SiMKit
Release Notes

for SiMKit version 3.0 and 3.0.3

First Edition

NXP Semiconductors
DM/Tool and Flow Solutions

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Preface

These are the release notes for *SiMKit* version 3.0 and 3.0.3. All changes with respect to *SiMKit 2.5* 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 *NXP Semiconductors*
– *ADS*, the circuit simulator from *Agilent*.

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

`http://www.nxp.com/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

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	102	pspe	psp102e	psp102e	e[a]	no	no
psp	1020	psp	psp1020	psp1020	g[a]	no	no
psp	1021	psp	psp1021	psp1021	g[a]	no	no
pspnqs	102	pspnqse	pspnqs102e	pspnqs102e	e[a]	no	no
pspnqs	1020	pspnqs	pspnqs1020	pspnqs1020	g[a]	no	no
pspnqs	1021	pspnqs	pspnqs1021	pspnqs1021	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

Table 1: Real SiMKit models

Model	Level	Pstar	Spectre	ADS	e/g	t	s
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
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	mos2002e	mos2002e	e	no	no
mos	2002[b]	mnet/mpet	mos2002et	mos2002et	e	yes	no

Table 1: Real SiMKit models

Model	Level	Pstar	Spectre	ADS	e/g	t	s
mos	2002[b]	mn/mp	mos2002	mos2002	g	no	no
mos	2002[b]	mnt/mpt	mos2002t	mos2002t	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	mos4000	e	no	no
mos	40	mnt/mpt	mos40t	mos4000t	e	yes	no

a. For PSP the electrical model is referred to as the local model and the geometrical model as global.
b. Mos 2002 is an official model, version 2002.1 in *SiMKit 3.0*.

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

General improvements

Architectural change for flexible topologies

The internal architecture of the *SiMKit* has been completely revised. The reason for this revision is to prepare the *SiMKit* for models with a flexible topology, i.e. models that can add, collapse or remove branches or internal nodes based on certain parameters.

The *SiMKit* users will not notice anything of this change until the models are making use of this functionality. In *SiMKit 3.0* PSP and PSPNQS are the only models that do so. Please read the PSP information elsewhere in the release notes.

Interfaces between the models and the simulators have been adjusted as far as *Pstar*, *Spectre* and *ADS* are concerned. Interfaces to other simulators will have to be adapted by their owners.

The *ADS* and *Spectre* simulators do not support changing the topology of an instance during simulation (e.g. by a sweep, or an alter). The simulation will be stopped when this is tried, because otherwise erroneous results will be generated.

Documentation on the *SiMKit* interface can be obtained via the Helpdesk address listed in these release notes, and can also be found on the NXP models website.

Update in cadenv scripts for rspec

In the *SiMKit* `cadenv` script `rspec` is also `cadenv`-ed. When *SiMKit* was uninstalled, `rspec` was not. This behaviour differs from the default behaviour of other tools in the (AMSDE and/or RFDE) flow. This has been corrected: when the *SiMKit* is uninstalled (with `cadenv -u`) the `rspec` installation is now also removed.

Pstar specific improvements

Pstar 5.4 and SiMKit 3.0

Please note that *Pstar 5.4* will only work with *SiMKit 3.0* and not with previous *SiMKit* versions. *SiMKit 3.0* can be used in combination with *Pstar 5.3* and older versions, but changing the topology of flexible models is not supported in these combinations. *Pstar 5.3* and older will issue an error message when a parameter that influences the topology is set to something other than the default value.

Spectre specific improvements

Model group selection supported

All binning models in the *SiMKit* (psp1021, pspnqs1021, mos11011, mos11011t, mos11021, mos11021t) now support the *Spectre* automatic **Model Group** selection feature. This feature is based on comparing the instance parameters `L` and `W` to lie within model parameter ranges [`LMIN`, `LMAX`) and [`WMIN`, `WMAX`). The model parameters `LMIN`, `LMAX`, `WMIN` and `WMAX` have been added to the models listed above.

DCmatch mismatch analysis

For all the PSP and MOS Model 1102 models it is now possible to perform in *Spectre* a DC device mismatch analysis.

✓ Note

This DCMatch implementation is for testing purposes only!

For more information on DCMatch, read the information from Cadence, e.g.

```
spectre -h dcmatch
```

In the *Spectre*-adapter the implementation for PSP and MOS Model 1102 has been kept as simple as possible.

In *SiMKit 3.0* the geometry scaling is not included, but should be handled in the process-block.

Two extra parameters are defined for each model:

– `MVT` and `MBE` for psp102e, pspnq102e, mos1102e and mos1102et.
– `MVTO` and `MBEO` for psp1020, psp1021, pspnqs1020, pspnqs1021, mos11020, mos11020t, mos11021 and mos11021t.

The default value of `MVT`, `MVTO`, `MBE` and `MBEO` is zero.

The output consists of:

– 3-sigma output variation
– 3-sigma beta variation
– 3-sigma threshold voltage variation
– 3-sigma gate voltage variation
– 3-sigma current mismatch to nominal current ratio.

