
Performance Comparison using HICUM- and SQ0- Bipolar Models

by

Jörg Berkner, Josef Schmal, Axel Schmidt
Infineon Technologies AG
Munich, Germany

Performance Comparison HICUM vs. SQ0

Objective

We made a comparison between two simulations using a SQ0-Subcircuit model and the HICUM model with respect to

- used CPU time
- used memory
- possible convergence problems

to answer the question:

How does HICUM affect the efficiency of the circuit design process ?

Performance Comparison HICUM vs. SQ0 Conditions

- Used Simulator: Spectre 4.4.6-010602
- Used simulation modes: DC, AC, Transient, PSS IIP3, PSS 1dB ICP
- HICUM as implemented in Spectre 4.4.6-010602
- For HICUM simulations, only a for certain part of the transistors the HICUM model was used
- Self heating feature in HICUM was not used
- SQ0 - Model = SGP subcircuit model, as implemented at Infineon

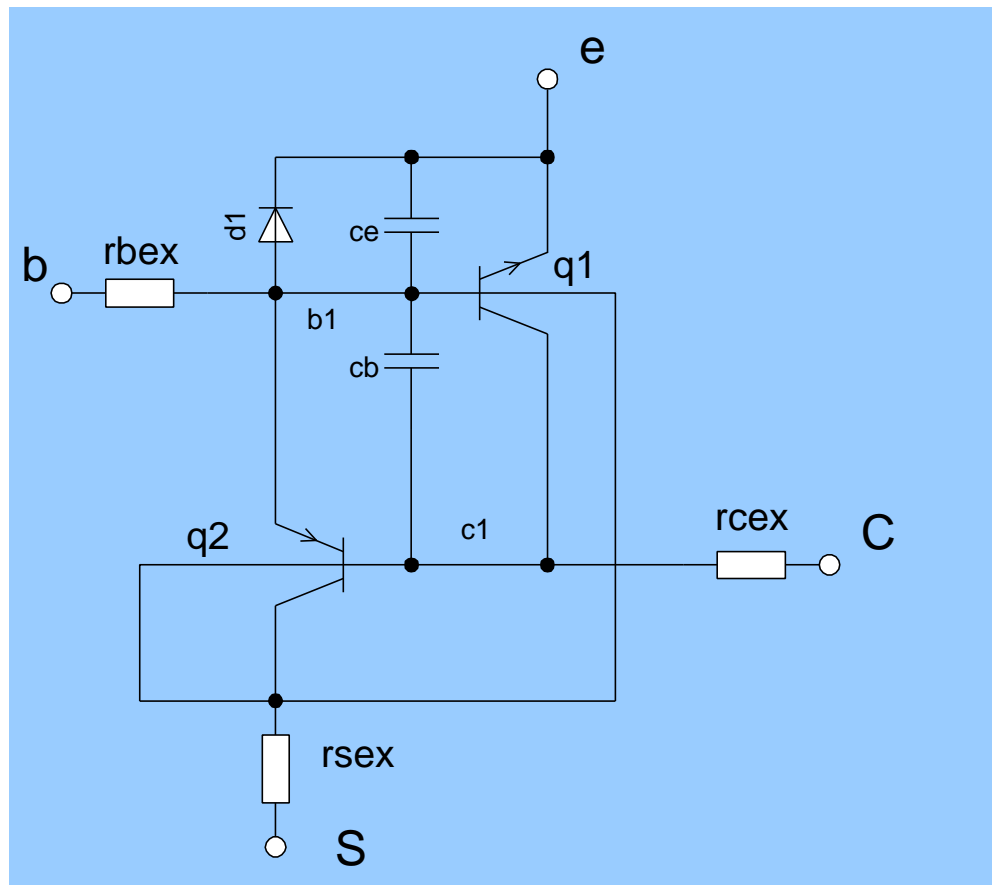
Performance Comparison HICUM vs. SQ0 Siemens / Infineon Models SQ0 and SQ3

- At Siemens / Infineon the SGP model is implemented in two versions: SQ0 - model and SQ3 - model
- SQ0: equations are identical to SGP
- SQ3 is based on SGP, but modified with respect to the following topics:
 - + independent base current modeling,
 - + different transit time equation,
 - + improved temperature modeling
- Both the models SQ0 and SQ3 are used in the design environment in a subcircuit model

