Modeling of Infineon BFP740 using

HICUM level 0v1.2

in QUCS 0.0.15

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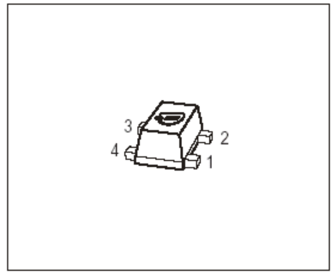
- why QUCS ?
- thermal impedance
- dc
- s-parameter
- noise
- discussion

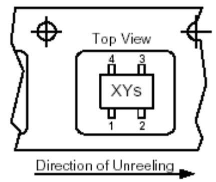
Infineon

BFP740F

NPN Silicon Germanium RF Transistor

- High gain ultra low noise RF transistor
- Provides outstanding performance for a wide range of wireless applications up to 10 GHz and more
- Ideal for CDMA and WLAN applications
- Outstanding noise figure F = 0.5 dB at 1.8 GHz
  Outstanding noise figure F = 0.75 dB at 6 GHz
- High maximum stable gain
  G_{ms} = 27.5 dB at 1.8 GHz
- Gold metallization for extra high reliability
- 150 GHz f_T-Silicon Germanium technology
- Pb-free (RoHS compliant) package [1)]
- Qualified according AEC Q101





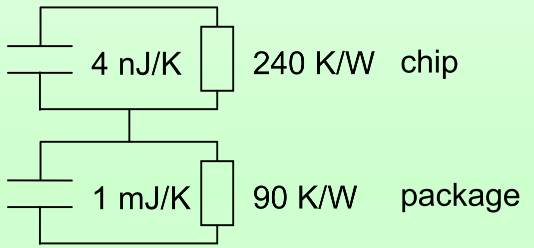
AEC Qualified RoHS

ESD (**E**lectro**s**tatic **d**ischarge) sensitive device, observe handling precaution!

Type	Marking	Pin Configuration						Package
BFP740F	R7s	1=B	2=E	3=C	4=E	-	-	TSFP-4

