.`	A	high-current parameter for effect on tf
`ptf`	`0.`	º	excess phase at f=1/(2*π*tf)
`cjc`	`0.`	F	zero-bias base-collector depletion capacitance
`vjc`	`0.75`	V	base-collector built-in potential
`mjc`	`0.33`	-	base-collector junction grading coefficient
`xcjc`	`1.`	-	`fraction of base-collector depletion capacitance connected to internal base node`
`tr`	`0.`	s	ideal reverse transit time
		-	dummy, not used
		-	dummy, not used
		-	dummy, not used
		-	dummy, not used
`cjs`	`0.`	F	zero-bias collector-substrate capacitance
`vjs`	`0.75`	V	substrate-junction built-in potential
`mjs`	`0.5`	-	substrate-junction exponential factor
`xtb`	`0`	-	forward and reverse beta temperature coefficient
`eg`	`1.11`	eV	energy gap for temperature effect on is
`xti`	`3.`	-	saturation current temperature exponent
`kf`	`0.`	-	flicker noise coefficient

`af`	`1.`	-	flicker noise exponent
`fc`	`0.5`	-	coefficient for forward-bias depletion
Following parameters are read from the model card, but are not used in the current version of the model:			
`nk`		-	high-current roll-off coefficient
`iss`		A	substrate p-n saturation current
`ns`		-	substrate p-n emission coefficient
`qco`		C	epitaxial region charge factor
`rco`		Ω	epitaxial region resistance
`vo`		V	carrier mobility "knee" voltage
`gamma`		-	epitaxial region doping factor
`tre1`		1/ºC	RE temperature coefficient(linear)
`tre2`		1/(ºC)^2	RE temperature coefficient(quadratic)
`tbr1`		1/ºC	RB temperature coefficient(linear)
`tbr2`		1/(ºC)^2	RB temperature coefficient(quadratic)
`trm1`		1/ºC	RBM temperature coefficient(linear)
`trm2`		1/(ºC)^2	RBM temperature coefficient(quadratic)
`trc1`		1/ºC	RC temperature coefficient(linear)
`trc2`		1/(ºC)^2	RC temperature coefficient(quadratic)

A5.4. JFET model card parameters

SPICE JFET model is built into Alecsis.

> Physical units and parameter explanations are not given in the following table for most of the parameters. We will give these units and explanations in new versions of this Manual.

Table A5.5. JFET model card parameters in Alecsis.

name	default	unit	meaning
		-	dummy, not used
`vto`	`-2.0`		
`beta`	`1e-4`		
`lambda`	`0.0`		
`rd`	`0.0`		
`rs`	`0.0`		
`cgs`	`0.0`		
`cgd`	`0.0`		
`pb`	`1.0`		
`is`	`1e-14`		
`kf`	`0.0`		
`af`	`1.0`		
`fc`	`0.5`		
		-	dummy, not used
		-	dummy, not used
		-	dummy, not used

		-	dummy, not used
Following parameters are read from the model card, but are not used in the current version of the model:			
		-	dummy, not used
		-	dummy, not used
		-	dummy, not used
`n`			gate p-n emission coefficient
`isr`			gate p-n recombination current parameter
`nr`			emission coefficient for ISR
`alpha`			ionization coefficient
`vk`			ionization "knee" voltage
`m`			gate p-n grading coefficient
`vtotc`			VTO temperature coefficient
`betatce`			BETA exponential temperature coefficient
`xti`			IS temperature coefficient