Performance Comparison HICUM vs. SQ0

SQ0 / SQ3 Model Subcircuit models

- SQ0-subcircuit model: q1 = SQ0 and q2 = SQ0
- SQ3-subcircuit model: q1 = SQ3 and q2 = SQ0



Performance Comparison HICUM vs. SQ0

HICUM Implementation Problems in Spectre

Following problems appeared using HICUM and Spectre:

spectre name	version / revision	hicum version	remarks / bugs
spectre 443	4.4.3.100	?	parameter hfe, hjei, tsf refused
spectre 446	4.4.6.-06-01-2002	2.1.	<p>HFE, HJEI, TSF accepted new parameters: MSR, HC, TNOM, DEBUG ICH=0 creates warning THCS=0 creates error, must be >0 FTHC=0 creates error, must be >0 ALHC=0 creates error, must be >0 CJCI0=0 creates error, must be >0 CJEI0=0 creates error, must be >0</p>

Performance Comparison HICUM vs. SQ0 Circuits

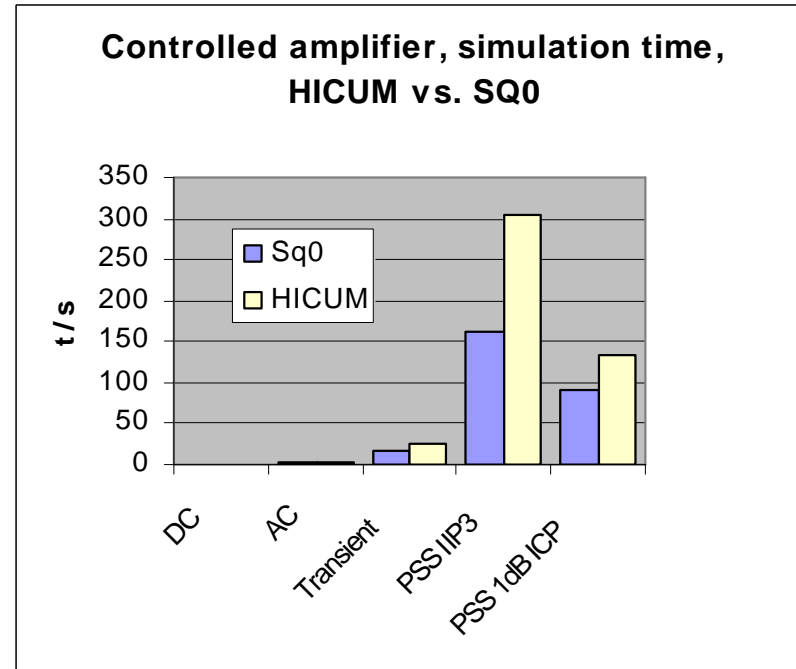
Following circuits have been investigated:

- Controlled amplifier (569 active and passive devices)
- LNA / Demodulator (1937 active and passive devices)
- Limiter (2250 active and passive devices)
- Band Gap

Performance Comparison HICUM vs. SQ0

Controlled amplifier, Simulation time

- # Devices: 569
HIC=49, SQ0=2,
BSIM3v3=102,
Cap=231, Dio=13,
Res=172
- Simulation modes:
DC, AC, Transient, PSS
IIP3 (Input Intercept point
3rd order), PSS 1-dB-ICP
(Input Compr. Point)