thermal network from pulsed measurements

two-pole thermal RC-network



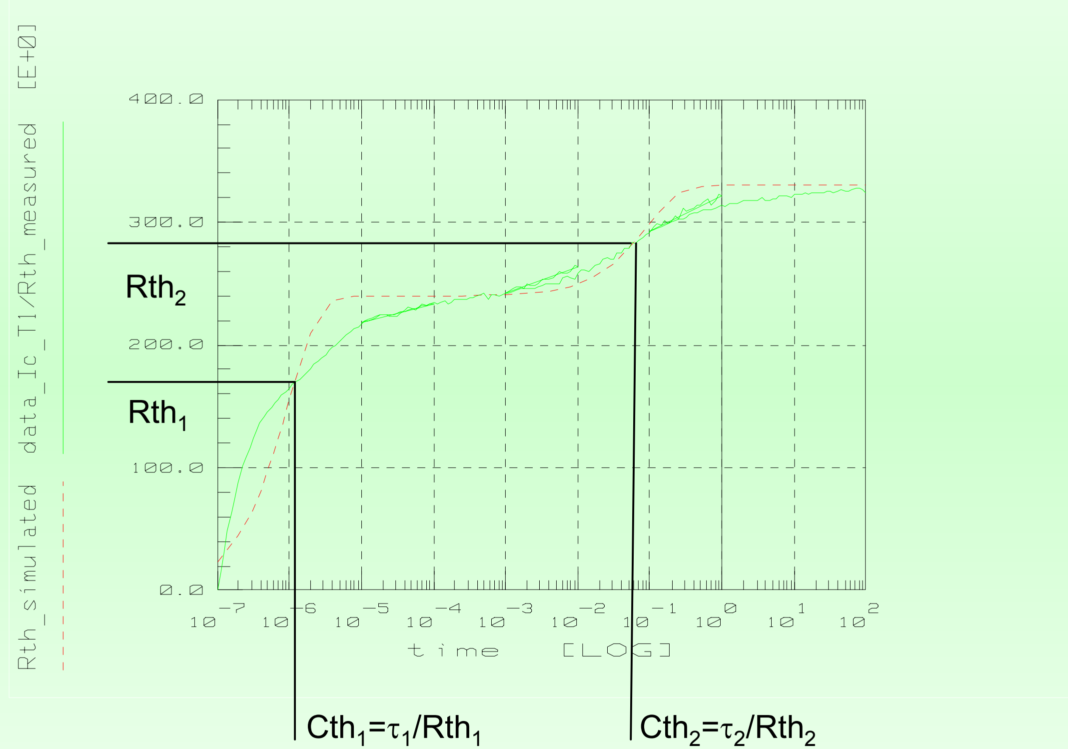
Data sheet value

Thermal Resistance

Parameter	Symbol	Value	Unit
Junction - soldering point[2]	R_{thJS}	≤ 370	K/W

Electrical Characteristics at T_A = 25°C, unless otherwise specified

I_c=4 mA, V_c=1.9 V, time 100 ns ... 100 s, T=24 °C



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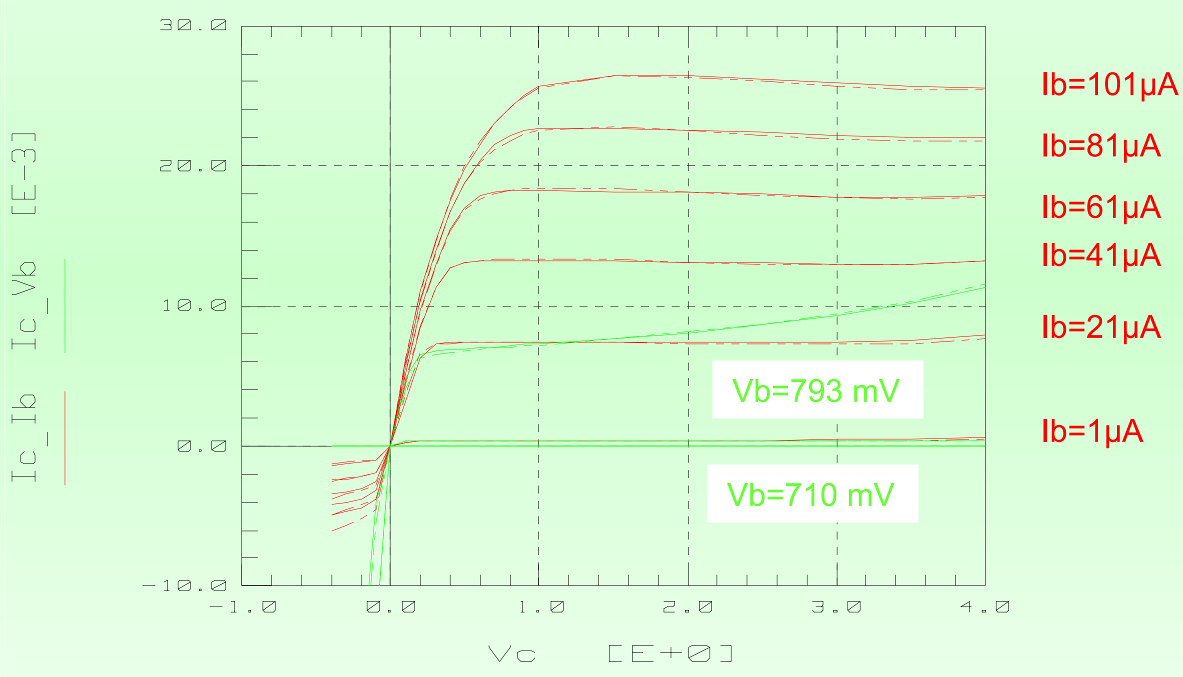
output characteristic Ic

infineon **BFP740F**

Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	V_{CEO}		V
T_A > 0°C		4	
T_A ≤ 0°C		3.5	
Collector-emitter voltage	V_{CES}	13	
Collector-base voltage	V_{CBO}	13	
Emitter-base voltage	V_{EBO}	1.2	
Collector current	I_C	30	mA
Base current	I_B	3	
Total power dissipation[1)]	P_{tot}	160	mW
T_S ≤ 90°C			
Junction temperature	T_j	150	°C
Ambient temperature	T_A	-65 ... 150	

measured and simulated forced Ib and forced Vb data



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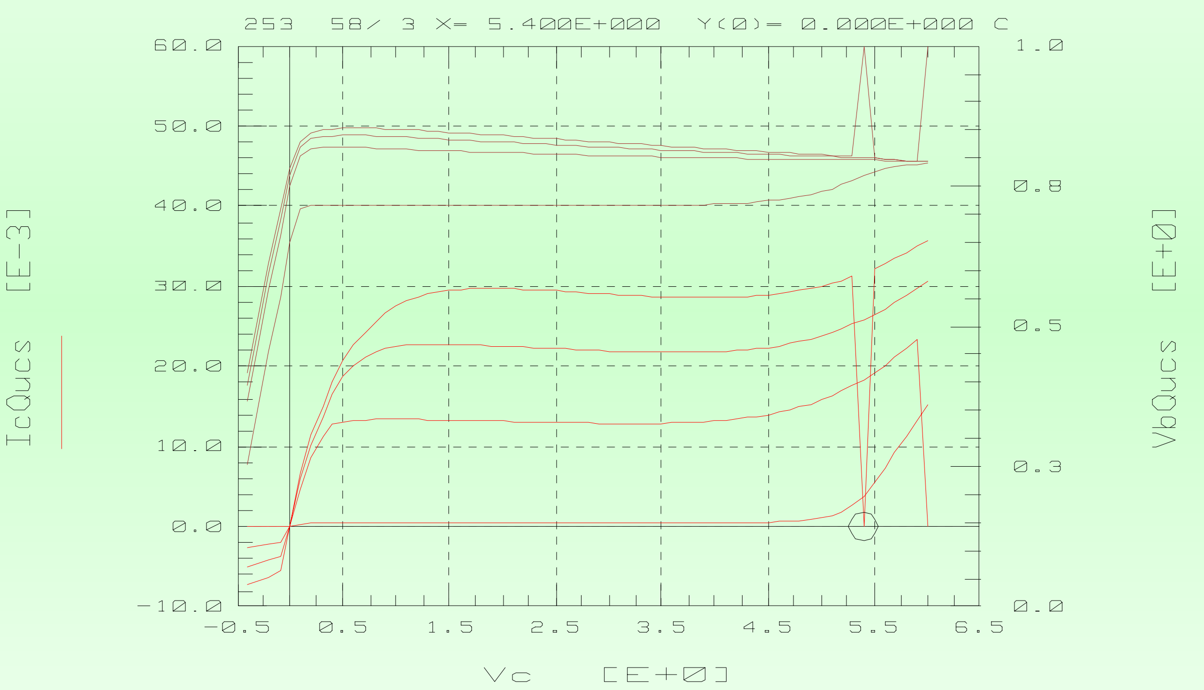
output chracteristics convergency problems

