

Experience with Hicum L0 v1.2 (improved IFX version)

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IFAG AIM AP T PFM EDA



Never stop thinking

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- **Reverse Early Effect**

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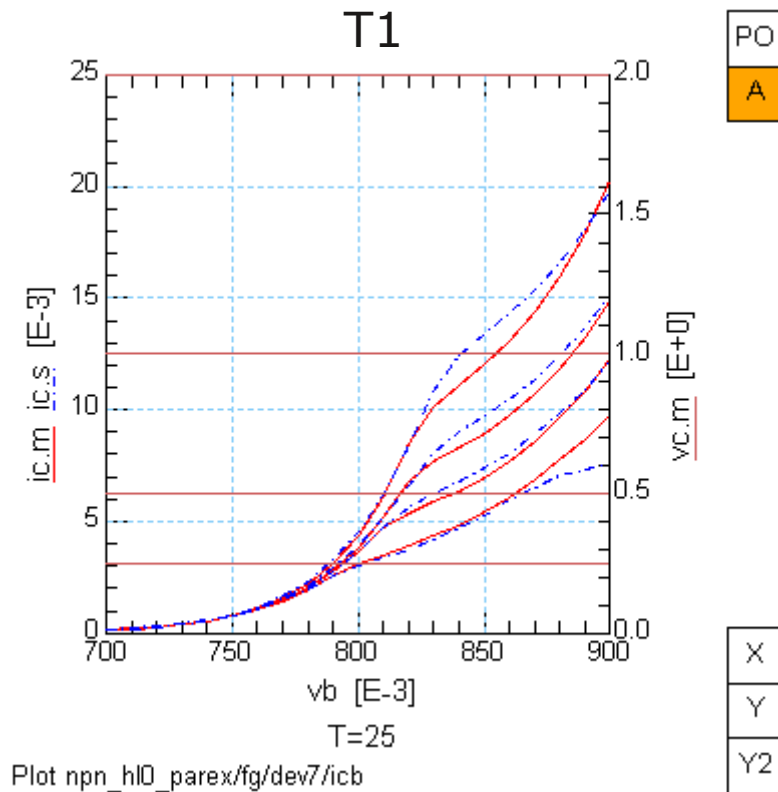
- **Results Technology 2**

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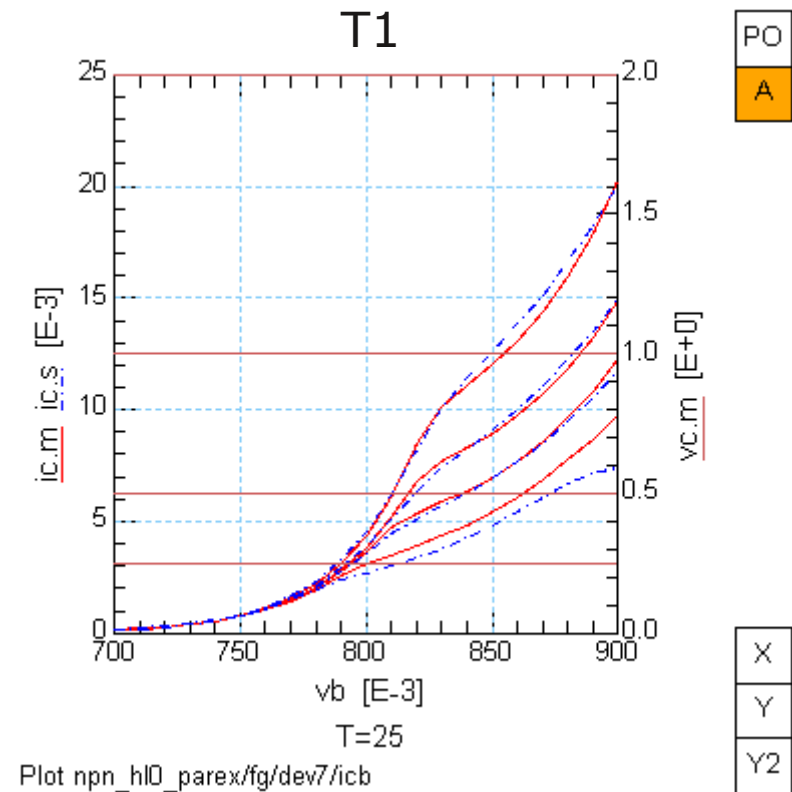
Experience with Hicum L0 v1.2 Advantages (1)



- Improved model allows a better fit of I_c in the high current range



HLO v1.12
 IQF=7m, IQFH=3m, TFH=1f



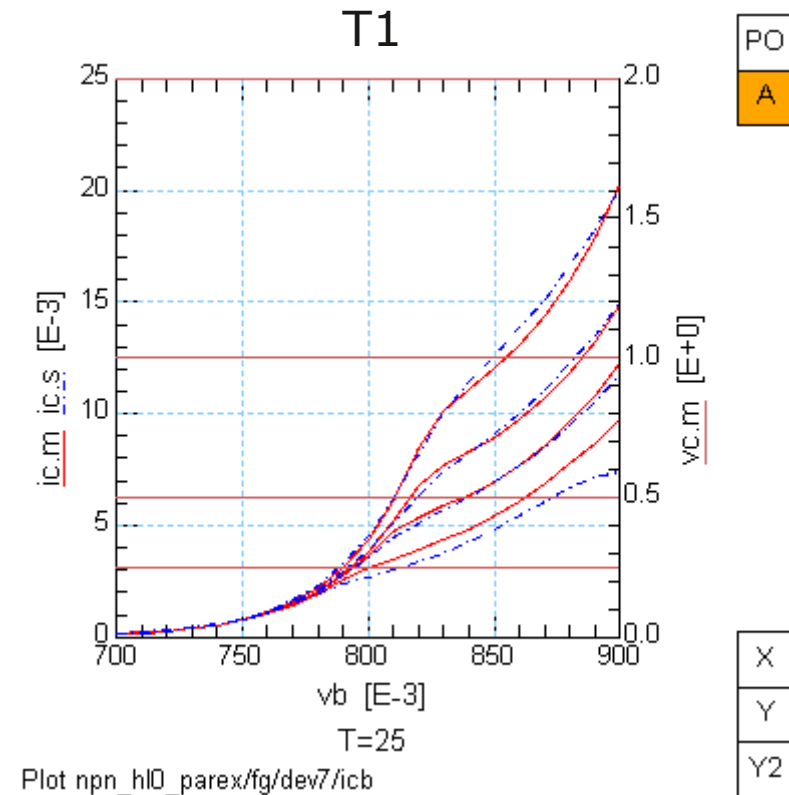
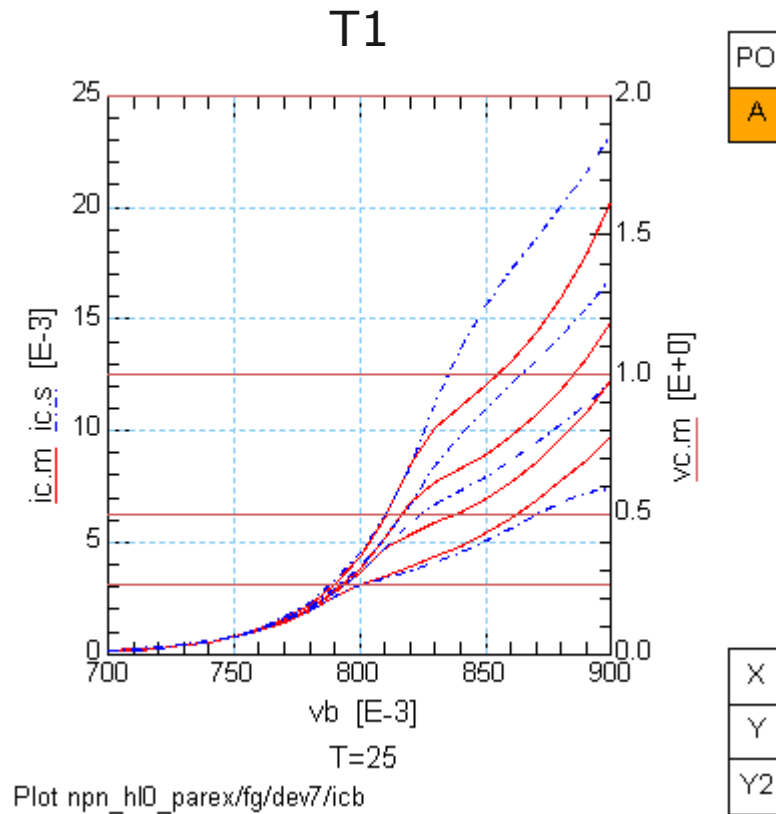
HLO v1.2
 IQF=7m, IQFH=650μ, TFH=1f, AHQ=0.5

Note: All simulations with VA-code and hpeesofsim 2006A.403 Feb 7 2007

Experience with Hicum L0 v1.2 Advantages (2)



- Essential is the use of AHQ, which allows a better fit



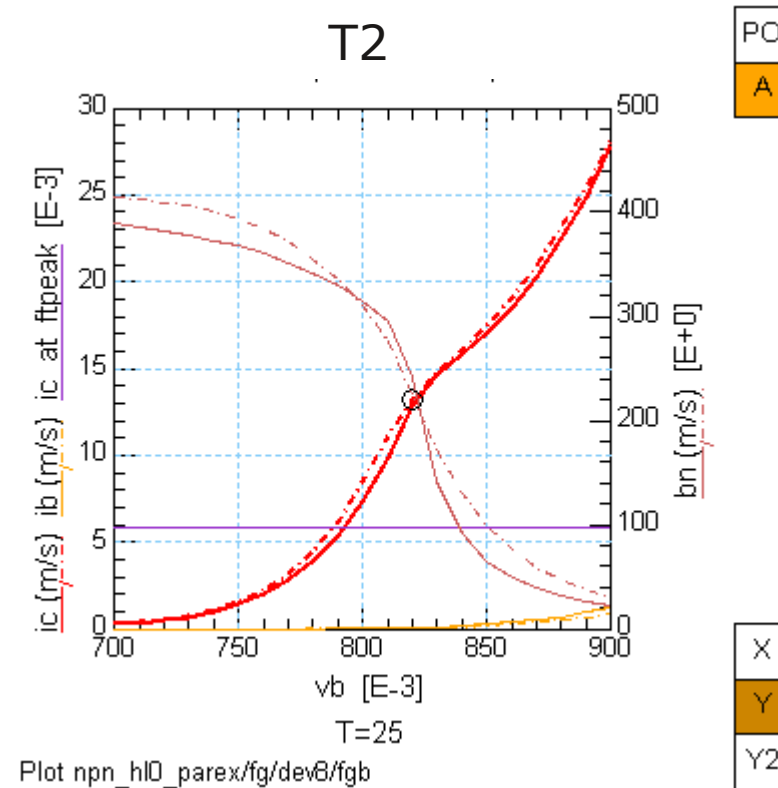
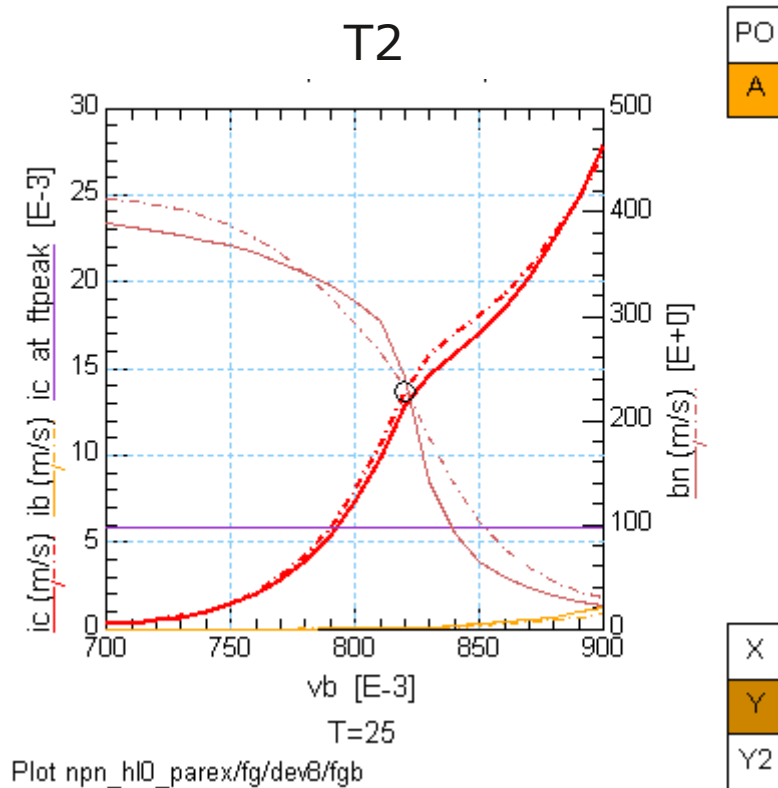
HL0 v1.2
IQF=7m, IQFH=650 μ , AHQ=0

