

SiMKit *Release Notes*

for SiMKit version 2.1

First Edition

Philips
ED&T/Analogue Simulation

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Preface

These are the release notes for *SiMKit* version 2.1.

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 is self-heating and s is substrate model.

Table 1: *SiMKit* models (in release 2.1)

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	100	pspe	psp100	psp100	e	no	no
psp	1000	psp	psp1000	psp1000	g	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
mos	1100	mne/mpe	mos1100e	mos1100e	e	no	no

Table 1: SiMKit models (in release 2.1)

Model	Level	Pstar	Spectre	ADS	e/g	t	s
mos	1100	mn/mp	mos1100	mos1100	g	no	no
mos	1101	mne/mpe	mos1101	mos1101	e	no	no
mos	1101	mnet/mpet	mos1101t	mos1101t	e	yes	no
mos	11010	mnt/mpt	mos11010t	mos11010t	g	yes	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	mos1102	mos1102	e	no	no
mos	1102	mnet/mpet	mos1102t	mos1102t	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	3100	mn/mp	mos3100	mos3100	e	no	no
mos	3100	mnt/mpt	mos3100t	mos3100t	e	yes	no
mos	40	mn/mp	mos40	mos40	e	no	no
mos	40	mnt/mpt	mos40t	mos40t	e	yes	no

Table 2: 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
modella	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 **New functionality**

New functionality

SiMKit has been extended with two new models: Juncap level 200 and PSP. The MOS20 and Modella models have been extended with self-heating.

The following table summarizes how to call the new Juncap level 200 and PSP, plus the Modella and MOS20 self-heating models.

Table 3: Older models (*Pstar* and *Spectre* specific)

Model	Level	Pstar	Spectre	ADS
juncap	200	juncap	juncap200	juncap200
psp	100	pspe	psp100	psp100
psp	1000	psp	psp1000	psp1000
modella	500	tplt	bjt500t	bjt500t
mos	2001	mnet/mpet	mos2001et	mos2001et
mos	2001	mnt/mpt	mos2001t	mos2001t

Juncap level 200 is a new compact model, developed by *Philips Research*, to describe the source and drain junctions of a MOSFET. It is the successor of the Juncap level 1 model and contains physics-based descriptions of:

- depletion capacitance
- ideal current
- Shockley-Read-Hall current
- trap-assisted tunneling
- band-to-band-tunneling
- avalanche breakdown, and
- shot noise.

Juncap level 200 is released as a free-standing model, but is also integrated in the PSP model.

✓ Note

The default type for Juncap level 200 is n. This is different from Juncap level 1, where the default type in *Spectre* is p. The default gender in *ADS* for Juncap level 200 is 1, where the

default gender for Juncap level 1 was -1 (or in fact anything not equal to 1).

So, for Juncap level 200 use in:

- *Pstar* type = 1 for n type, type = -1 for p type
 - *Spectre* type = n for n type, type = p for p type
 - *ADS* gender = 1 for n type, gender = -1 for p type
-

The PSP model is a new compact MOSFET model, which has been jointly developed by *Philips Research* and *Penn State University*. It is a surface-potential based MOS Model, containing all relevant physical effects (mobility reduction, velocity saturation, DIBL, gate current, lateral doping gradient effects, etc.), to model present-day and upcoming deep-submicron CMOS technologies. Unlike previous *Philips* MOS models, the source/drain junction model, c.q. the Juncap level 200 model, is an integrated part of the PSP model.

✓ Note

The operating point output and non quasi-static behaviour are not included in the current PSP implementation.

The source code for these models has been generated in an automatic way from a *Verilog-A* description of the models. Optimization of the source code will be done in the coming releases of these models.

2 Issues

ADS specific issues

- As of *SiMKit 2.0.1* an *ADS* design kit, which makes it possible to use the *SiMKit* models in the schematic entry for *ADS*, is included in the *SiMKit* package. In *SiMKit 1.3* this design kit was a separate package.

If you have the *SiMKit_designkit 1.3* installed and you cadenv *SiMKit 2.1*, some files must be modified in order to make the design kit work. First, cadenv *SiMKit 2.1* and then change the **DESIGN_KIT_MODEL_PATH** variable in the following files:

- **de_sim.cfg** (located in the startup directory)
- **de_sim.cfg** (located in your project directory)
- **hpeesofsim.cfg** (located in your project directory)

The correct value of that variable is:

```
DESIGN_KIT_MODEL_PATH=$CADENV_HOME/.caddata/simkit/  
adsdesignkit/bin/hpux11
```

where **hpux11** can also be **linux_x86** depending on the operating system in use. Typing **hpeesofarch** in the command line gives you the operating system that you are using.

- To use *SiMKit* with *ADS*, you need at least *ADS2003C*.
- Add limiting to the *ADS* adapter:
We have started to implement limiting functionality. Currently, the evaluation of diode equation, exponent functions, currents and temperature are limited. Further limiting is possible and will be implemented in a future release.
- In the MXT504T npn model in the design kit, the **th** and **b** node were switched. This has been corrected. This problem was reported by *TU Delft*.
- The parameter **KAVL** has been added. This problem was reported by *TU Delft*.

Spectre specific issues

- 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 advise using the following *cadence_ic* versions in combination with *SiMKit 2.1*:

- On *Linux*: 4.4.6.100.*, 5.0.33.500.1.11, 5.10.41.500.0.7
- On *HP* : 4.4.6.100.*, 5.0.32.500.9 , 5.10.41.500.0.7

✓ 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 _____
With *cadence_ic 5.0.33.500.0.6* we have seen problems in combination with *SiMKit 1.3, 1.3.1.1.1* and *2.0.1*. But not with *SiMKit 2.1*.