Vc from -0.4V to 6.0 V in 0.1 V steps

Ib from 1 μA to 121 μA in 40 μA steps



Housholder QR is the best converging solver

a mixture of avalanche and thermal effects causes convergency problems

the same problems occur in the latest QUCS 0.0.16 where four L0 models (1.12,1.2,1.2g,1.3) are implemented

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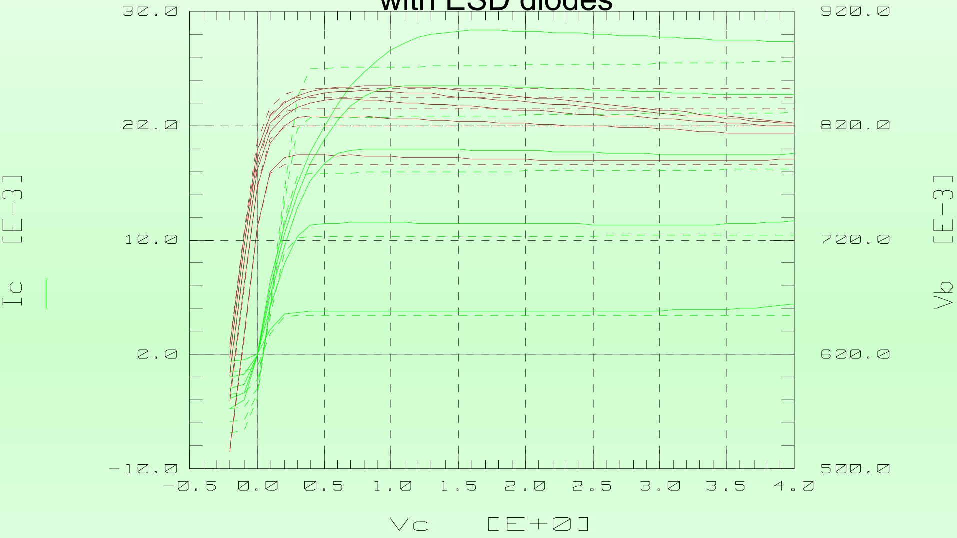
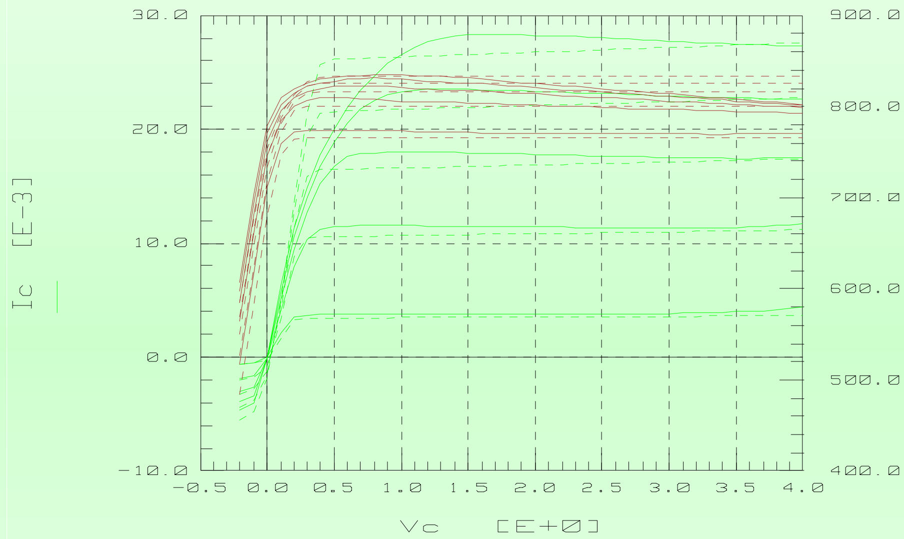
Gummel-Poon Model (ADS) supplied by Infineon