HL0 v1.2
IQF=7m, IQFH=650 μ , AHQ=0.5

Experience with Hicum L0 v1.2 Advantages (3)



- Improved model allows a better fit of I_c in the high current range



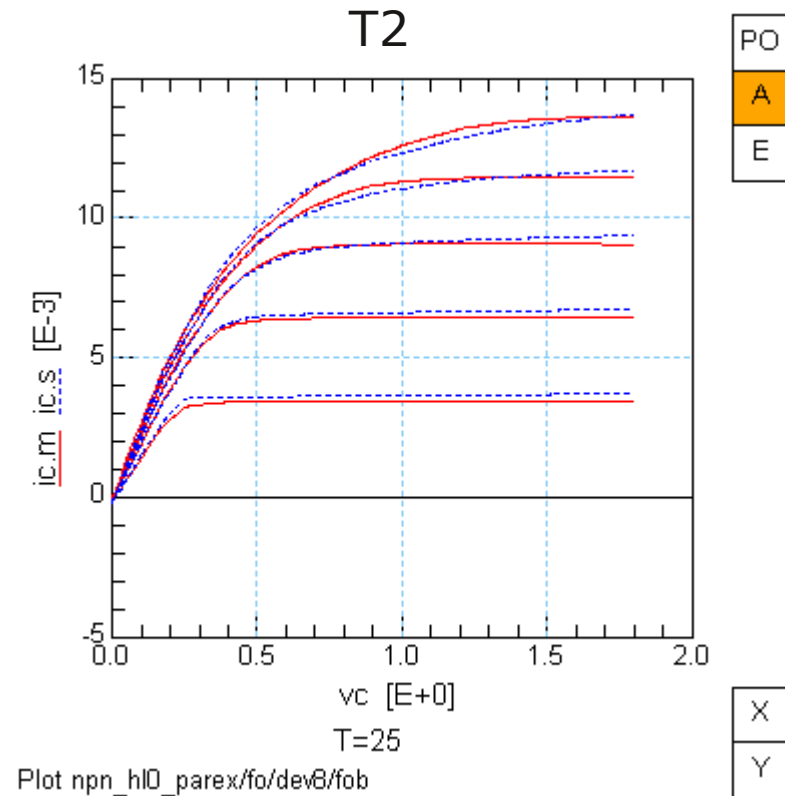
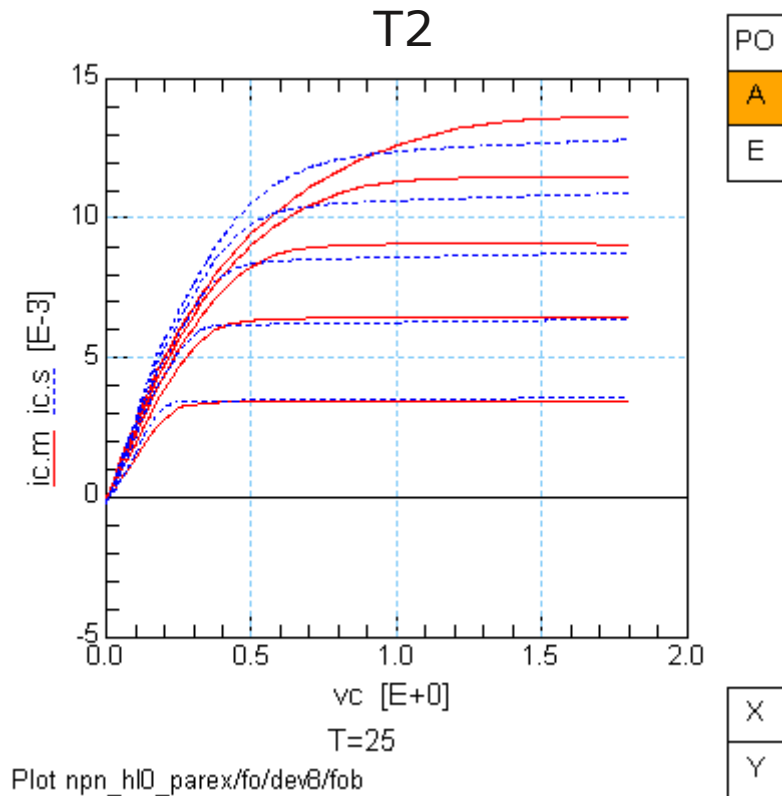
HLO v1.12
 $I_{QF}=18m$, $I_{QFH}=6m$, $TFH=1f$

HLO v1.2
 $I_{QF}=24m$, $I_{QFH}=1.2$, $TFH=1f$, $AHQ=0.5$

Experience with Hicum L0 v1.2 Advantages (4)



- fwd output curve makes the advantage of AHQ clear visible



HLO v1.12
IQF=18m, IQFH=6m, TFH=1f

HLO v1.2
IQF=24m, IQFH=1.2m, TFH=1f, AHQ=0.5

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Experience with Hicum L0 v1.2 Reverse Early Effect



- HICUM L0 v1.2 includes a reverse early voltage again, which makes basically sense
- However, for the devices under investigation, the use of VER delivered no real advantage compared to the usage of MCF alone

$$q_J = 1 + \frac{q_{JCI}}{VEF} + \frac{q_{je}}{VER}$$

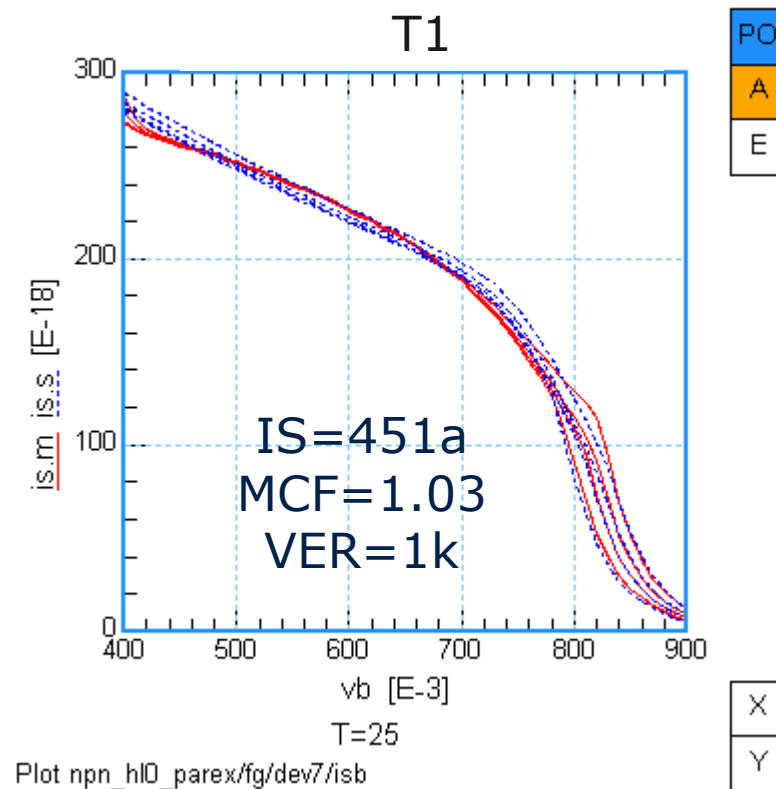
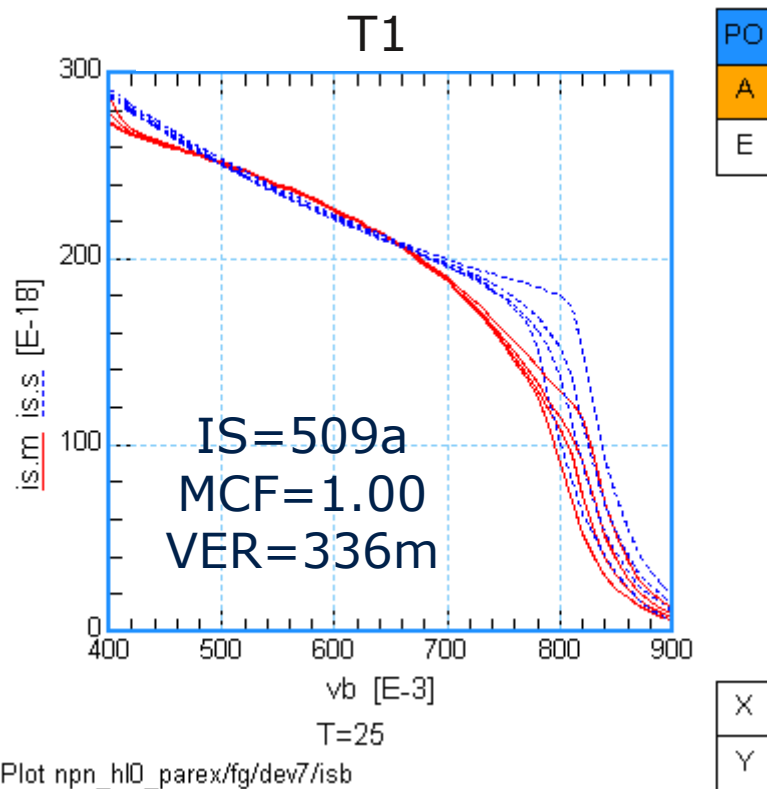


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Experience with Hicum L0 v1.2 Problems (1)



The screenshot shows the IC-CAP/Simulation Debugger interface. The 'Input File' pane contains the following text:

```
Options \  
Temp = 25\  
ASCII_Rawfile=no UseNutmegFormat=yes  
define npn_h10_parex (C B E S )  
  
Options V_RelTol=1e-6 V_AbsTol=1e-12 I_R  
  
; ->specify the location of your veril  
; ->for recompilation (when you had ap  
; open the Simulation Debugger (in o  
; hicum level 0 version: 1.12
```

The 'Output File' pane contains the following text:

```
hpeesofsim (*) 2006A,403 Feb 7 2007 (64-bit built: 02/07/07 19:48:27)  
Copyright Agilent Technologies, 1989-2006.  
  
Loading Verilog-A module 'hic0_full' from  
'/home/berkner/hpeesof/agilent-model-cache/cml/1.34/sun58_64/va_20085_2008'  
  
Error detected by hpeesofsim in Verilog-A device setup during circuit set up.  
Range error in device 'XCKT,X1' ; Parameter 'tfh'
```

The error message in the Output File pane is circled in red.

