SiMKit

Release Notes for simkit version 5.0_pub

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Preface

These are the release notes for simkit version 5.0_pub. Changes with respect to simkit 4.9_pub are reported in these release notes.

The main developments of this release are:
- Version 505 of the Mextram model was added.
- The JFET Independent Dual-Gate model (JFETIDG) has been added.
- The PSP103 model was updated to PSP103.6 and a numerical stability of the computation of Vdsp and Vdspedge was improved.
- The ovcheck models have been extended with model parameters to specify
  - the names of branches to be used in SOA messages
  - optional messages to be used in SOA messages
  - printing SOA messages in DC has been restored.
- The SOA messages given during a transient analysis have been extended with the duration of the violation.
- The SOA messages given in the overview at the end of the analysis have been extended with a percentage overshoot outside of the safe region.
- Extension of operating output information with 'ctype'/'jtype' and 'von'.
- Improved robustness with Spectre simulations by using different compiler settings.
- Solved a bug on Windows compiler compatibility for ADS 2017.

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 and APS: the Cadence circuit simulators.
- ADS: the Keysight circuit simulator.
  Simkit 5.0_pub supports ADS 2012, 2014, 2015, 2016, 2017. The SiMKit distribution is also available for ADS on Windows for the same versions.

Mica from NXP, AFS from Mentor, GoldenGate from Keysight and several other simulators (e.g. APLAC/MWO from AWR) do provide an adapter for the SiMKit models.

For a complete description, please refer to:

http://www.nxp.com/models/simkit.html

New models

Mextram 505 (505.0.0)

Version 505 of Mextram model was added. This version is not backward compatible with version 504.

Additions and changes compared to 504.12.1 are:
- Lower case model parameters are used. Users of case sensitive simulators need to pay special attention to this in model card specification.
- Names are added to noise sources
- A CB junction Zener tunneling current model is added, with parameters izcb, nzcb, vgzcb, and tvgzv.
- Non-ideality factors nff and nfr in forward and reverse transport current In, are added respectively. The corresponding temperature parameters are tnff and tnfr.
- Diffusion charge and diffusion capacitance expressions are modified accordingly to maintain the same transit time.
- Non-ideality factors nbi and nsbi in ideal forward base currents IB1 and ISB1, are added respectively.
- ISB2, side-wall non-ideal forward base current, is added with parameters ibfs and mlfs.
- ibrel, side-wall non-ideal forward base current for reliability modeling, is added.
- All base current components have their own saturation current and non-ideality factors where needed. Current gains (bf, bri) are no longer used.

- Non-ideal reverse base current is now formulated the same way as forward
  non-ideal base current. The parameter mlr is introduced, the parameter vlr is no longer used.
- 1/f noise of all ideal base currents is now calculated from kf and af, and placed between B2 and E1. 1/f noise of all non-ideal base currents is now calculated from kfn and afn, and placed between B1 and E1.
- Avalanche current Iavl is calculating in In as initiating current, and Iavl limits are also modulated accordingly.
- A new avalanche factor (gem) model is added and used as default, with parameters aavl, cavl, itoavl, bavl, vdcavl, tbavl.
- swavl, a switch parameter for avalanche factor, is added. swavl=0, no avalanche current; swavl=1 (default), the new avalanche factor model; swavl=2, Mextram 504 avalanche model. exavl is meaningful only when swavl=2.
- Parameter vdcctc, diffusion voltage dedicated for CB depletion capacitance, is added.
- swvjunc, switch for Vjunc calculation, is added. swvjunc=0 (default), 1 and 2 (like 504):
  swvjunc=0: Vjunc = VB2C2
  swvjunc=1: Vjunc = VB2C1
  swvjunc=2: Vjunc = VB2C1 + Vxi0
- swvchc, switch for transition voltage width Vch in CB capacitance-voltage curve smoothing, is added. swvchc=0 (default) and 1 (like 504).
  swvchc=0: Vch = 0.1 . VdCT
  swvchc=1: Vch = VdCT . (0.1 + 2 . IC1C2 / (IC1C2 + Iqs))
- Iex is now corrected to describe extrinsic BC junction current as hole injection into collector. In 504, it was described as electron injection current from collector to extrinsic base, which is not the case for real devices.
- iks means true substrate current's knee.
- Default value of exsub is 1 instead of 0.
- Range of icss is changed from (-inf, inf) to [0.0, inf).
- p0 and pW are clipped to avoid convergence problems at high VCB.
- Xext coding is improved to allow Xext = 0.
- To be more flexible we introduce in Mextram 505 new saturation current and knee current parameters by removing all current gain parameters. The following conversion can be used to convert 504 parameters to 505 parameters when desired:
  ibi = is / bf(504)
  ibx = is / bri(504)
  ikbx = ik / bri(504)
  Substrate knee current parameter in Mextram 505 uses same name but different meaning as that in Mextram 504:
  iks(505) = iks(504) · iss / is