Ib from 10 µA to 110µA in 25 µA steps

with ESD diodes





--------------- simulated

——————— measured

well known problems with Gummel-Poon:

no quasi-saturation

no avalanche effect

no self heating

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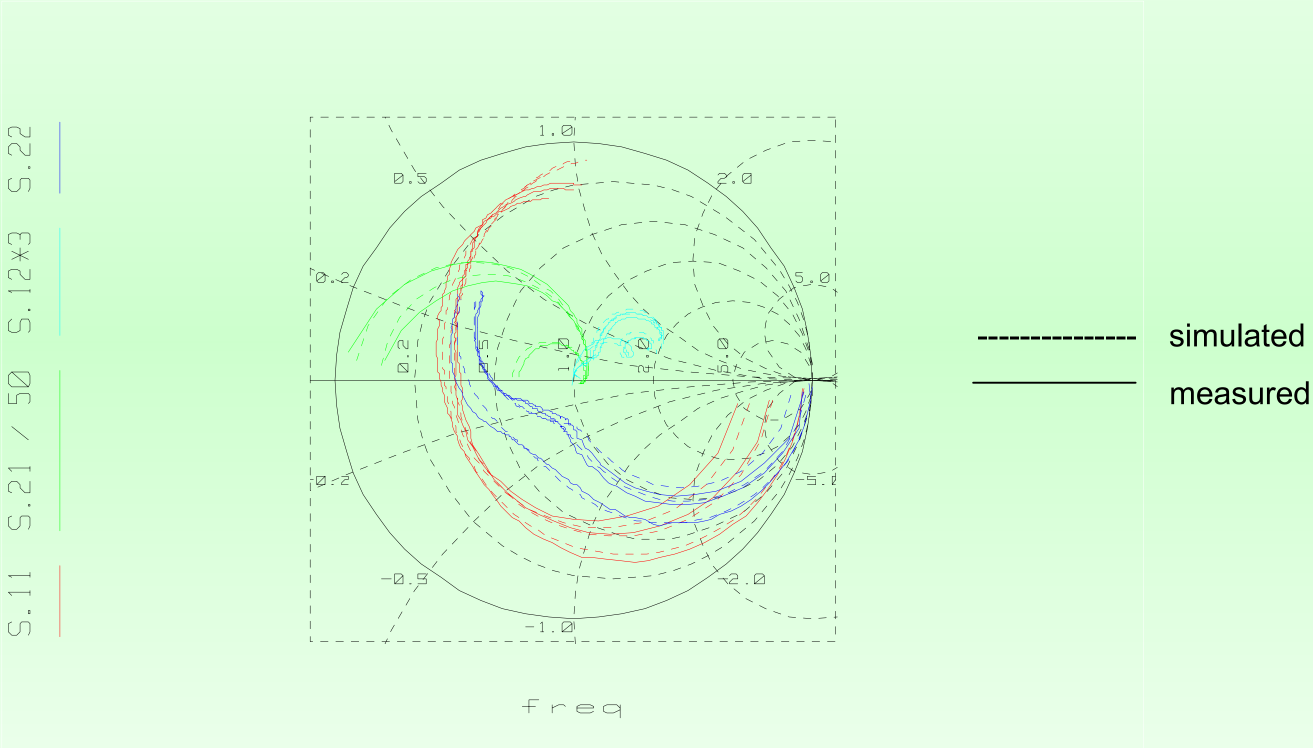
small signal HICUM

S-parameter from 50 MHz to 14.05 GHz measured on FR4 Substrate with TRL/TRM calibration.

Operating Points: Vc=2.0 V, Ic_1 =3.8 mA, Ic_2 =17.9 mA, Ic_3 =28.3 mA, Ib_1 =10 µA, Ib_2 =60 µA, Ib_3 =110 µA



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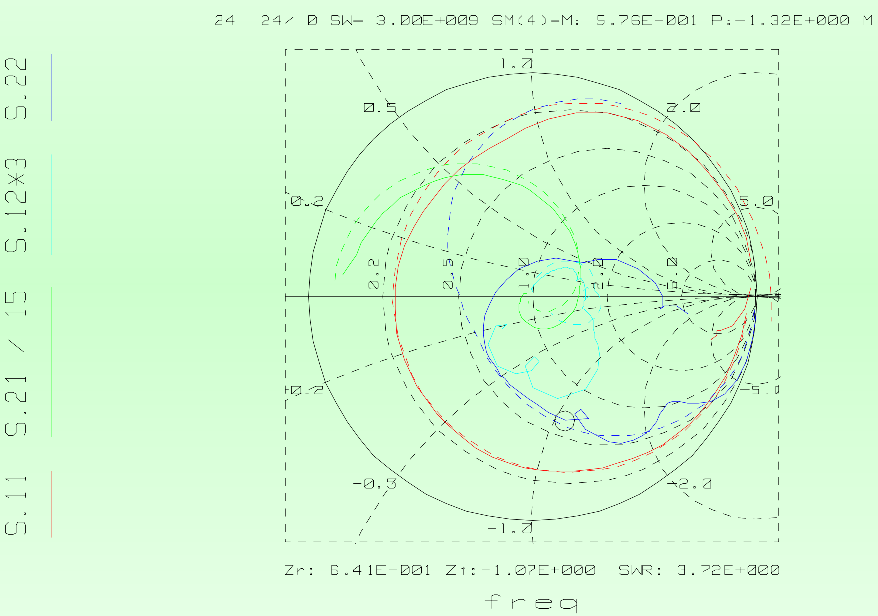
small signal SGP Infineon

