SiMKit
Release Notes

for SiMKit version 2.3

First Edition

Philips
ED&T/Analogue Simulation

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Preface

These are the release notes for *SiMKit* version 2.3. All changes with respect to *SiMKit 2.2* are reported in these release notes.

Overview

SiMKit is a simulator-independent compact transistor model library.

Simulator-specific connections are handled through so-called adapters that provide the correct interfacing to:
– *Spectre*, the circuit simulator from *Cadence*
– *Pstar*, the circuit simulator from *Philips*
– *ADS*, the circuit simulator from *Agilent*.

The *SiMKit* library contains the most recent versions of the *Philips* transistor models. The following tables list the *SiMKit* models. The first table lists the *SiMKit* models, the second table lists the models for which only a *Pstar* and *Spectre* implementation are available.
For a full description please check:

`http://www.semiconductors.philips.com/Philips_Models/`

In the following tables e/g stands for electric / geometric, t stands for self-heating and s stands for substrate model.

Table 1: Real SiMKit models (in release 2.3)

Model	Level	Pstar	Spectre	ADS	e/g	t	s
juncap	1	juncap	juncap	juncap	e	no	no
juncap	200	juncap	juncap200	juncap200	e	no	no
psp	101	pspe	psp101e	psp101e	e[a]	no	no
psp	1010	psp	psp1010	psp1010	g[a]	no	no
psp	1011	psp	psp1011	psp1011	g[a]	no	no
modella	500	tpl	bjt500	bjt500	e	no	no
modella	500	tplt	bjt500t	bjt500t	e	yes	no
mextram	504	tns/tps	bjt504	bjt504	e	no	yes
mextram	504	tnst/tpst	bjt504t	bjt504t	e	yes	yes
mextram	504	tn/tp	bjtd504	bjtd504	e	no	no
mextram	504	tnt/tpt	bjtd504t	bjtd504t	e	yes	no

Table 1: Real SiMKit models (in release 2.3)

Model	Level	Pstar	Spectre	ADS	e/g	t	s
mos	1100	mne/mpe	mos1100e	mos1100e	e	no	no
mos	1100	mn/mp	mos1100	mos1100	g	no	no
mos	1101	mne/mpe	mos1101e	mos1101e	e	no	no
mos	1101	mnet/mpet	mos1101et	mos1101et	e	yes	no
mos	11010	mn/mp	mos11010	mos11010	g	no	no
mos	11010	mnt/mpt	mos11010t	mos11010t	g	yes	no
mos	11011	mn/mp	mos11011	mos11011	g	no	no
mos	11011	mnt/mpt	mos11011t	mos11011t	g	yes	no
mos	1102	mne/mpe	mos1102e	mos1102e	e	no	no
mos	1102	mnet/mpet	mos1102et	mos1102et	e	yes	no
mos	11020	mn/mp	mos11020	mos11020	g	no	no
mos	11020	mnt/mpt	mos11020t	mos11020t	g	yes	no
mos	11021	mn/mp	mos11021	mos11021	g	no	no
mos	11021	mnt/mpt	mos11021t	mos11021t	g	yes	no
mos	2001	mne/mpe	mos2001e	mos2001e	e	no	no
mos	2001	mnet/mpet	mos2001et	mos2001et	e	yes	no
mos	2001	mn/mp	mos2001	mos2001	g	no	no
mos	2001	mnt/mpt	mos2001t	mos2001t	g	yes	no
mos	2002[b]	mne/mpe	mos2002	mos2002	g	no	no
mos	2002[b]	mn/mp	mos2002	mos2002	g	no	no
mos	3100	mn/mp	mos3100	mos3100	e	no	no
mos	3100	mnt/mpt	mos3100t	mos3100t	e	yes	no
mos	40	mn/mp	mos40	mos4000	e	no	no

Table 1: Real SiMKit models (in release 2.3)

Model	Level	Pstar	Spectre	ADS	e/g	t	s
mos	40	mnt/mpt	mos40t	mos4000t	e	yes	no

a. Note that for the PSP-model the electrical model is referred to as the local model and the geometrical model as global.
b. Note that the Mos 2002 is a test version in *SiMKit 2.3*.