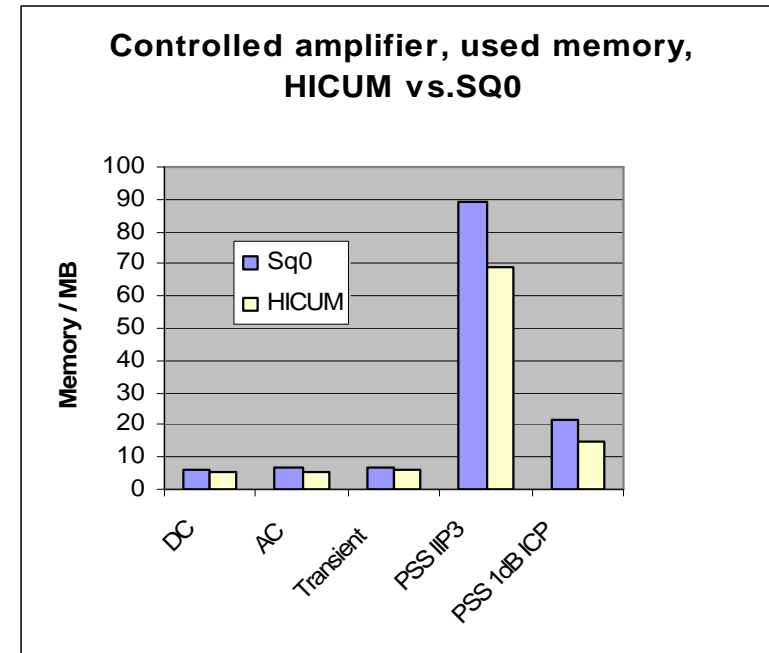


Controlled Amplifier			
Simulation time (s, %)	SQ0-Sbckt	HICUM	
DC	1.27	1.2	94%
AC	2.74	3.76	137%
Transient	16.1	26.9	167%
PSS IIP3	163	304	187%
PSS 1db ICP	91.5	135	148%

Performance Comparison HICUM vs. SQ0

Controlled amplifier, Used memory

- # Devices: 569
HIC=49, SQ0=2,
BSIM3v3=102, Cap=231,
Dio=13,
Res=172
- Simulation modes:
DC, AC, Transient, PSS
(Input Intercept point 3rd
order, IIP3), PSS (Input
Compr. Point, 1-dB- ICP)

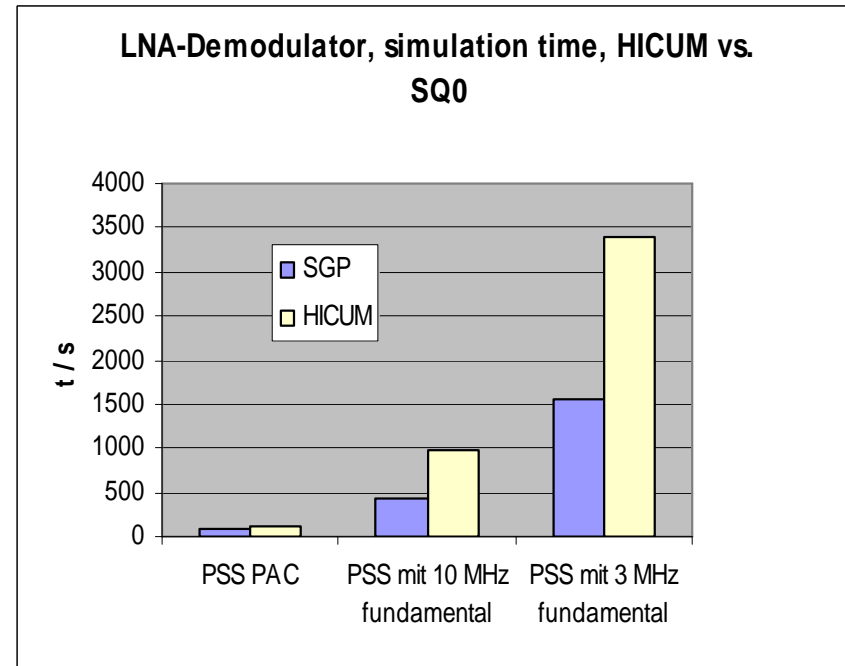


Controlled Amplifier			
Used Memory (MB, %)	SQ0-Sbckt	HICUM	
DC	6.38	5.65	89%
AC	6.5	5.72	88%
Transient	6.53	5.78	89%
PSS IIP3	88.9	69.2	78%
PSS 1db ICP	21.7	15	69%

Performance Comparison HICUM vs. SQ0

LNA-Demodulator, Simulation time

- # Devices: 1937, HIC=87, SQ0=47, BSIM3v3=93, C=933, R=708, Dio=69
- Simulation modes: PSS PAC, PSS at 10 MHz fund, PSS at 3 MHz fund.