- For TFH=0 hpeesofsim delivered a range error
- Often TFH is not necessary, that is why TFH=0 should not create an range error

Experience with Hicium L0 v1.2 Problems (2)



The screenshot shows the IC-CAP/Simulation Debugger interface. The 'Input File' pane on the left contains Verilog code and options. The 'Output File' pane on the right shows the simulation log. A red oval highlights an error message in the output file:

```
hpeesofsim (*) 2006A.403 Feb 7 2007 (64-bit built: 02/07/07 19:48:27)  
Copyright Agilent Technologies, 1989-2006.  
  
Loading Verilog-A module 'hic0_full' from  
'/home/berkner/hpeesof/agilent-model-cache/cml/1.34/sun58_64/va_20085_2008'  
  
Error detected by hpeesofsim in Verilog-A device setup during circuit set up.  
Range error in device 'XCKT,X1,X1' ; Parameter 'ahc'
```

- The same problem appears for $AHC=0$
- AHC is the smoothing factor for the injection width, $AHC=0.1$ is default
- $AHC>0$ is usually applied, however $AHC=0$ should not create a range error

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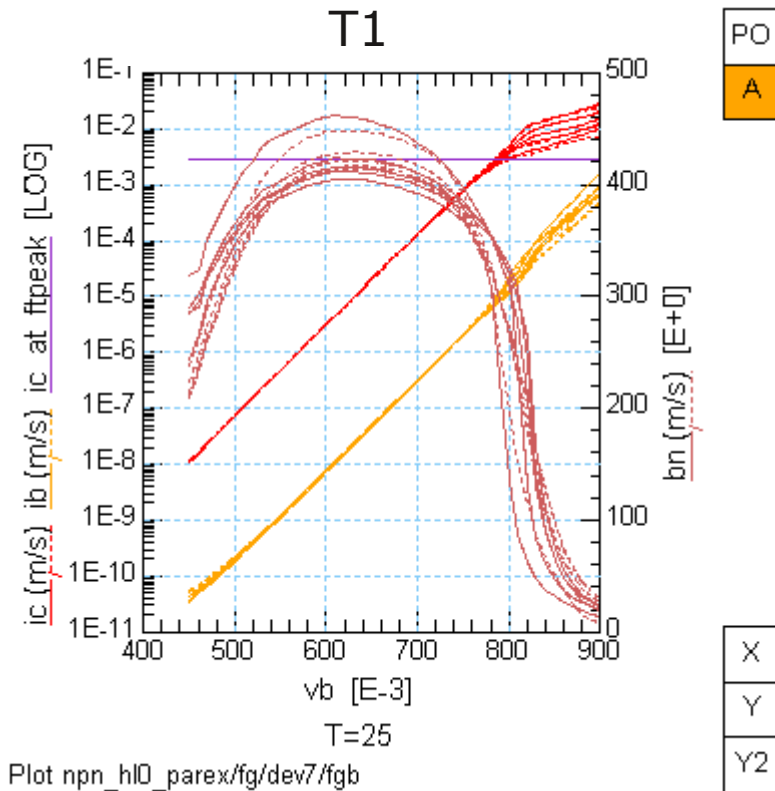
- **Results Technology 1**

- **Results Technology 2**

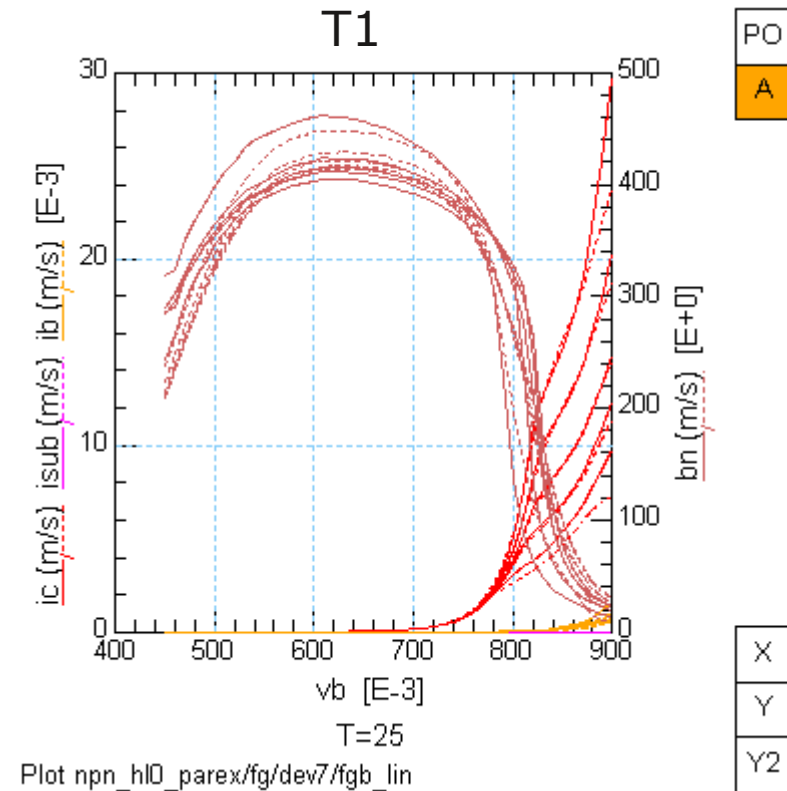
- **Summary**

Experience with Hicum L0 v1.2

Results: Technology 1



$I_c, I_b, B_n = f(V_{be}), V_c = \text{Par}$

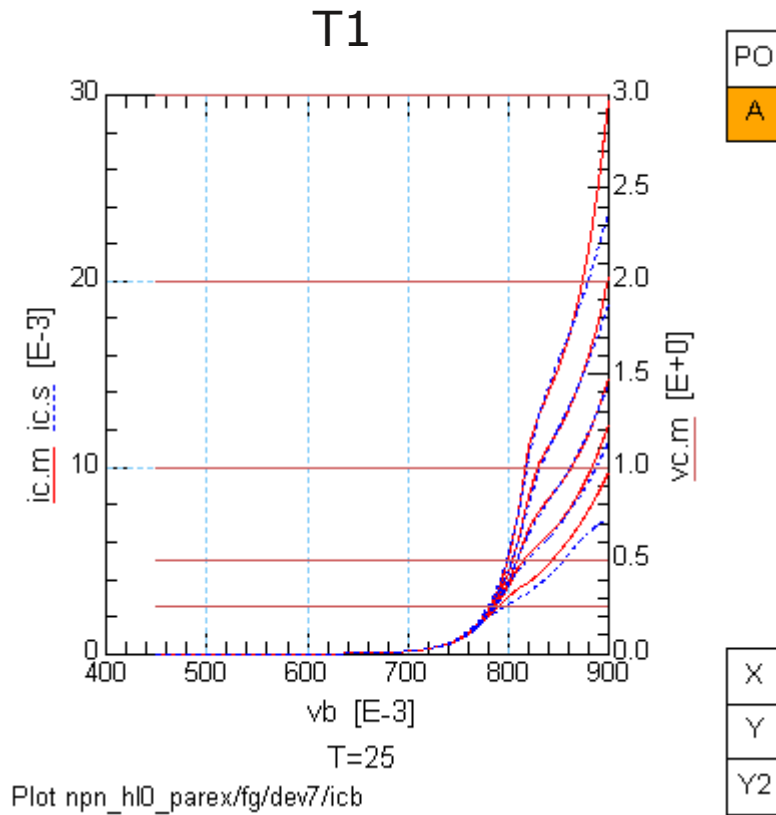


$I_c, B_n = f(V_{be}), V_c = \text{Par}$

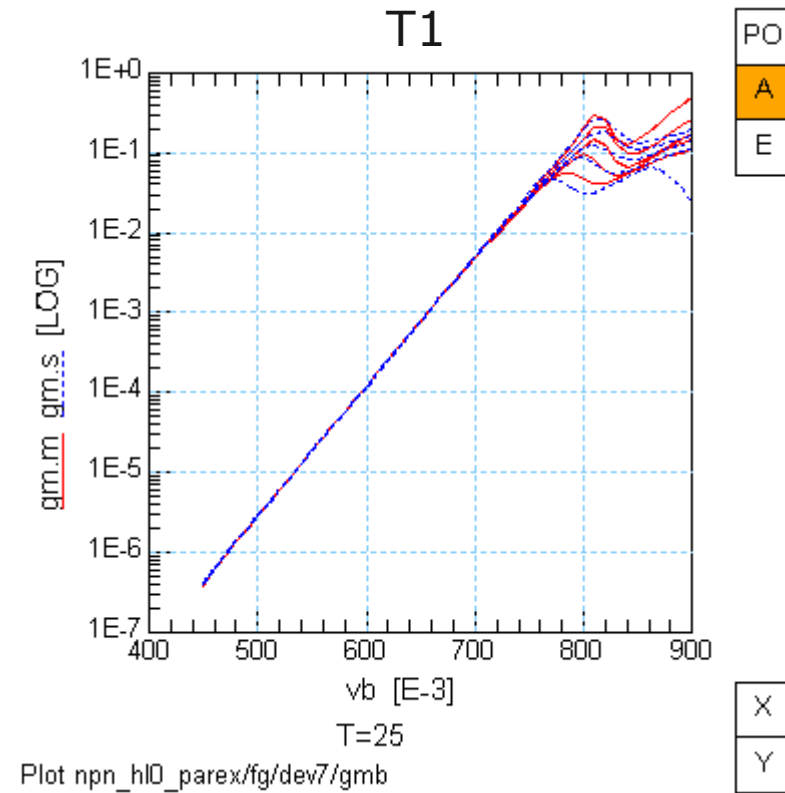
Note: All simulations with VA-code and hpeesofsim 2006A.403 Feb 7 2007