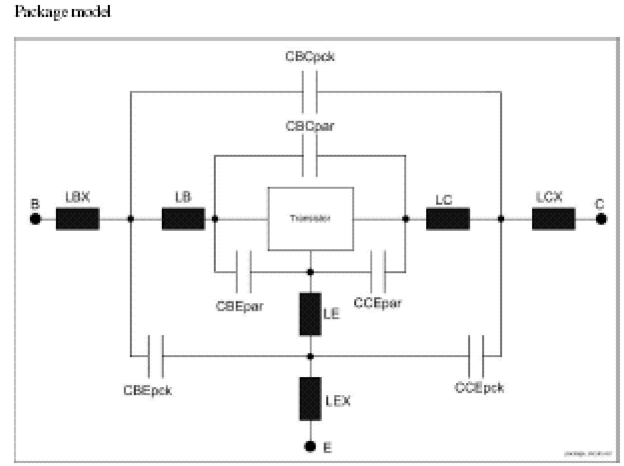
S-parameter supplied by Infineon from 100 MHz to 20 GHz measured substrate and calibration unknown.

Operating Point: Vc=2.0 V, Ic_1 =4.0 mA, valid up to 3 GHz for S12 and S22; Package model from Dec. 2008



--------------- simulated

——————— measured



L:Lbx	2	20	L=432.1p
L:Lcx	1	10	L=679p
L:Lex	0	30	L=105.2p
C:Cbcpck	20	10	C=27.6f
C:Ccepck	10	30	C=0.293f
C:Cbepck	20	30	C=97.62f
L:Lb	20	22	L=628.7p
L:Lc	10	11	L=0.137p
L:Le	30	33	L=8.3p
C:Cbepar	22	33	C=266.6f
C:Cbcpar	22	11	C=60f
C:Ccepar	11	33	C=123.4f

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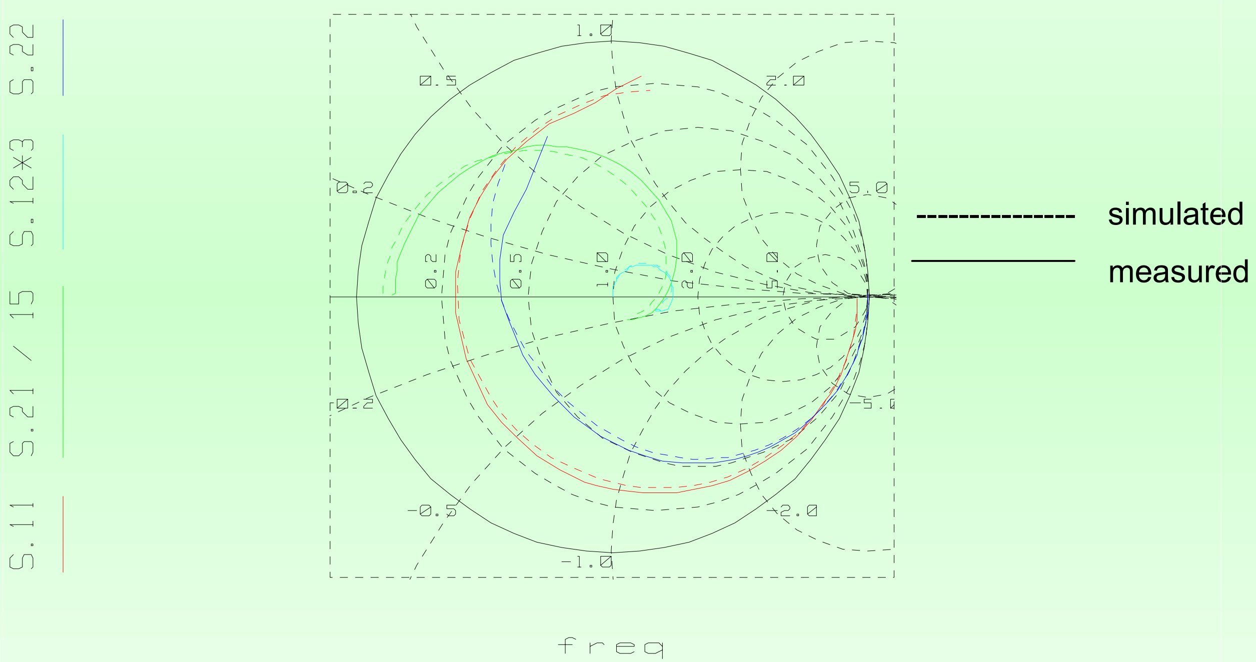
small signal SGP InfineonESD

S-parameter supplied by Infineon from 10 MHz to 10 GHz measured substrate and calibration unknown.