Table 2: Other older models (Pstar and Spectre specific)

Model	Level	Pstar	Spectre
diode	500	d	dio500
mos	3002	mn/mp	mos3002
mos	902	mn/mp	mos902
mos	902	mne/mpe	-
mos	903	mn/mp	mos903
mos	903	mne/mpe	-
mextram	503	tn/tp	bjt503
mextram	503	tns/tps	bjt503
lpnp	301	tpl	bjt301
mos	705	mne/mpe	mos705

Release notes

The release notes can be obtained by entering the following command:

```
cadenv -q simkit
```

1 Improvements

PSP

The modifications to PSP level 100 have upgraded the model to PSP level 101. This new version is not backward-compatible with the previous version.

In this *SiMKit* version, only the PSP models based on level 101 are supported. There is an electrical (local) model, PSP level 101, a geometrical (global) model PSP level 1010, and a binning model PSP level 1011.

Below is a summary of the changes in PSP level 101 with respect to PSP level 100.

General improvements

- A complete set of binning scaling rules has been added as a phenomenological alternative to the physics-based geometrical scaling rules.
- BSIM-like instance parameters AS, AD, PS, and PD were added for the junction model.
- To avoid confusion between zeros and "O"s, zeros no longer occur in parameter names. They have all been replaced by "O"s.
- Some global parameter names have an additional "O" in their names in order to avoid duplicate names in the global and local model.
- Induced gate noise limiting has been implemented in PSP. The effect is that the value of the induced gate noise does not increase in an unlimited way (proportional to the frequency squared), but becomes constant for higher frequencies.

Modification of the electrical (local) model PSP level 101

- The parameters AF, BF, F0, and NSUB have been removed. They have been replaced by DPHIB and NEFF. These modifications improve both the short-channel fits and the reciprocity of capacitances at $V_{DS} = 0$.
- The CLM-model has been modified to improve the Gummel-symmetry properties of the model.
- The drain induced barrier lowering model has been modified.
- The new parameter FETA has been introduced.
- The range of the parameters THESATG, THESATB, RSG, and RSB has been extended to include negative values.
- Inner-fringe capacitances have been removed, in order to ensure the reciprocity of capacitances at $V_{DS} = 0$.
- Model behavior at large ($> 1V$) forward V_B has been improved.
- Gummel-symmetry properties at forward V_B have been improved.
- The SO parameter has been removed. Its value was fixed to the default ($SO = 0.98$).

Modifications to the geometrical scaling rules PSP level 1010

- Length-scaling for CS has been added; this greatly improves short-channel idvg and gm fits.
- Scaling rules for the new parameters NEFF and DPHIB have been added.
- $L \cdot W$-scaling has been added for THESAT and CT.
- ALP2 scaling has been modified.
- Length-scaling for A4 has been added.
- The parameters DLQ and DWQ have been added to allow for an offset in ΔL between IV and CV.

Maintenance

- Gate current now exactly vanishes at zero bias.
- Some numerical issues were solved.
- Some minor bugs in the JUNCAP2-implementation within PSP were solved.
- Junctions are no longer swapped when $V_{DS} < 0$.

M1101

- One of the functions in the model has been made more numerically robust, thus solving floating point exceptions on *HP*.
- The units of the M1101 parameters POCGSO, PLCGSO, PWCGSO and PLWCGSO have been corrected to Farad - note that this has no influence on the calculations, only on the text output.

M1102

- The units of the M1101 parameters POCGSO, PLCGSO, PWCGSO and PLWCGSO have been corrected to Farad - note that this has no influence on the calculations, only on the text output.
- Induced gate noise limiting has been implemented in M1102. The effect is that the value of the induced gate noise does not increase in an unlimited way (proportional to the frequency squared), but becomes constant for higher frequencies.

– Convergence problems:
  A combination of a specific temperature of 125 and specific process parameters (cmos065) setting led to a division by zero in MOS1102. This caused floating point exceptions and bad convergence. The code has been improved.
– Problems have been reported with the modeling accuracy of `Gm` /`Vt` modeling. The problems can be circumvented by Coulomb scattering. Therefore, Coulomb scattering has also been implemented in M1102. The implementation is similar as in the PSP model. The default values of the parameters are such that backwards compatibility is guaranteed. The new parameters are:

Table 3: New Coulomb scattering parameters.