Experience with Hicum L0 v1.2

Results: Technology 1



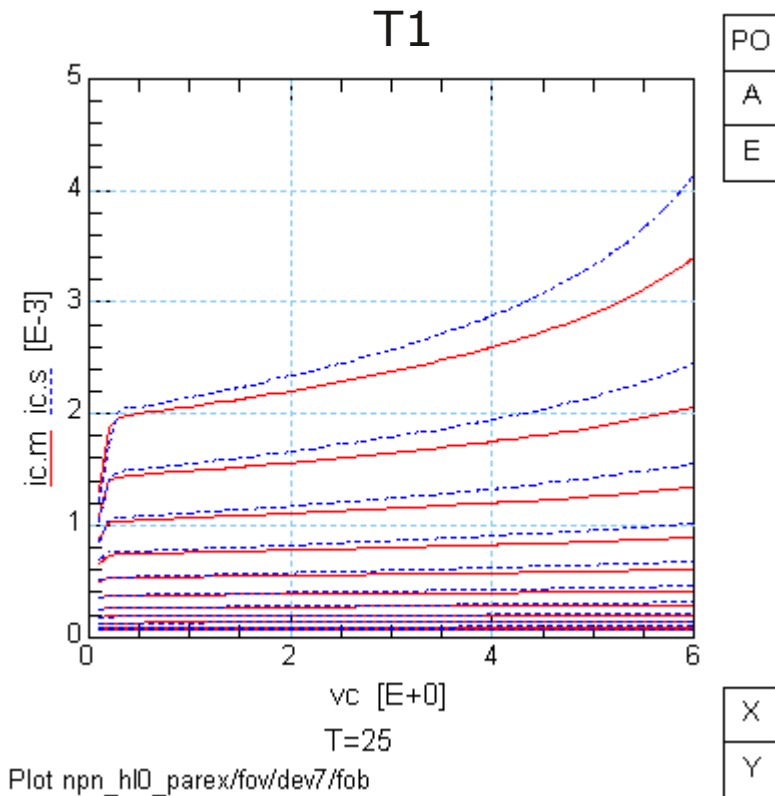
$$I_c = f(V_{be}), V_c = \text{Par}$$



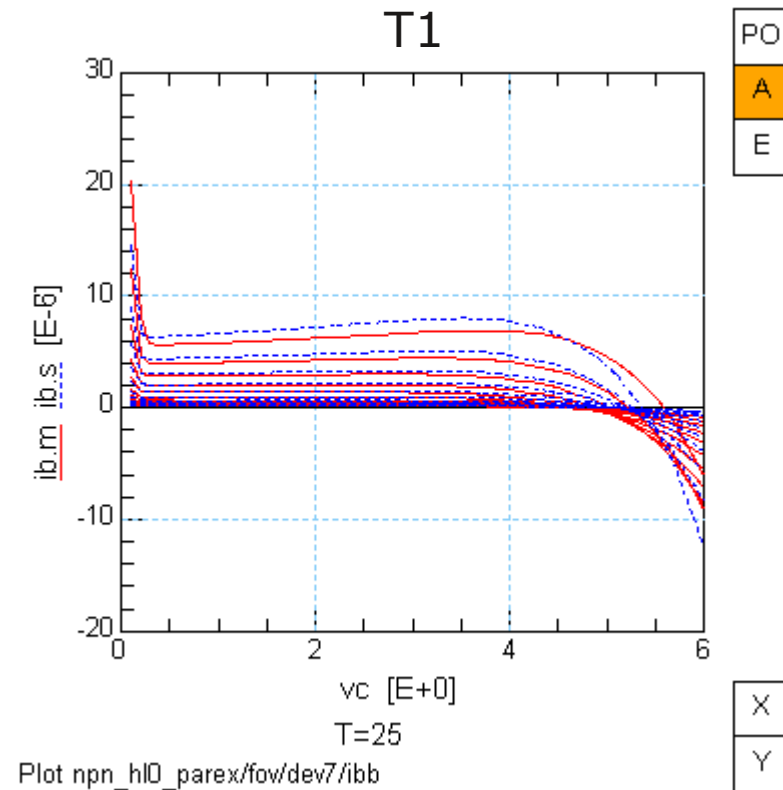
$$g_m = f(V_{be}), V_c = \text{Par}$$

Experience with Hicem L0 v1.2

Results: Technology 1



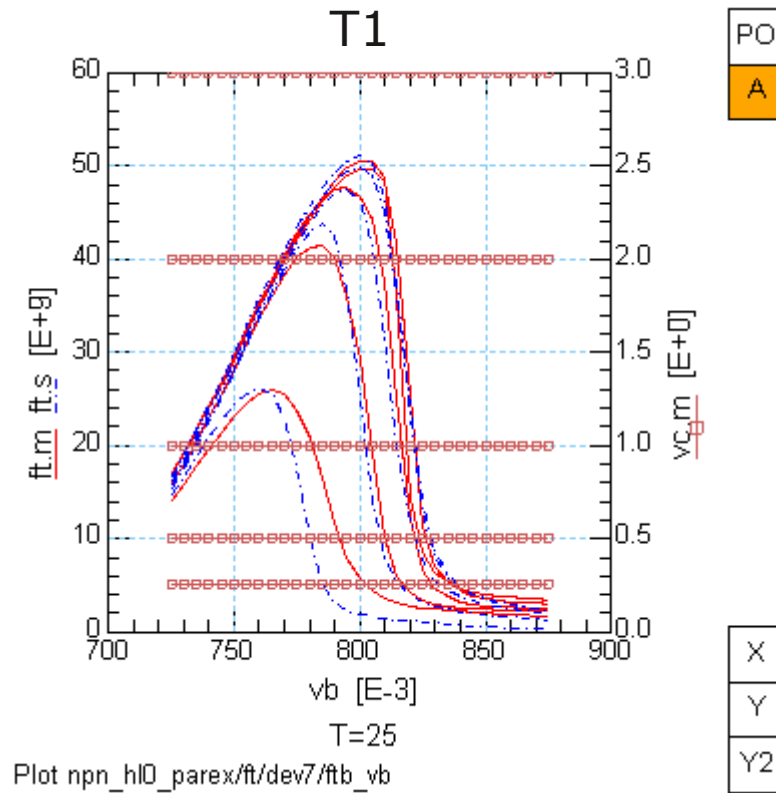
$$I_c = f(V_{ce}), V_b = \text{Par}$$



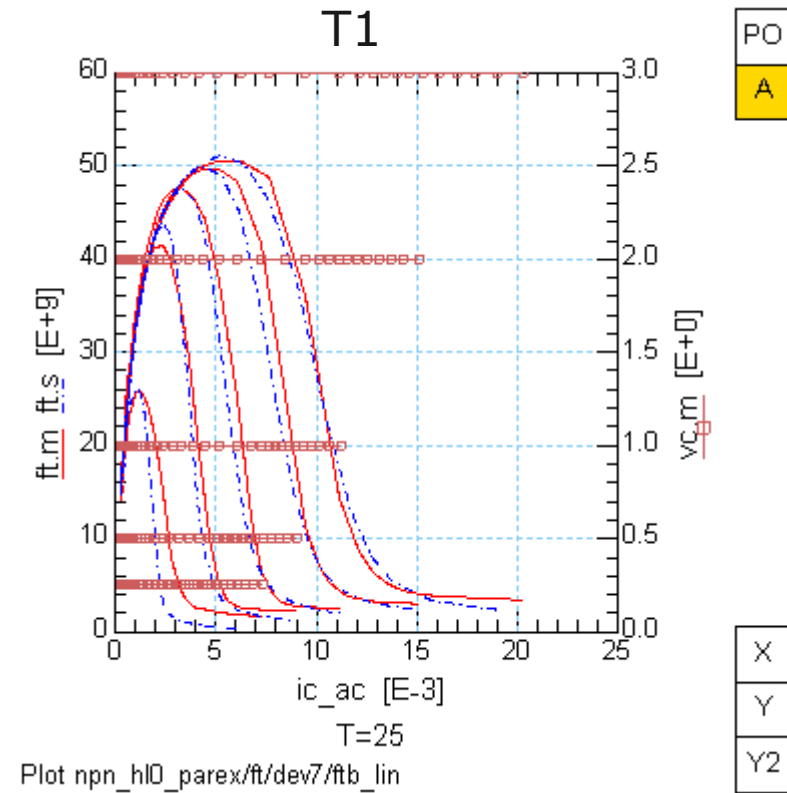
$$I_b = f(V_{ce}), V_b = \text{Par}$$

Experience with Hicem L0 v1.2

Results: Technology 1



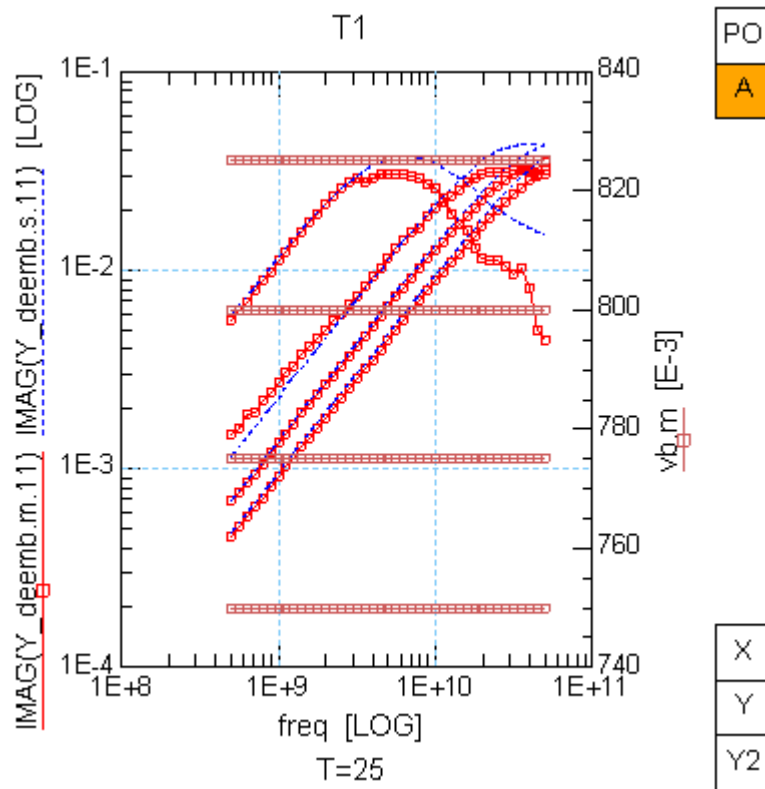
$$f_t = f(V_b), V_{ce} = \text{Par}$$



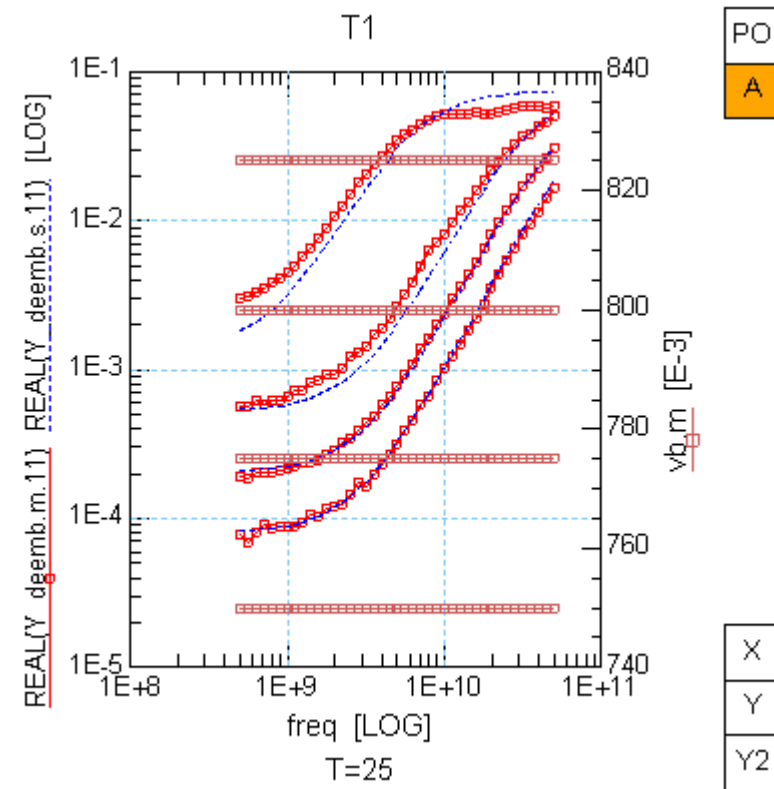