- Known problem: For MOS11 devices the noise parameters are not shown (or zero) for *cadence_ic* versions 5.10.41.500.0.7 (5.0.33.500.0.6_ads).
- If you change the gender of a device with an alter statement (for example: `alter gender alter mod=MM3100 param=type value=n`), a warning is displayed informing you that the device parameters are set to their default values.
- The following *Spectre* statements are not supported by the *SiMKit*:
 - alter group statements for *SiMKit* model parameters
 - scale statements in the options list.
- For Juncap level 1 it is currently not possible to use the `type` statement. Existing netlists will have to be converted before they will work correctly.
- Suggested changes by *Cadence* required for *UltraSim* functionality have been implemented in the *CFI 4.0* version.

Pstar specific issues

- In some cases, the convergence of jobs with *Pstar 4.8* and *SiMKit 2.0.1* was slower than for the same jobs with *Pstar 4.7* and *SiMKit 1.3*. This was caused by differences in the limiting functions in Juncap level 1 (see [Juncap level 1 issues on page 8](#)) and a change in *Pstar*'s strategy for finding a DC solution.
- For Juncap level 200 and PSP there is no `print_scaled_parameters` output.

ProMOST specific issues

- Suppress clip warnings.
- IC_TEMP_SCALING was not set for electrical models, this has been corrected.
- Return Operating Point names, for correct initialisation.

General model issues

- Problem with self-heating for MOS40 resulted in the implementation of a temperature limiting for all self-heating models.

Juncap level 1 issues

- Limiting of the junction voltage has been changed, mainly for *Pstar*.

Mextram 504 issues

- Division almost by zero: the calculation of I_{avl} was changed. This problem was reported by *Analog Devices*.
- Initialization of $IV(Gem)$ has been added in avalanche current. This problem was reported by *Analog Devices*.
- Avoid division by zero when I_{qs} (substrate current) becomes zero and an overflow protected version of $\exp()$ is now used to calculate some variables. These problems were reported by *Cadence*.
- The parameter KAVL (switch for white noise contribution due to avalanche) is limited $0 \leq KAVL \leq 1$.
- Scaling rule for saturation current has been changed, the parameter DAIS (a parameter for fine tuning of temperature dependence of collector-emitter saturation current) has been added.

MOS 11 issues

- Not all model parameters were visible in *Spectre*. For example, the parameter VFB (flat-band voltage at the reference temperature) was missing. This has been corrected.
- Possible numerical problems in the function `func_Vov()` (used for calculating equations describing the surface potential in gate overlap regions), for m1102 are now avoided.
- `Weff` and `leff` were part of the electrical parameter set. They do not belong there so they have been removed.
- Changed default value of NT (thermal noise coefficient) to 1.624e-20. It now corresponds with the reference temperature TR in MOS1101 and MOS1102.
- In m1102, the implementation of the induced gate noise was corrected so that it corresponds to the (existing) documentation.

MOS 20 issues

- Convergence problems were solved by correcting the implementation of derivatives of `Ddibl` (used in calculation of the drain-induced barrier lowering and static feedback equations) and `Fj_dr` (used in calculation of drift region charges).
- Wrong clipping values were corrected for LAMD (quotient of the depletion layer thickness to the effective thickness of the drift region at $V_{sb} = 0V$) and RD (on-resistance of the drift region, at reference temperature).

MOS 31 issues

Lower clip values of parameters RON (ohmic resistance at zero bias) and RSAT (space charge resistance at zero bias) changed from 1e-6 to 1.0.

Modella issues

Noise source RSB (substrate base leakage resistance) was not printed for *Pstar*, this has been corrected.

MOS 40 issues

Lower clip values of parameters RON (ohmic resistance at zero bias) and RSAT (space charge resistance at zero bias) changed from 1e-6 to 1.0.

Issues for other (older) models

The lower clip value of the reference temperature (TREF) has been changed from -273.15 to -273 for all older *Pstar* models (see the list under [Overview on page vi](#)).

Issues for users of the SiMKit Interface

- The internal parameter structure and clipping has been changed. A new *SiMKit* Interface description document is available and can be obtained by contacting the *ED&T* helpdesk.
- Forward declaration of `log1p()` added to `sk.h`.
- For some HP-native compilers the initialisation of all `SK_BRANCH` elements has been added.

Issues for Modelbooks

The modelbook updates related to this *SiMKit* release are delayed until later this year.

3 **Known limitations**

Known limitations

The following known limitations are in *SiMKit 2.1*:

- Self-heating problem in high-voltage MOS devices:
There are still some problems with the limiting of the temperature in the HV-MOS devices (MOS31 and MOS40). This problem can cause the simulator to display warnings and errors. In the case of *Pstar* the error might be:

```
<Device mos40t instance MNT is too hot>
```

If you encounter this problem, please contact our helpdesk so that we can help you find a workaround.

- The following *Spectre* statements are not supported by the *SiMKit*:
 - alter group statements for *SiMKit* parameters
 - scale statements
- For Juncap level 1 it is currently not possible to use the `type` statement in *Spectre*. Existing netlists will have to be converted before they will work correctly.
- In *Spectre*, the noise parameters of MOS11 devices are not shown (or zero) for *cadence_ic* versions 5.10.41.500.0.7 (5.0.33.500.0.6_ads).

We plan to solve these known problems in a future *SiMKit* release.