JFETIDG version 1.0.3 (jfetidg and jfetidgt)

The independent dual-gate JFET model model was added. The model comes in two flavors: a five-terminal version with self-heating (jfetidgt) and a four-terminal version without self-heating (jfetidg).

Model improvements and bug-fixes

PSP (PSP 103.6.0 including JUNCAP2 200.5.0)

The PSP103 model was updated to PSP103.6:
- Induced gate noise: clipped value of migid in line with c_igid.
- Thermal noise of edge transistor: bug fix to avoid possible division by zero during the calculation of redge.
- Improvement of gm/Id in weak inversion: new model of interface states.
- Addition of new parameter NSUBEDGELEXP: exponent for channel length dependence of edge transistor substrate doping.
- Minimum values of calculated local parameters NOV and NOVD in global mode: now in lines with minimum values of local model parameters.

A numerical instability was found in the calculation of the (internal variables) Vdsp and Vdspedge. This problem has been fixed in the SiMKit 5.0_pub implementation, but still exists in the official PSP103.6. It has been reported to LETI for resolution in a future version.

The functionality of the PSP102 (PSP 102.5.0) model has not been changed.

The ovcheck models have been extended with new model parameters

New model parameters have been added to the ovcheck models to specify

- the names of branches to be used in SOA messages
- optional messages to be used in SOA messages

****
ovcheck, level 1
****

Synopsis:
Name (t1 t2) ModelName

Model Synopsis:
model ModelName ovcheck <parameter=value> ...

==========
Model Parameters
==========

1	level=1	Level of device.
2	paramchk=0	Level of clip warning info.
3	vlow=0 V	Vlow voltage.

```
4       vhigh=0 V            Vhigh voltage.
5       vballmsg=1           All ovcheck messages if set to 1.
6       tmin=0 s             tmin value.
7       tdelay=0 s           tdelay value.
8       stop=0               Stop simulation on overvoltage when STOP==1.
9       branch1="V(n1,n2)"   Name of branch to be used in SOA message.
10      message1             Informational message to be used in SOA
message.
```

****
ovcheck, level 6
****

Synopsis:
Name (t1 t2 t3 t4 t5 t6 t7 t8 t9 t10 t11 t12) ModelName

Model Synopsis:
model ModelName ovcheck6 <parameter=value> ...

==========
Model Parameters
==========

```
1       level=6              Level of device.
2       paramchk=0           Level of clip warning info.
3       vlow1=0 V            Vlow voltage first pair.
4       vhigh1=0 V           Vhigh voltage first pair.
5       vlow2=0 V            Vlow voltage second pair.
6       vhigh2=0 V           Vhigh voltage second pair.
7       vlow3=0 V            Vlow voltage third pair.
8       vhigh3=0 V           Vhigh voltage third pair.
9       vlow4=0 V            Vlow voltage fourth pair.
10      vhigh4=0 V           Vhigh voltage fourth pair.
11      vlow5=0 V            Vlow voltage fifth pair.
12      vhigh5=0 V           Vhigh voltage fifth pair.
13      vlow6=0 V            Vlow voltage sixth pair.
14      vhigh6=0 V           Vhigh voltage sixth pair.
15      vballmsg=1           All ovcheck messages if set to 1.
16      tmin=0 s             tmin value.
17      tdelay=0 s           tdelay value.
18      stop=0               Stop simulation on overvoltage when STOP==1.
19      branch1="V(n1,n2)"   Name of 1st branch to be used in SOA
messages.
20      branch2="V(n3,n4)"   Name of 2nd branch to be used in SOA
messages.
21      branch3="V(n5,n6)"   Name of 3rd branch to be used in SOA
messages.
22      branch4="V(n7,n8)"   Name of 4th branch to be used in SOA
messages.
23      branch5="V(n9,n10)"  Name of 5th branch to be used in SOA
messages.
```

```
24      branch6="V(n11,n12)" Name of 6th branch to be used in SOA
messages.
25      message1             Informational message for 1st branch to be
used in
                             SOA messages.
26      message2             Informational message for 2nd branch to be
used in
                             SOA messages.
27      message3             Informational message for 3rd branch to be
used in
                             SOA messages.
28      message4             Informational message for 4th branch to be
used in
                             SOA messages.
29      message5             Informational message for 5th branch to be
used in
                             SOA messages.
30      message6             Informational message for 6th branch to be
used in
                             SOA messages.
```