$$f_t = f(I_c), V_{ce} = \text{Par}$$

Experience with Hicem L0 v1.2

Results: Technology 1



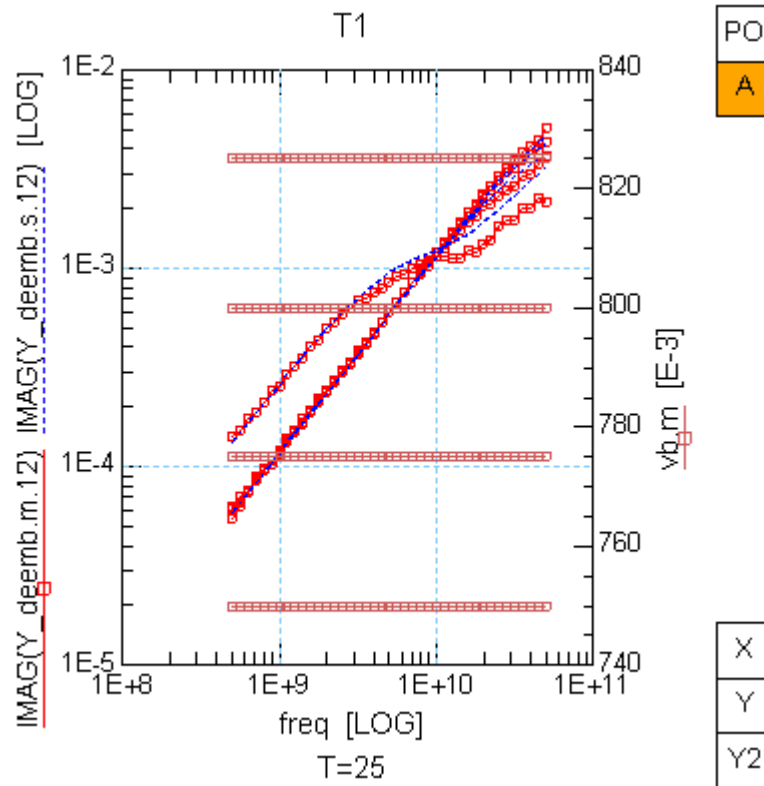
$Y_{11i}=f(f), V_b=Par$



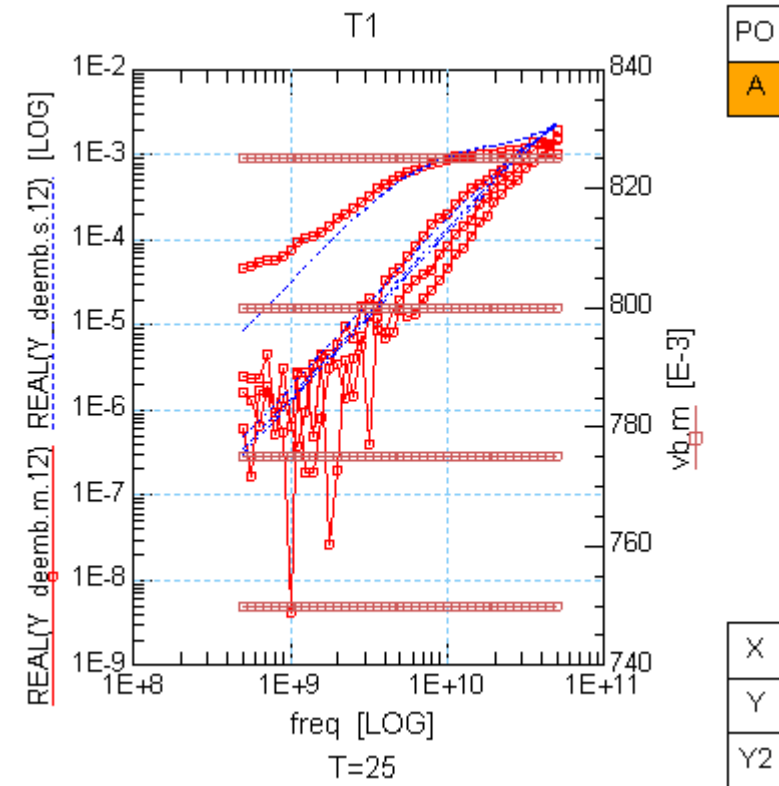
$Y_{11r}=f(f), V_b=Par$

Experience with Hicup L0 v1.2

Results: Technology 1



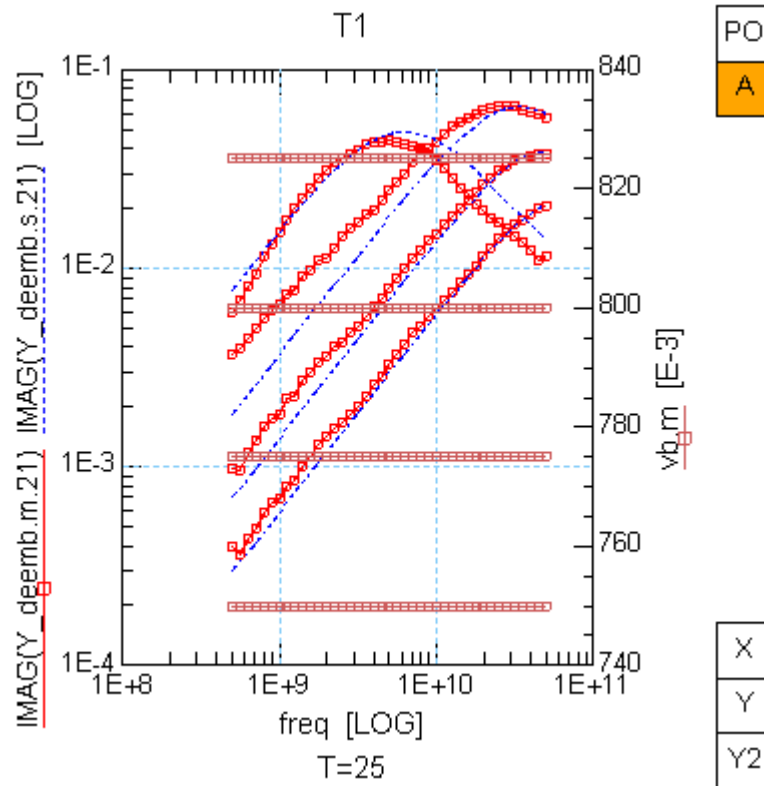
$Y_{12i}=f(f), V_b=Par$



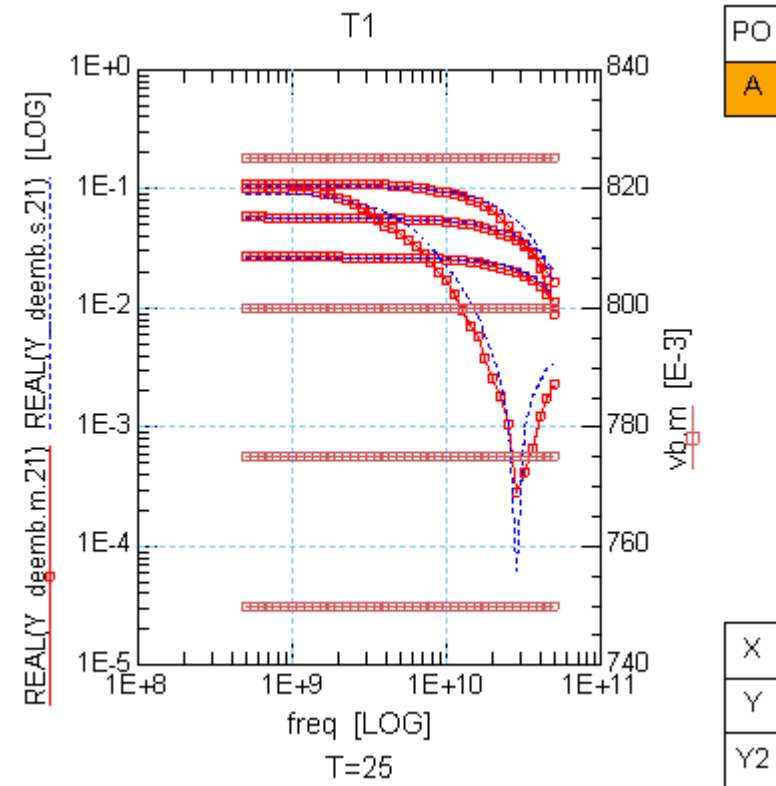
$Y_{12r}=f(f), V_b=Par$

Experience with Hicum L0 v1.2

Results: Technology 1



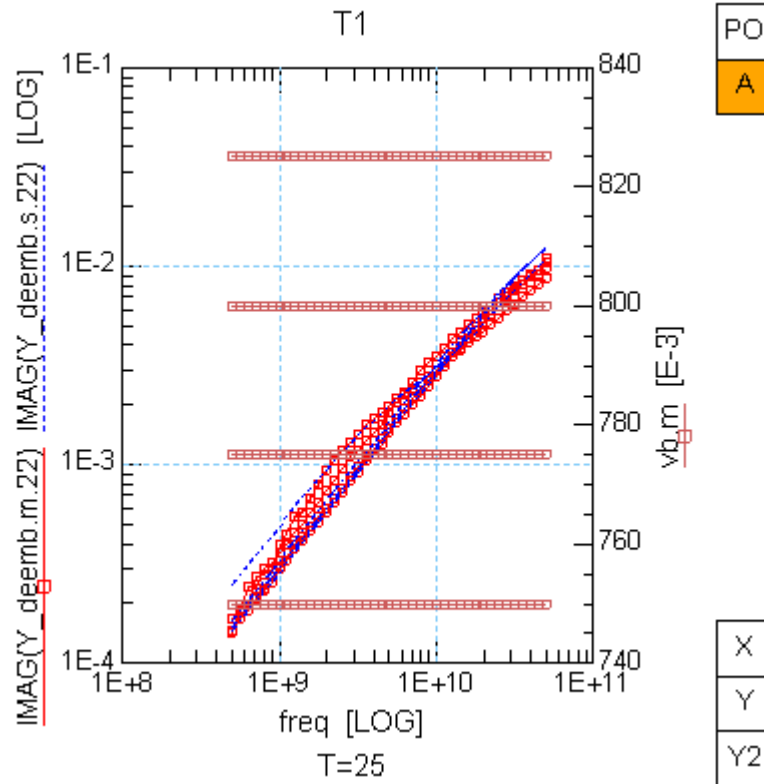
$Y_{21i}=f(f), V_b=Par$



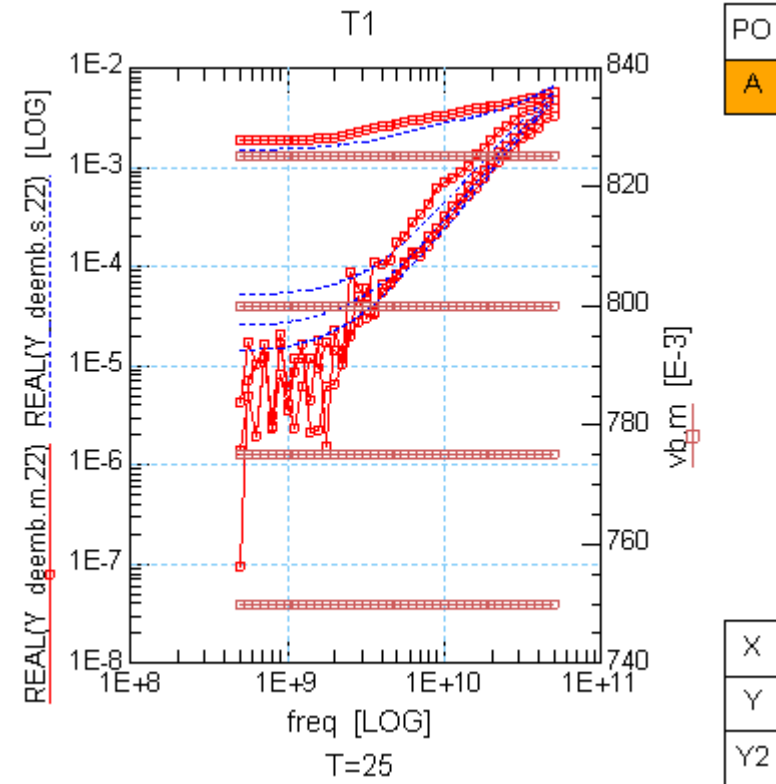
$Y_{21r}=f(f), V_b=Par$

Experience with Hicum L0 v1.2