Parameter	**Default**	**Description**
CS	0	Coefficient of Coulomb scattering.
ETACS	0	Exponent of the temperature dependence of CS.
CSR	0	Factor of the Coulomb scattering.
SLCS	0	Coefficient of the length dependence of CS.
CSEXP	1	Exponent of the length dependence of CS.
SWCS	0	Coefficient of the width dependence of CS.
ETACS	0	Exponent of the temperature dependence of CS.
POCS	0	Coefficient of the geometry independent part of CS.
PLCS	0	Coefficient of the length dependence of CS.
PWCS	0	Coefficient of the width dependence of CS.
PLWCS	0	Coefficient of the length times width dependence of CS.
POTETACS	0	Coefficient of the geometry independent part of ETACS.
PLTETACS	0	Coefficient of the length dependence of ETACS.
PWTETACS	0	Coefficient of the width dependence of ETACS.
PLWTETACS	0	Coefficient of the length times width dependence of ETACS.

Mos 20

- A new model description for the compact high-voltage MOS transistor model called MOS Model 20, level 2002 is available as a test version. With respect to the MM20 Model, level 2001, in this MM20 Model, level 2002, quasisaturation is included, an effect which is typical for high-voltage LDMOS devices.
- The source code for level 2001 was checked for performance issues. Some minor improvements have been implemented.

Mos 40

- The source code was checked for performance issues. Some minor improvements have been implemented.
- The lower clip value of the parameters `RON` and `RSAT` has been set to $1.e^{-2}$.

Mos 3100

- When source and drain are interchanged for a symmetrical model the results should be the same. However, for the self-heating mos3100 this was not the case. This problem has been solved.
- The source code was checked on performance issues. Some minor improvements have been implemented.
- The lower clip value of the parameters `RON` and `RSAT` has been set to $1.e^{-2}$.

Software

In the file `common_device_code.c`, in the functions `reset_inst_params` and `reset_model_params`, the variable in the loop (for PMOS devices) was corrected.

Modella

To avoid floating point exceptions, the code has been made more numerically robust.

2 Circuit simulator related issues

Pstar specific issues

All MOS models (including PSP)

One of the DC convergence aids was not correctly implemented. In certain situations this caused strange behaviour, e.g. discontinuity in the drain current, when the drain current had very low values (`~1e-15`).

New change block parameter

Pstar had the option to print the scaled device parameters. This was done by specifying

```
change;
print_scaled_device_parameters=true;
end;
```

If the user set this flag on `false`, the unscaled parameter set of the device was printed. With the flag on `true` the parameter set after temparature scaling was printed.

In the *SiMKit* models two scalings are possible, the geometrical and the temperature scaling.

For some specialists, e.g. in characterisation, it is possible to print all the parameter sets separately, for all types of scaling. Therefore *Pstar 5.2* has been extended with a new change parameter: `print_device_parameters`. This new parameter replaces `print_scaled_device_parameters`, which will be obsolete in *Pstar 5.2*, and removed in *Pstar 5.3*.

`print_device_parameters` can have the following three values:

unscaled (default)	The parameter set as defined in the modelbook will be printed, including clipping. (Also refered to as the maxiset.)
geomscaled:	The clipped geometrically scaled parameters will be printed. For electrical models "unscaled" or "geomscaled" will result in the same set of parameters being printed. (Also refered to as the miniset.)
tempscaled	The clipped temperature scaled parameters will be printed. (Also refered to as the electrical set.)

✓ Note

The combination of *Pstar 5.0* with *SiMKit 2.0.1* is not recommended. Please use higher *SiMKit* versions especially when encountering convergence problems.

Bipolar transistor level 1 (PMK model)

The output parameters `CJC` and `CJS` were calculated using the unclipped values of `VDC` and `VDS`. This has been corrected and the clipped values now are used.

ADS specific issues

– The *ADS* adapter has been improved for Harmonic Balance combined with noise analysis. The improvement is seen in the performance. The performance issue was reported as a Mextram504 problem, where it was most visible, but the improvement is valid for all models.
– The temp sweep for certain *SiMKit* models does not work properly in *ADS* unless a definition of an instance parameter temp is used:

```
qmod:q1 d g 0 0 Temp=temp
```

ADS Installation notes

– The *SiMKit* cadenv script relies on the `ADSVERSION` variable to be set in the startup scripts of all the *ADS* versions installed on the system.