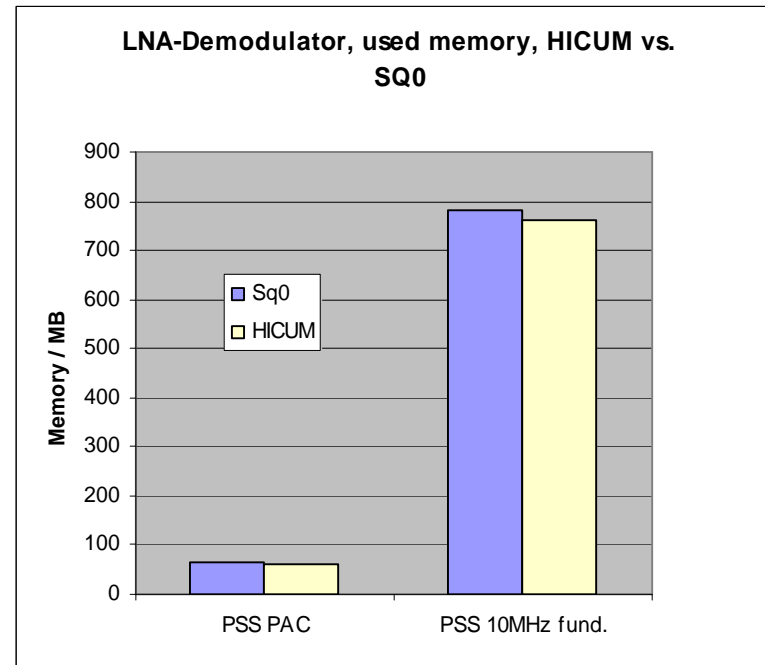


LNA-Demodulator			
Simulation time (s, %)	SQ0-Sbckt	HICUM	
PSS PAC	72.8	112	154%
PSS mit 10 MHz fundamental	431	971	225%
PSS mit 3 MHz fundamental	1548	3391	219%

Performance Comparison HICUM vs. SQ0

LNA-Demodulator, Used memory

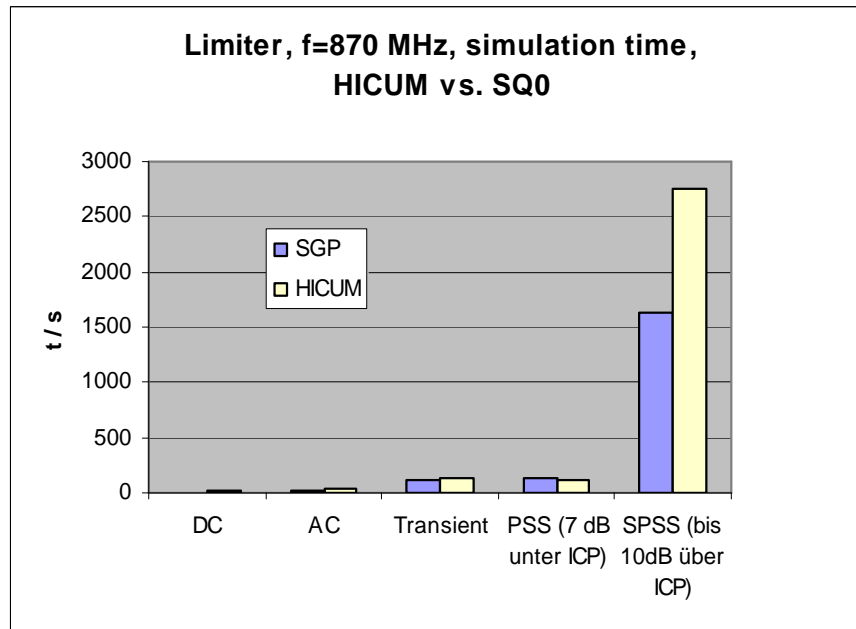
- # Devices: 1937,
HIC=87, SQ0=47,
BSIM3v3=93, C=933,
R=708, Dio=69
- Simulation modes:
PSS PAC,
PSS at 10 MHz fund,
PSS at 3 MHz fund.



LNA-Demodulator			
Used Memory (MB)	SQ0-Sbckt	HICUM	
PSS PAC	65.2	60.8	93%
PSS mit 10 MHz fundamental	780	761	98%
PSS mit 3 MHz fundamental	ca.2000	ca.2000	