Model Improvements

PSP

1. Added a **Well Proximity Effect** -model.

2. Added parameters EPSROX (electrical or local), EPSROXO (geometrical or global), POEPSROX (binning) representing relative dielectric constant of gate oxide. Default value is 3.9. Note that introduction of this parameter leads to small numerical differences as compared to PSP 102.1. These differences are typically smaller than 1e-4.

3. Added instance parameters DELVTO (threshold voltage shift parameter) and FACTUO (zero-field mobility pre-factor) to the electrical (or local), geometrical (or global) and binning model.

4. Added NF (number of fingers) support to geometrical (or global) and binning model.

5. Extended the stress model to support NF.

6. Added substrate resistance network and external gate resistance to the QS version of the PSP-model.

   This implied adding RGO, RBULKO, RWELLO, RJUNSO, RJUNDO (geometrical or global and binning), and RG, RBULK, RWELL, RJUNS, RJUND (electrical or local) to the PSP-model.

   Now, PSP and PSPNQS have an identical topology for the parasitic resistance network. Note that addition of the parasitic resistance network to PSP implies that PSP now has five internal nodes. When one or more of the resistor values are set to zero, the *SiMKit* will remove superfluous internal nodes. As a result, there is no computational overhead if the parasitic resistances are not used. For PSP as well as PSPNQS the default value of the parasitic resistances is zero. Note that for PSPNQS these defaults used to be 1e-3 Ohm in previous *SiMKit* versions.

7. Added geometry scaling for gate resistance in global and binning model. This involved addition of model parameters:

   – RSHG (Gate electrode diffusion sheet resistance),
   – RINT (Contact resistance between silicide and poly),
   – DLSIL (Silicide extension over the physical gate length),
   – RVPOLY (Vertical poly resistance) and
   instance parameters:

- NGCON (Number of gate contacts) and
- XGW (Distance from the gate contact to the channel edge).

8. Integration of JUNCAP-express into PSP. PSP is equipped with a switch-parameter SWJUNEXP. When SWJUNEXP=0 (default) the full JUNCAP2 model is evaluated, similar to previous version of PSP. When SWJUNEXP=1, the Express-model will be evaluated leading to a very significant reduction of model-evalutation time for the PSP-model. (The same holds for the standalone JUNCAP2 model). Moreover, this involved the addition of two parameters VJUNREF and FJUNQ.

9. Reformulation of impact ionisation code to avoid numerical problems.

10. Some minor bug fixes, and minor implementation changes.

11. The following PSP updates are implemented in *SiMKit 3.0.2*:

- solved issue with Gmin for Vds<0.
- corrected error in expression for OP-variable cjssti.
- added clipping for fbbt-variables to nonnegative values (JUNCAP).
- fixed issue in calculation of vfmin (JUNCAP).
- minor implementation change in JUNCAP init instance.
- fixed noise calculation for parasitic resistance.

12. Flexible topology
The flexible topology implementation for the PSP model contained a serious error in *SiMKit 3.0.2* that caused wrong results when the model was instantiated more than once. This error has been solved in *SiMKit 3.0.3*.

Juncap 2

The newly introduced express-option of the JUNCAP2 model, invoked by setting SWJUNEXP=1, allows the user to trade some simulation accuracy for simulation speed. In transient analyses, a simulation time reduction of up to a factor of 5 (of the simulation time associated with JUNCAP2) has been demonstrated with a very limited loss of accuracy. This is achieved by a creating a strongly simplified IV-model, combined with a more extensive initialisation code.

Mos level 1100, 1101 and 1102

In some cases, at high temperatures convergence problems were seen caused by the clipping of the internal (scaled) parameter ETAMOB to zero. These problems are prevented by clipping ETAMOB to 1e-12. The original problem occured for the process block CMOS065LP_50A_M7_2T.

All models

A small improvement has been made to the noise implementation. Previously there was a problem with the non-correlated noise sources in a model. This can have consequences for the non-correlated noise, shot noise, flicker noise and thermal noise.

Diode level 500

The clipping of an internal parameter VBR_T was incorrect. VBR_T is calculated as follows (see eq. 3.19 of the modelbook):

```
VBR_T   = VBR * pow ( Tn, 0.1) ,  where Tn = Tk/Trk
```

In the previous *SiMKit* versions, VBR_T was clipped to 0.1 when the value was less than 0.05 instead of 0.1.

PMK device TN, level 2

When the TN level 2 model is used in reverse as a diode, the Q2 **current** became negative. However, in this way the transistor should function as a diode, so the current should not be less than zero. Therefore, clipping of Q2 has been added.

In *SiMKit 3.0.2* the parameter NKF has been introduced for this device and the formula qb has been changed from:

```
qb =0.5 * ql * ( (1+4*q2)**0.5 + 1)
```

to:

```
qb =0.5 * ql * ( (1+4*q2)**NFK + 1)
```

2 Known limitations

Known limitations

Flexible Topology in ADS and Spectre

For both *Spectre* and *ADS* a model can only choose one topology at a time. This topology must remain fixed throughout the simulation. So, e.g. a sweep of the parameter `RGO` (gate resistor) in PSP going from zero to another value is not possible. The simulator will stop with an appropriate message - because continuation would result in erroneous results.

Internal node names in *ADS* for models with a flexible topology (in *SiMKit 3.0* that is only PSP and PSPNQS) might be wrong in the output.