  The *ADS* startup scripts are located in the `philips` directory and each *ADS* version has its own version of this script. The rule for setting the `ADSVERSION` variable is:

```
# Added ADSVERSION
export ADSVERSION=$(cadenv | grep "^ads " | \
sed "s/^ads[ ]*//g" | sed "s/[ .].*$//g"| \
sed "s/[ _].*$//g")
```

  This rule assumes that special cadenv versions are indicated by adding an underscore followed by some specific text, for example, adding `eva`, after the original version (2004A, 2005A etc.). In this example, adding `2005A_eva` would result in `ADSVERSION=2005A`, but `2005A.eva` would not.
– *SiMKit 2.3* no longer supports `ADS2003C` on *Linux*. This is because on the *Linux* platform we no longer have access to the `gcc` compiler version that is needed to build the *SiMKit* for *ADS 2003C*.

ADS designkit specific issues

Mextram 504

- The missing parameter `DAIS` has been added.
- The double occurence of the MLF parameter has been removed.

Juncap

The `Ab`, `Ls` and `Lg` parameters were implemented as model parameters for juncap level 1 and juncap level 200 in the designkit, but they are instance parameters. This has been changed.

Spectre specific issues

– For all *SiMKit* models the *Spectre* simulator option `scale` is now supported. The scale factor scales the device instance parameters. Besides the `scale` factor, there's also a `scalem` factor that scales all geometric model parameters. The use of this parameter is not yet allowed; you can define it, but it does not have any influence.
– If you want to use *Spectre* stand-alone, the order in the cadenv of *SiMKit* and *cadence_ic* is very important. You must first cadenv *cadence_ic* and then *SiMKit*. This is because *SiMKit* sets a wrapper around the *Spectre* start-up script in the cadenv package *cadence_philips*. The version of the *cadence_philips* package should be 2004.3.2, or higher. A cadenv of *cadence_ic*, or some of the flows like AMSDE, overwrites these wrappers.
– We have tested the following *cadence_ic* versions in combination with *SiMKit 2.2*:
  – On *Linux*: 5.0.33.500.1.11, 5.10.41.500.2.23
  – On *HP* : 4.4.6.100.92, 5.0.32.500.1.11 , 5.0.33_USR3.16.35, 5.10.41_USR2.19.52

✓ Note

Do not use *cadence_ic 5.0.0.500.38*. It does not work with *SiMKit* due to a small error in *Spectre*.

✓ Note

We have seen problems in *cadence_ic 5.10.41.500.0.7* in combination with *SiMKit*. Please do not use this version.

We have tested the following *cadence_mmsim* versions in combination with *SiMKit 2.3*:

– On *Linux*: 6.0.1.174
– On *HP* : 6.0.1.174

– The `-r` option of `rspec` has been extended to support *spectre6* (part of *cadence_mmsim*): The format for the `-r` option is now:

```
rspec -r <package>:<release>
```

where `<package>` is the name of the a *Cadence* package containing *Spectre*, such as *cadence_ic* or *cadence_mmsim* and `<release>` is the release number used in the cadenv command (the `-r` of cadenv).

✓ Note

`rspec` does not check whether the specified package contains the *Spectre* simulator, or if the specified release exists.

`<:>` is the separator and no other separators are allowed.

❑ **Example**

```
rspec -r cadence_mmsim:6.0.1.174 job.ckt
```

– The *SiMKit* models now support the the *Spectre* simulator statement `altergroup`.

Platform specific issues

- The standard release platform for *SiMKit* is now *Red Hat Enterprise 3.0*. This used to be *Red Hat 7.3*.
- This release of *SiMKit* is a one-tree distribution release; a single package that contains everything for all supported platforms.
- *SiMKit 2.3* has been ported to 64-bit for the following operating systems:
  - *HP-UX 11.11* and higher
  - *Red Hat Enterprise Linux 3* and higher.

Also simulator *Spectre* version 6.0 and higher.

The *ADS* simulator (*hpeesofsim*) and the *Pstar* simulator are not yet available as a 64-bit version.

3 Known limitations

Known limitations

The following known limitation is in *SiMKit 2.3*:

– For MOS11 devices the spectral noise density values are zero for *cadence_ic* versions that use *CMI3.0* (*cadence_ic 5.0.33.500.0.6_ads* and *cadence_ic 5.0.33.500.0.6*). The spectral noise density values can be incorrect for *cadence_ic* versions (5.10.41*). The *cadence_ic* versions with *CMI 1.0* (*cadence_ic 4.4.6.**) and *Spectre 6* (*cadence_mmsim 6.0.1.174*) show the correct values.
– The temp sweep for certain *SiMKit* models does not work properly in *ADS* unless a definition of an instance parameter temp is used:

```
qmod:q1 d g 0 0 Temp=temp
```