Performance Comparison HICUM vs. SQ0 Limiter, Simulation time

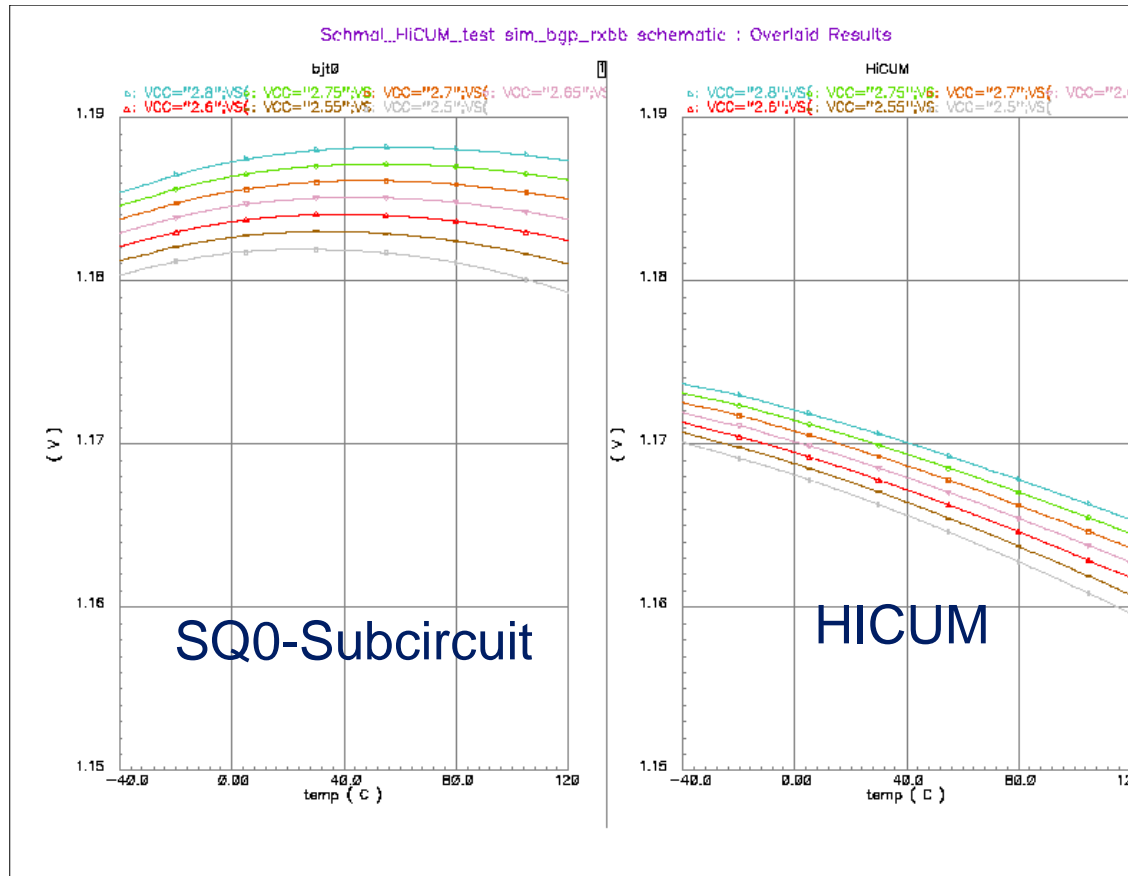
- # Devices: 2250, HIC=199, SQ0=128, BSIM3v3=154, Cap=841, Dio=152, Res=752, Ind=24
- Simulations modes: DC, AC, Transient, PSS (7 dB lower ICP), PSS (10 dB higher ICP)



Limiter, f=870MHz			
Simulation time (s, %)	SQ0-Sbckt	HICUM	
DC	5,2	23,5	452%
AC	24	40	167%
Transient	110	130	118%
PSS (7 dB lower ICP)	140	114	81%
PSS (10dB higher than ICP)	1635	2762	169%

Note: # Iterations for DC: SQ0=31, HIC=224, no convergence for PSS in one case observed

Performance Comparison HICUM vs. SQ0 Band Gap Reference



- V_{BG} vs. T , $T=-40 \dots 120$ C, $VCC=2.6\dots 2.8$ V, Step=0.05V

Performance Comparison HICUM vs. SQ0 Band Gap Reference

- Comparison of Simulation time and used memory for Band gap DC simulation with temperature sweep
- T=-40 ...120 C, VCC=2.6...2.8V, Step=0.05V

Band Gap	SQ0-Subckt	HICUM	%
Simulation time (s, %)	10	10.6	106
Used memory (MB, %)	3.73	3.6	97

Performance Comparison HICUM vs. SQ0

Conclusions

- Simulation time, used memory and convergence was compared using HICUM and the SQ0 subcircuit model
- Generally, using HICUM, the simulation time increases maximal by a factor of about 2
- Strongest increase in simulation time was observed during PSS simulations, whereas DC simulation demand about the same time
- Used memory is the same or even lower for HICUM
- No convergence problems with HICUM in most cases, however,
for DC simulation of the limiter an increased number of iterations was necessary and no convergence of PSS simulation of the limiter in one case was observed