Results: Technology 1



$Y_{22i} = f(f), V_b = \text{Par}$



$Y_{22r} = f(f), V_b = \text{Par}$

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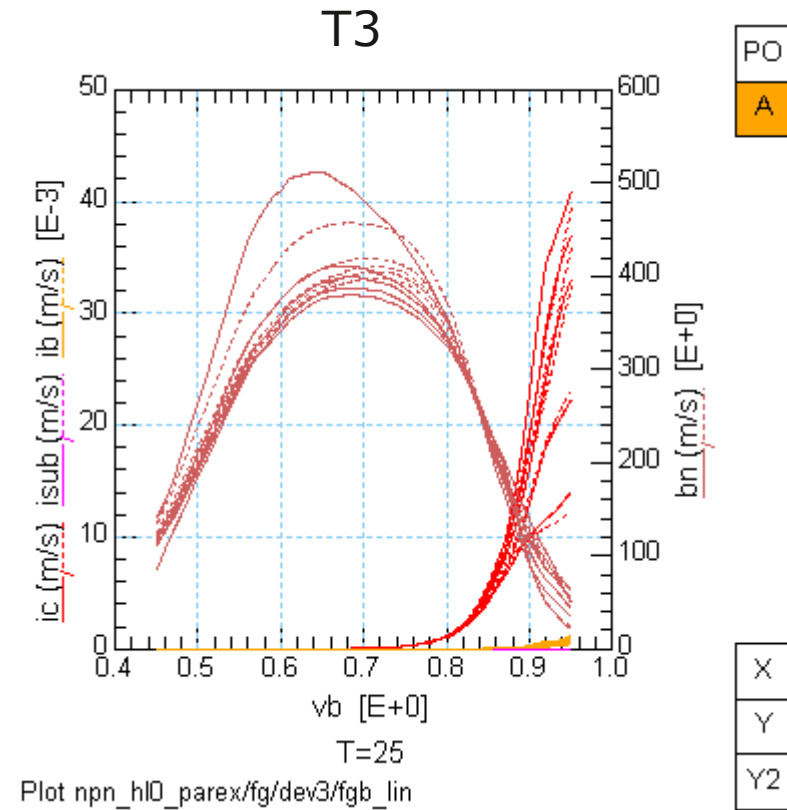
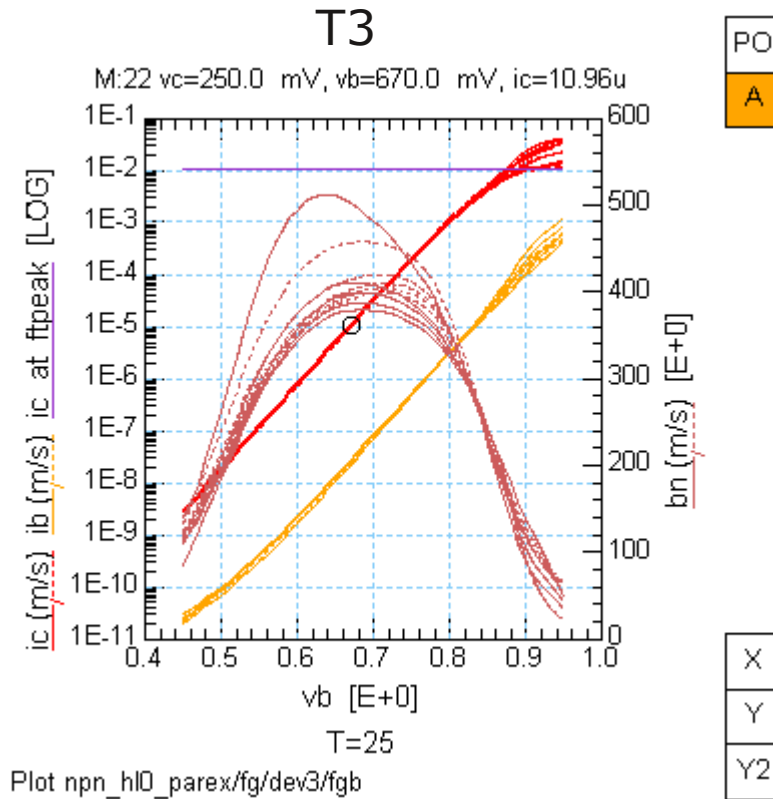
- **Results Technology 1**

- **Results Technology 2**

- **Summary**

Experience with Hicem L0 v1.2

Results: Technology 2



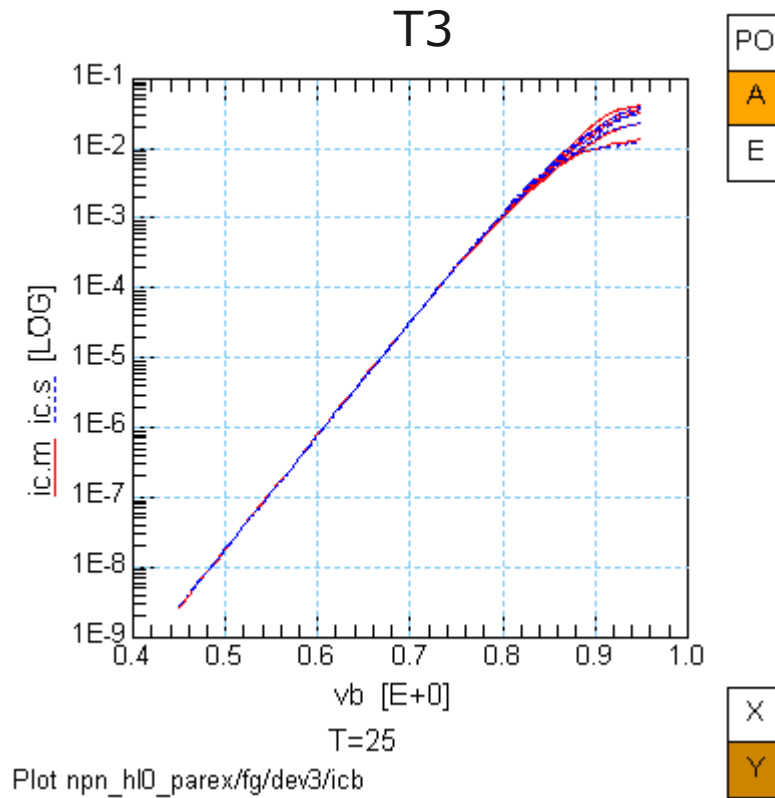
$I_c, I_b, B_n = f(V_{be}), V_c = \text{Par}$

$I_c, B_n = f(V_{be}), V_c = \text{Par}$

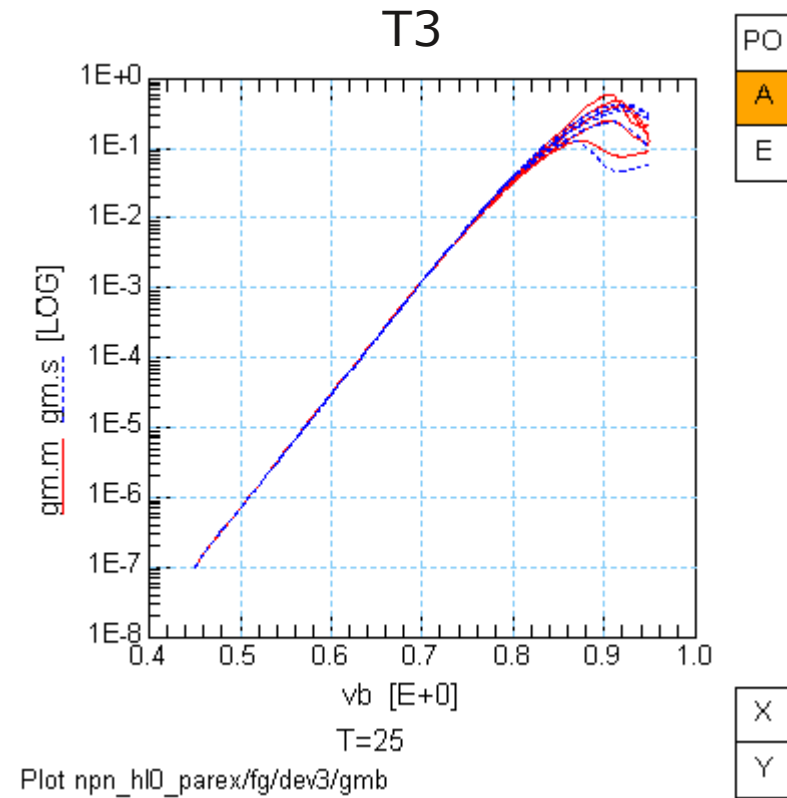
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Experience with Hicum L0 v1.2