Operating Point: Vc=2.0 V, Ic_1 =4.0 mA, valid up to 10 GHz with improved package model (June 2010)



L:Lbx 2 20 L=432.1p
L:Lcx 1 10 L=679p
L:Lex 0 30 L=105.2p
C:Cbcpck 20 10 C=27.6f
C:Ccepck 10 30 C=0.293f
C:Cbepck 20 30 C=97.62f
L:Lb 20 22 L=628.7p
L:Lc 10 11 L=0.137p
L:Le 30 33 L=8.3p
C:Cbepar 22 33 C=266.6f
C:Cbcpar 22 11 C=60f
C:Ccepar 11 33 C=123.4f
R:R_Tr 44 4 R=307.5

D1:M_D1 33 25
D2:M_D2 4 25

R:RBLfdb 22 25 R=3.2
R:RPS 33 4 R=0.115215
R:RSUB 30 4 R=0.06119

D3:M_D3 4 15
D4:M_D4 23 33
D5:M_D5 23 15

R:RLDNBL 15 11 R=14.8

BJTM2:X1 11 22 33 44

model D1 Diode Is=2.5E-017 N=1 Rs=6.1 Cjo=1E-014
model D2 Diode Is=2E-018 N=1 Rs=4170 Cjo=2.5E-014
model D3 Diode Is=3.5E-015 N=1.02 Rs=1380 Cjo=3E-014
model D4 Diode Is=3.5E-015 N=1 Rs=0.2 Cjo=3E-014
model D5 Diode Is=3.5E-015 N=1.02 Rs=4.7 Cjo=3E-014

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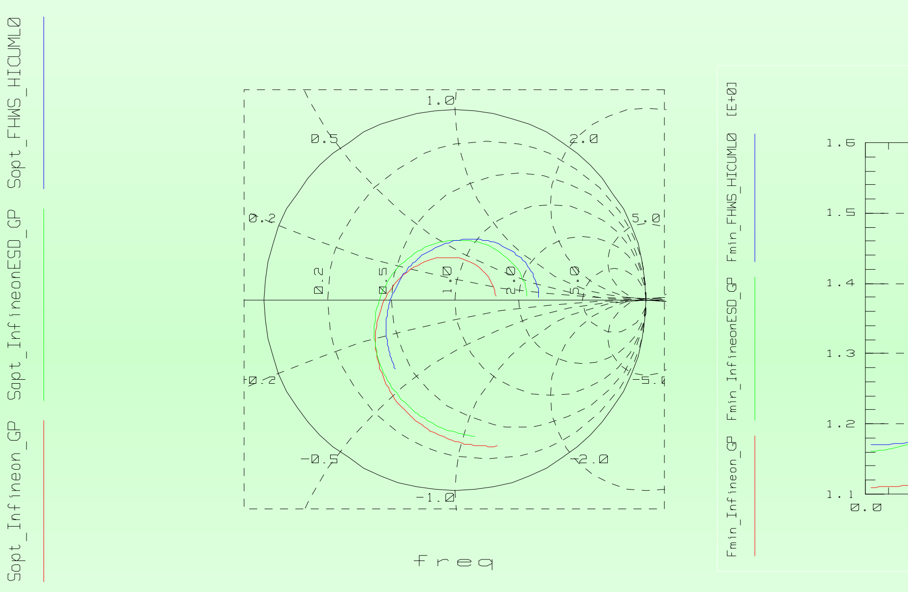
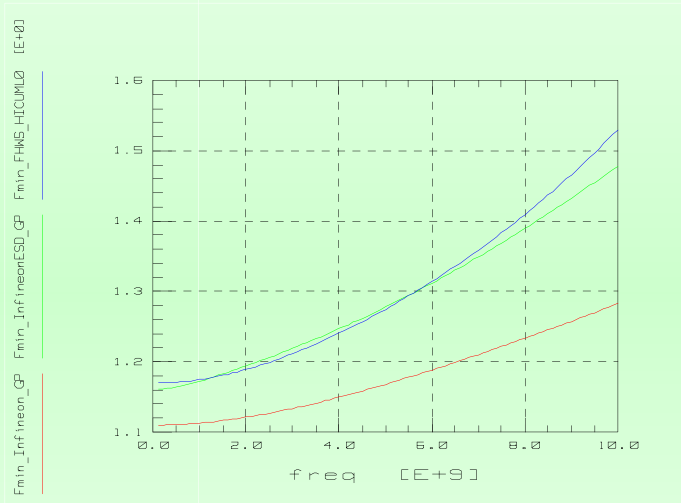
noise-simulation to 10 GHz