Safe Operating Area (SOA) message format

The SOA messages SiMKit gives during a transient analysis have been extended with the duration of the violation = exit_time - entry_time. This makes it easier to filter out violations below a certain duration. Also the number of digits in the list file is too low to calculate a duration accurately as post processing in e.g. a SOA browser.

Example:

```
    [OVCHECK_TR] instance: I0.MN12.m1, branch: Vsb,
                 boundary: "[-7.460e-01, 3.600e+00]",
                 exit value: -8.238e-01, exit time: 1.000e-11,
                 entry value: -7.312e-01, entry time: 1.465e-10,
                 duration: 1.365e-10,
                 peak value: -8.245e-01, peak time: 1.556e-11
```

The SOA messages SiMKit gives in the overview at the end of the analysis have been extended with a percentage overshoot outside of the safe region.
This percentage overshoot is defined as:

```
   (vlow - peakValue)  * 100.0 / abs(vlow)     if peakValue < vlow
   (peakValue - vhigh) * 100.0 / abs(vhigh)    if peakValue > vhigh
```

Note: The percentage will be inf% if the boundary on the safe area is zero.

Example:

```
[OVCHECK_TR_END] instance: I2.I253.MN2.m1, model: I2.I254.MN3.mn,
                 branch: Vgs,
                 boundary: "[-1.950e+00, 1.950e+00]", value: 2.814e+00,
                 exit value: 2.023e+00, exit time: 4.996e-08,
```

```
peak value: 3.383e+00, peak time: 2.890e-08,
duration: 2.453e-08, duration percentage: 49.1%,
overshoot percentage: 73.5%, state: triode
```

Note: For readability in these release notes the messages are split over several lines. In the simulator logfile the message will be one single line.

SOA messages have been restored in DC

Since SiMKit 4.9_pub SOA messages are not given any more in DC. This has been corrected. This is especially important for a DC-sweep.

Extension of operating output information with 'ctype'/'jtype' and 'von'

Similar to the PSP models, the operating point output lists of all other MOST models were extended with a parameter 'ctype' to indicate the channel type (1 for an NMOST and -1 for a PMOST). In the same way this was done for bipolar models with 'jtype' (1 for 'npn', -1 for 'pnp').

In addition, an operating point output parameter 'von' was added to all MOS transistors that have a threshold voltage. Compared to the 'vth', the 'von' is a signed threshold voltage, so: von = ctype * vth.

Support of parameters that are both model- and instance parameter

In SiMKit 5.0_pub support was added for models that have parameters that are both model- and instance parameter.

Spectre specific

By using slightly different compiler settings, the robustness was improved preventing some non-convergence issues with Spectre.

ADS specific

This version of SiMKit was compiled with Microsoft Visual 2015 and works fine with all ADS versions from 2012 to 2017.

In previous SiMKit versions we used Microsoft Visual 2013, and ADS 2017 rejected it at run time. The usage of the new version of the compiler was therefore mandatory.

In ADS, the pop-ups related to SiMKit were not disappearing automatically,
the user had to press on OK to proceed. This was annoying, and this has been
corrected: Pop-ups disappear after about 10 seconds.

Known limitations

Overvoltage checking:
- Overvoltage checks do not give warnings in ADS as in Spectre. The full functionality is only available in Spectre and APS and in Mentor AFS per 2015_Q1_update1.

Flexible topology in ADS and Spectre:
- A device will choose its topology based on the settings of certain parameters. So, e.g. a sweep of the parameter RGO (gate resistor) in PSP going from zero to another value, or a sweep over SWNQS in PSPNQS 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 5.0_pub those are PSP, PSPNQS, MXT504, M1101 and M1102) might be wrong in the simulator output. The simulation results are not affected by this.