Results: Technology 2



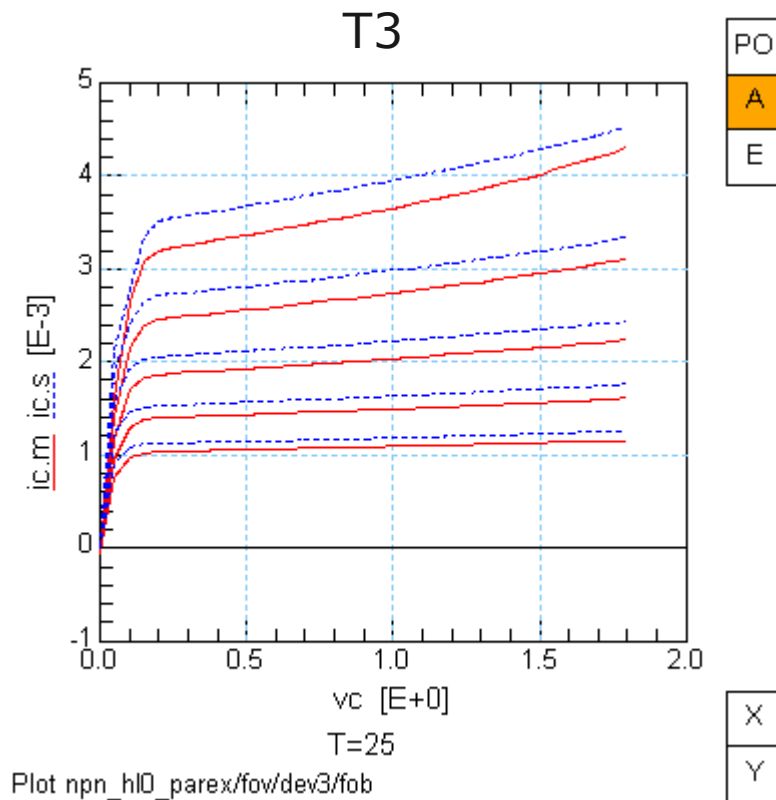
$$I_c = f(V_{be}), V_c = \text{Par}$$



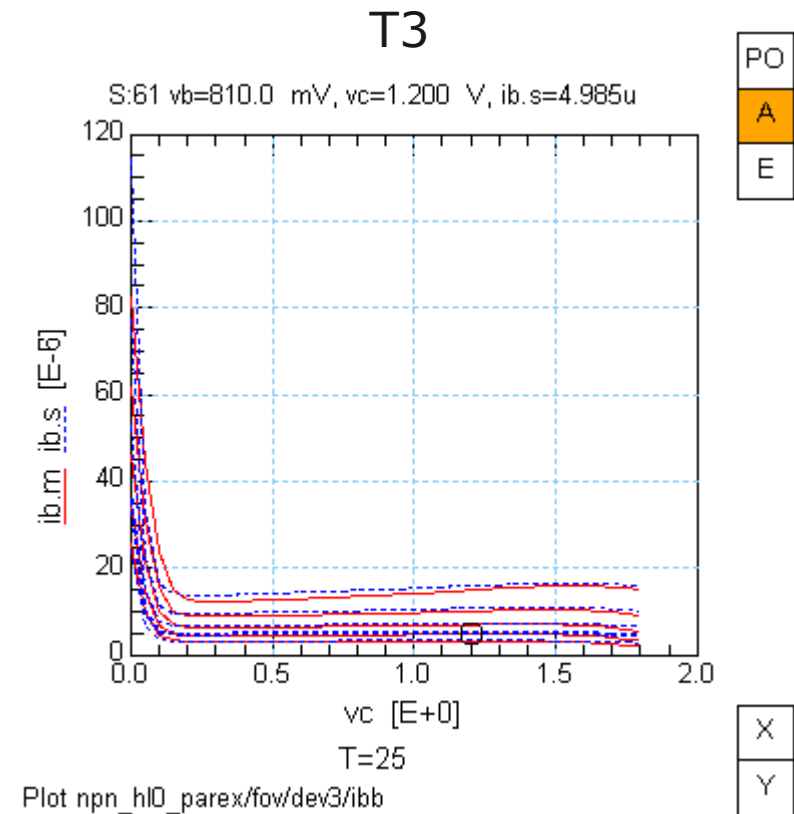
$$g_m = f(V_{be}), V_c = \text{Par}$$

Experience with Hicum L0 v1.2

Results: Technology 2



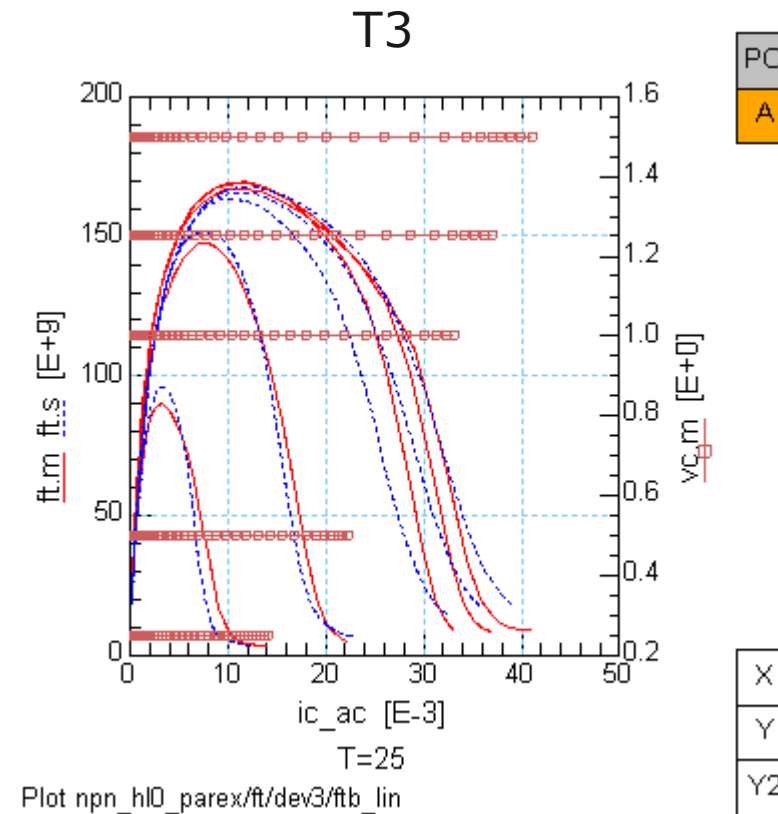
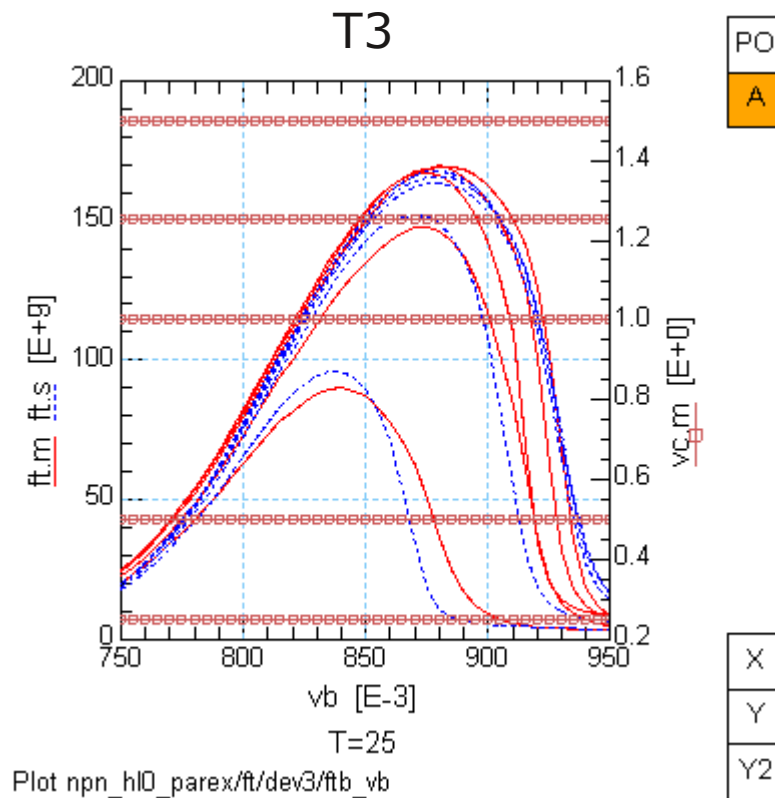
$$I_c = f(V_{ce}), V_b = \text{Par}$$