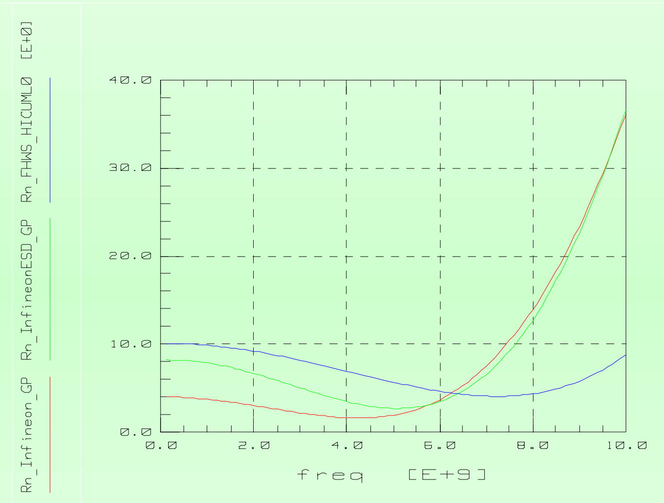
Sopt



Fmin



Rn / Ω



Infineon GP

Infineon ESD GP

FHWS HICUM L0

Operating Point
Vc=2V, Ic=10 mA

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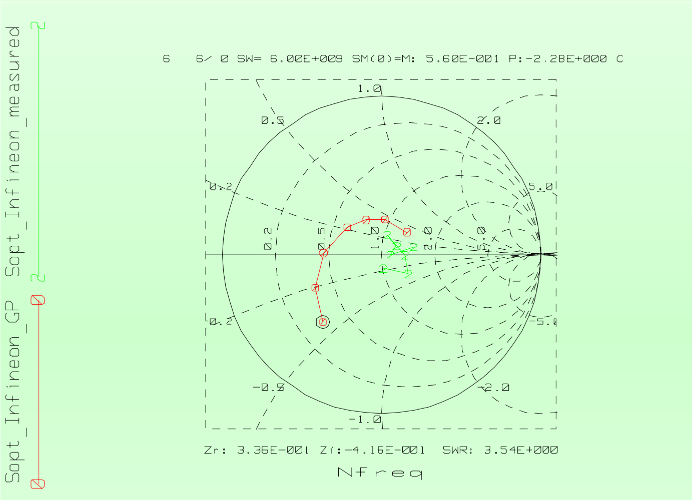
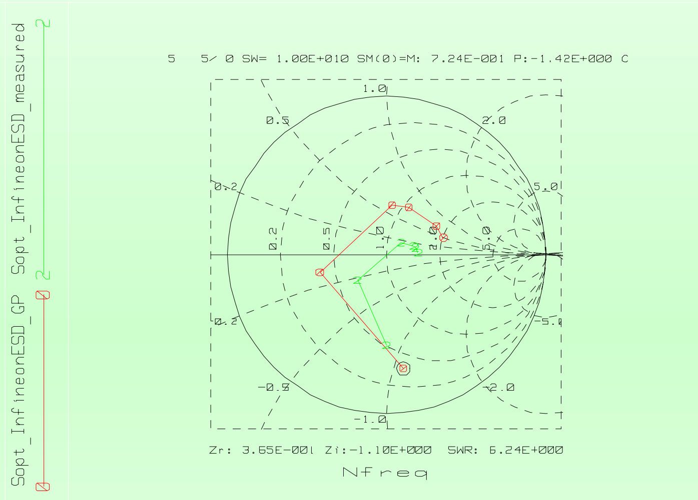
noise-measurement to 6/10 GHz - Sopt

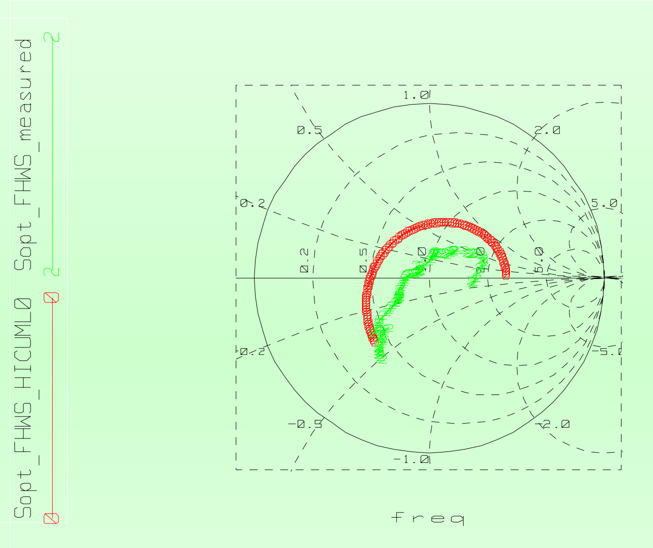
Infineon 6GHz



Infineon ESD 10 GHz



FHWS 10 GHz



simulated

measured

measured with deembedded LNA

operating point
Vc=2V, Ic=10 mA

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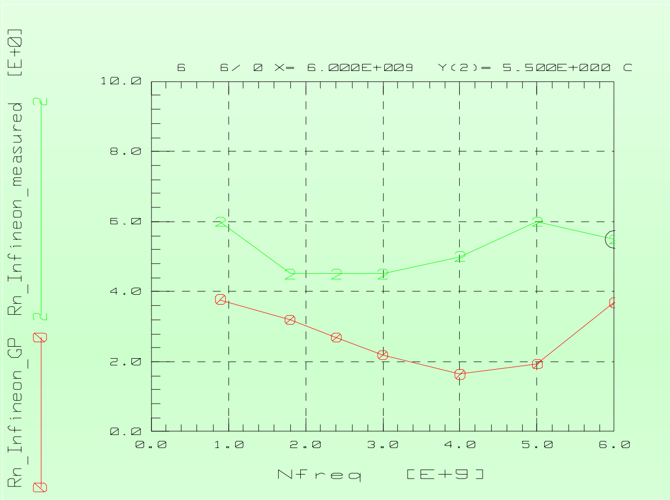
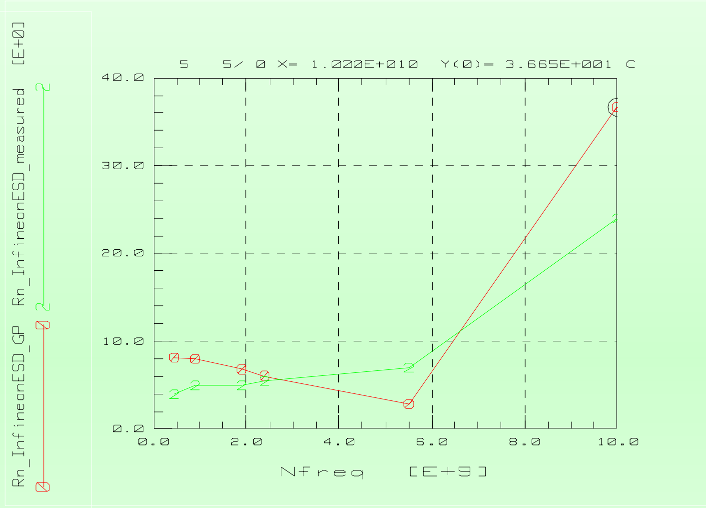
noise-measurement to 6/10 GHz - Rn