Transient noise:
- Transient noise simulations with MOST devices are currently not supported. The noise results are unreliable. A workaround is to switch off induced gate noise, which can be done in mos 1101 and 1102 by setting GATENOISE=1.
  In simkit 4.8.1_pub a switch SWIGN was added to PSP103:
  . For SWIGN=1 (default) the behavior is the same as in previous simkit versions.
  . For SWIGN=0 the induced gate noise is switched off.

SiMKit models

The SiMKit library contains the most recent versions of the NXP transistor models. The following tables list the SiMKit models. The first table lists the 'real' SiMKit models while the second table lists the pre-SiMKit models, for which only a Spectre implementation is available.

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	Spectre/APS/AFS	ADS	e/g	t	s

juncap	1	juncap	juncap	e	no	no
juncap	200	juncap200	juncap200	e	no	no
psp	102	psp102e	psp102e	e*	no	no
psp	1020	psp1020	psp1020	g*	no	no
psp	1021	psp1021	psp1021	g*	no	no
pspnqs	102	pspnqs102e	pspnqs102e	e*	no	no
pspnqs	1020	pspnqs1020	pspnqs1020	g*	no	no
pspnqs	1021	pspnqs1021	pspnqs1021	g*	no	no
psp	103	psp103	psp103	eg	no	no
psp	103	psp103t	psp103t	eg	yes	no
pspnqs	103	pspnqs103	pspnqs103	eg	no	no
modella	500	bjt500	bjt500	e	no	no
modella	500	bjt500t	bjt500t	e	yes	no
mextram	504	bjt504	bjt504	e	no	yes
mextram	504	bjt504t	bjt504t	e	yes	yes
mextram	504	bjtd504	bjtd504	e	no	no
mextram	504	bjtd504t	bjtd504t	e	yes	no
mextram	505	bjt505	bjt505	e	no	yes
mextram	505	bjt505t	bjt505t	e	yes	yes
mextram	505	bjtd505	bjtd505	e	no	no
mextram	505	bjtd505t	bjtd505t	e	yes	no
mos	903	mos903e	mos903e	e	no	no
mos	903	mos903	mos903	g	no	no
mos	903	mos903t	mos903t	g	yes	no
mos	1101	mos1101e	mos1101e	e	no	no
mos	1101	mos1101et	mos1101et	e	yes	no
mos	11010	mos11010	mos11010	g	no	no
mos	11010	mos11010t	mos11010t	g	yes	no
mos	11011	mos11011	mos11011	g	no	no
mos	11011	mos11011t	mos11011t	g	yes	no
mos	1102	mos1102e	mos1102e	e	no	no
mos	1102	mos1102et	mos1102et	e	yes	no
mos	11020	mos11020	mos11020	g	no	no
mos	11020	mos11020t	mos11020t	g	yes	no
mos	11021	mos11021	mos11021	g	no	no
mos	11021	mos11021t	mos11021t	g	yes	no
mos	3100	mos3100	mos3100	e	no	no
mos	3100	mos3100t	mos3100t	e	yes	no
mos	40	mos40	mos4000/mos40	e	no	no
mos	40	mos40t	mos4000t/mos40t	e	yes	no
rfldmos	602	rfldmos602t	rfldmos602t	g	yes	yes**
rfldmos	602	rfldmos602dt	rfldmos602dt	g	yes	yes**
jfetidg	1	jfetidg	jfetidg	g	no	no
jfetidgt	1	jfetidgt	jfetidgt	g	yes	no
ovcheck	1	ovcheck	ovcheck	-	-	-
ovcheck	6	ovcheck6	ovcheck6	-	-	-

* For PSP the electrical model is referred to as the local model and the geometrical model as the global model.

** In the rfldmos model, substrate effects are modeled but the substrate is connected to the source and not available as a separate terminal.

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

model	level	Spectre
diode	500	dio500
mos	902	mos902
mextram	503	bjt503
lpnp	301	bjt301
mos	705	mos705

From simkit 4.8_pub onwards, the mextram 3500 model is no longer supported.
From simkit 4.0_pub onwards, mos1100, mos2002 and mos3002 are no longer supported. If these models are needed, please use older simkit versions and simulator versions compatible with these older simkit versions.

SiMKit interface

Simkit 4.7_pub-5.0_pub incorporate interface version 10 which is backward compatible with version 9 used in 4.4_pub-4.6_pub and with version 8 used in simkit 4.0_pub-4.3_pub but not backward compatible with the interface versions used in simkit 3.8_pub and earlier.

The interface description document simkitInterfaceDescription.pdf is contained in the zipped model library.