$$I_b = f(V_{ce}), V_b = \text{Par}$$

Experience with Hicem L0 v1.2

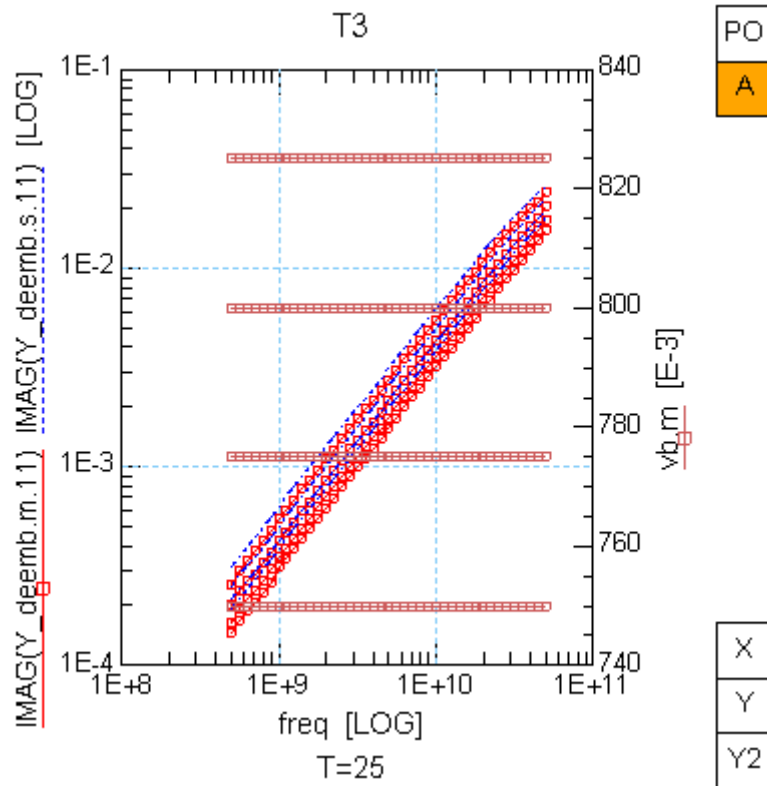
Results: Technology 2



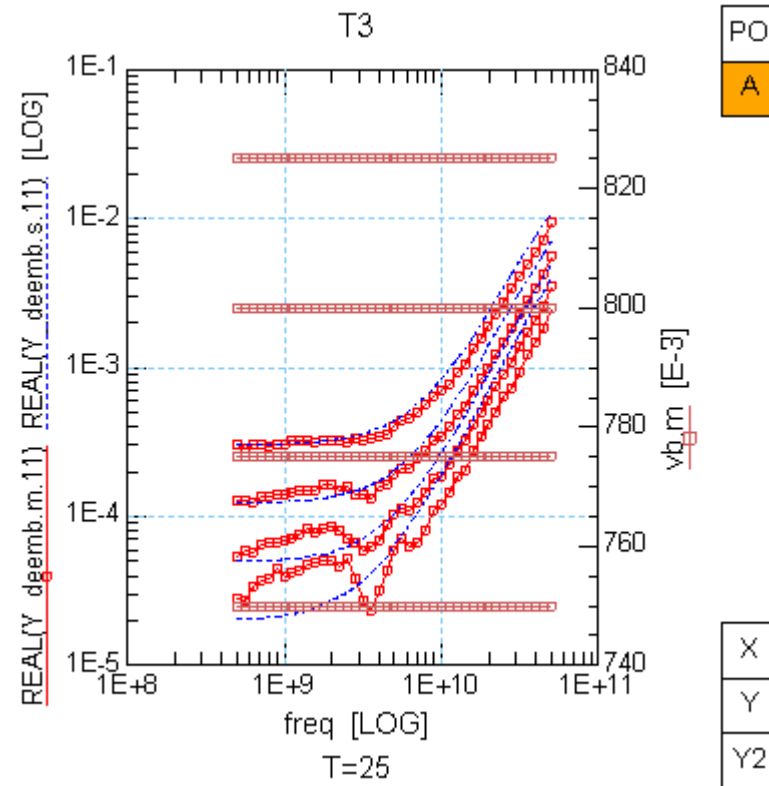
$ft = f(Vb), Vce = Par$

$ft = f(Ic), Vce = Par$

Experience with Hicum L0 v1.2 Results: Technology 2



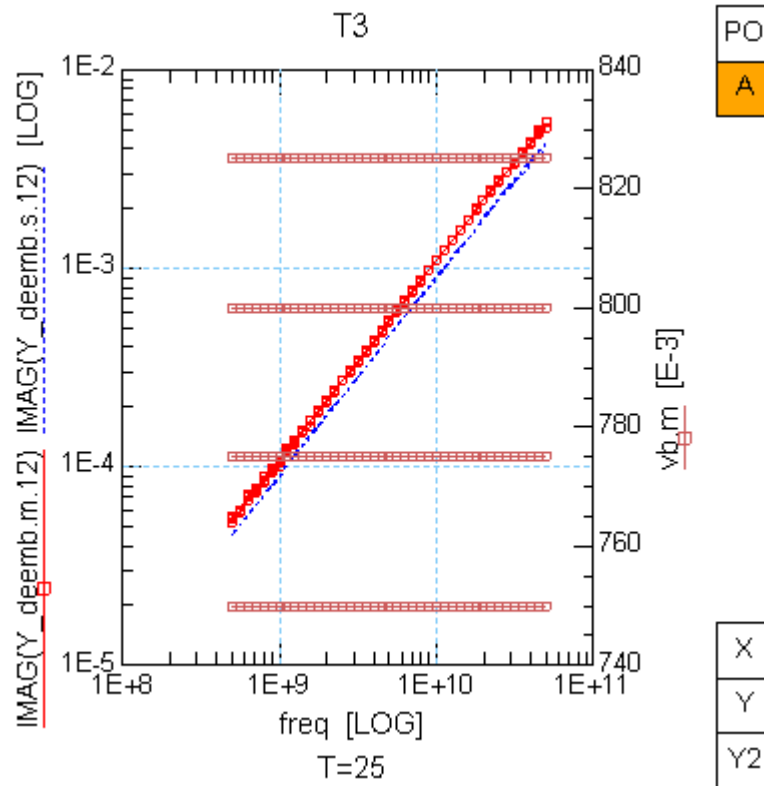
Y11i=f(f), Vb=Par



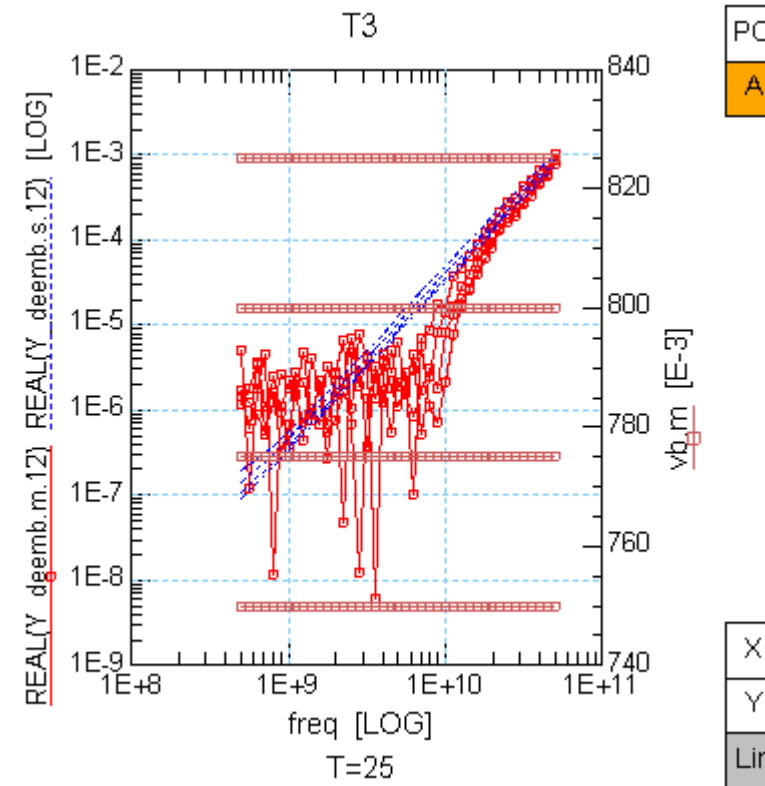
Y11r=f(f), Vb=Par

Experience with Hicem L0 v1.2

Results: Technology 2



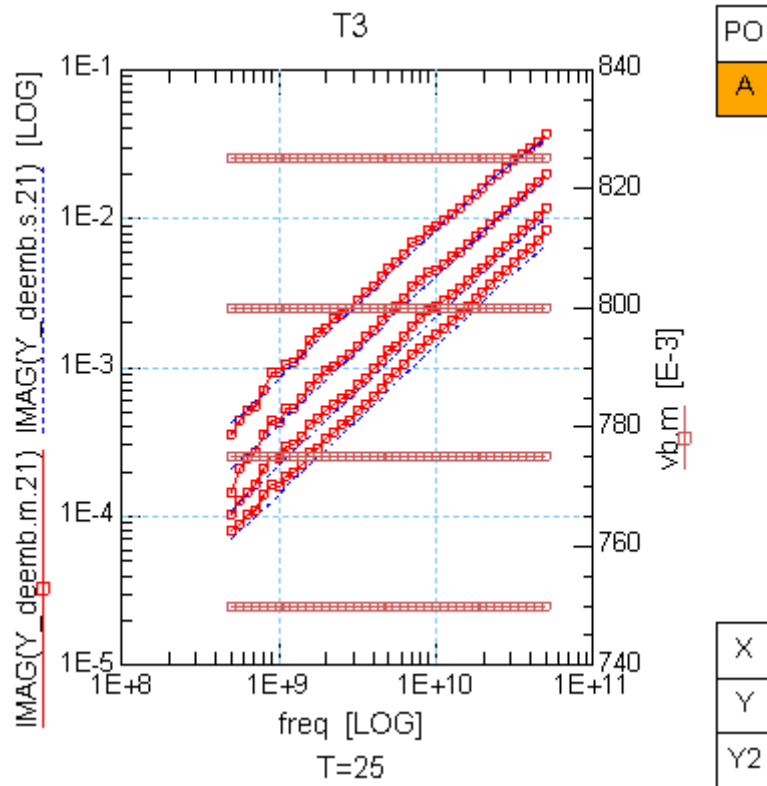
$Y_{12i}=f(f), V_b=Par$



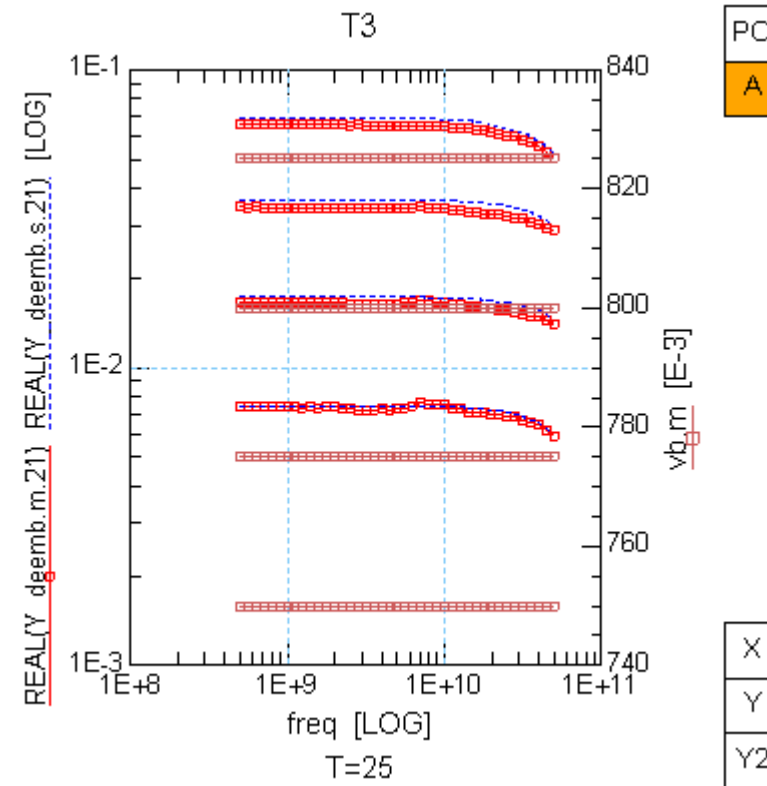
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Experience with Hicup L0 v1.2

Results: Technology 2



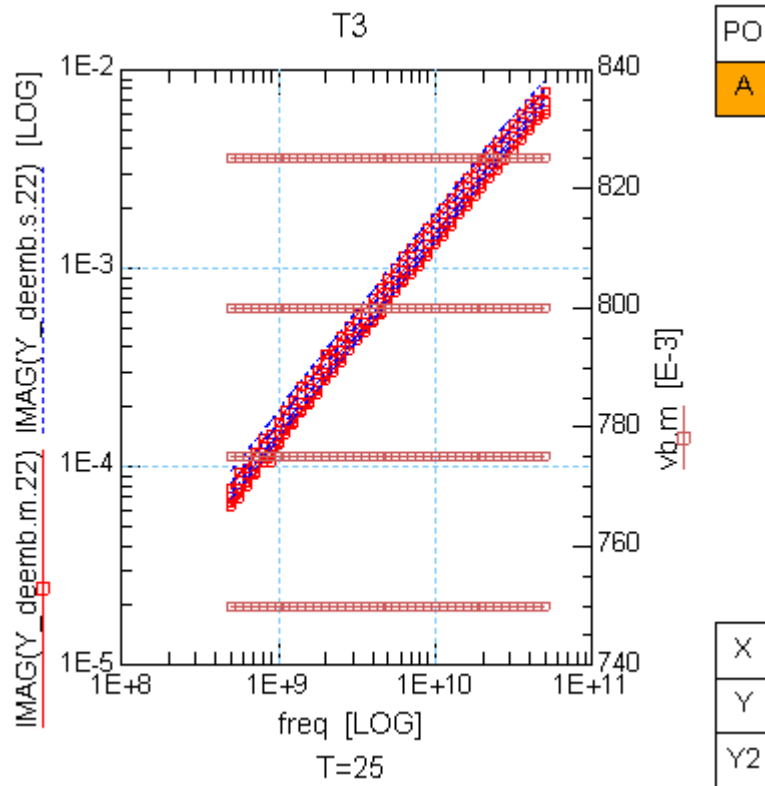
Y21i=f(f), Vb=Par



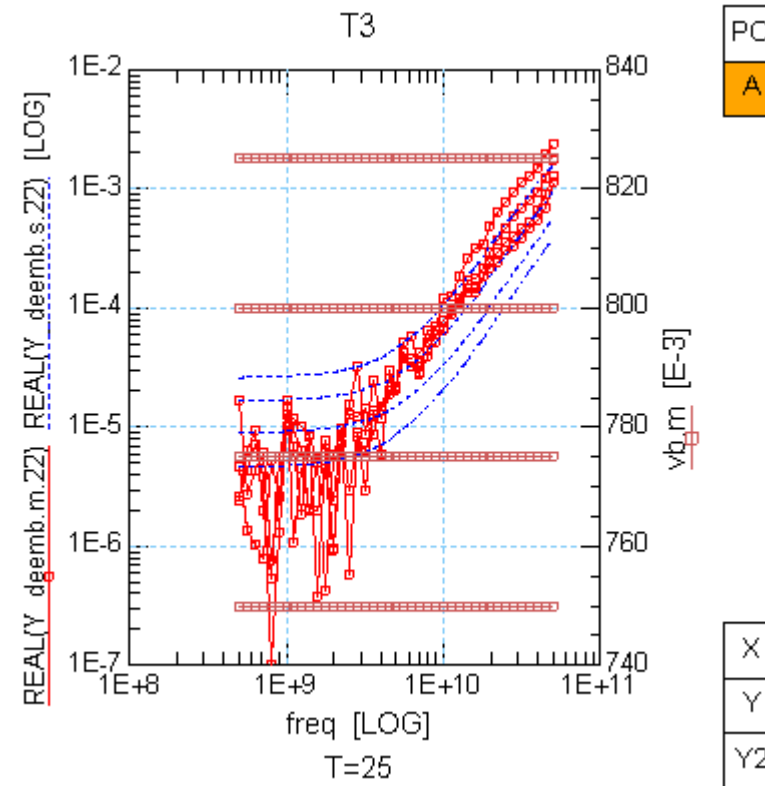
Y21r=f(f), Vb=Par

Experience with Hicum L0 v1.2

Results: Technology 2



$Y_{22i} = f(f), V_b = \text{Par}$



$Y_{22r} = f(f), V_b = \text{Par}$

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Experience with Hicum L0 v1.2 Summary



- Hicum L0 v1.2 delivers good results for modeling two Infineon technologies, especially with respect to
 1. I_c in high current range
 2. quasi-saturation in fwd output characteristic
 3. ft characteristics , especially fT roll off
 4. Y-parameters

- Minor problems observed with $TFH=0$, $AHC=0$ which may be solved with low effort

- Infineon request according to the agreement reached between ST, IFX and TUD on Hicum workshop 2008 (see email June 2, 2008) to deliver the improved Hicum model v1.2 to vendors Cadence, MENTOR and Agilent for implementation