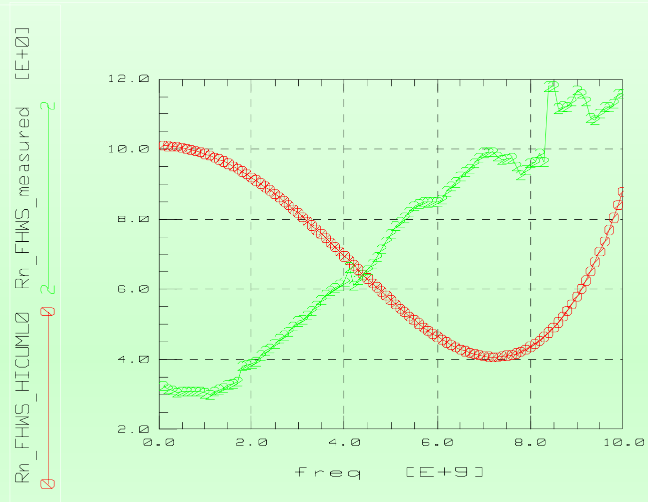
Infineon 6GHz



Infineon ESD 10 GHz



FHWS 10 GHz



simulated

measured

operating point
Vc=2V, Ic=10 mA

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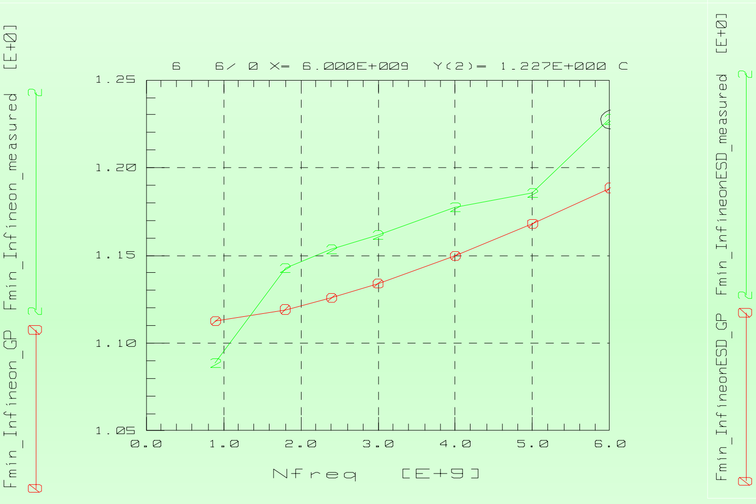
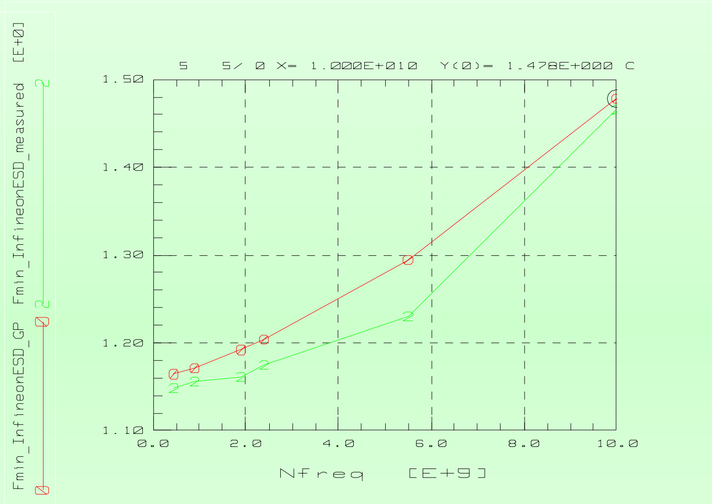
noise-measurement to 6/10 GHz - Fmin

Infineon 6GHz



Infineon ESD 10 GHz



FHWS 10 GHz

simulated
measured

operating point
Vc=2V, Ic=10 mA

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conclusions and discussions

- two-pole thermal network is necessary for accurate simulation in SMD-transistors
- HICUML0 in Qucs can simulate DC and S-parameters with some convergency problems especially at operating points with avalanche and thermal interaction
- even Gummel-Ponn model is sufficient to simulate S-parameters with Noise if the package model is good
- for Noise data the question occurs what is more accurate: measurement or simulation ?
- will HICUM L0 be used in future by manufacturers for custumer models?
- are there also convergency problems in the ic-design kit models with HICUML0?

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