

Problems during the extraction of the HICUM/L0 model parameters IQFH and TFH

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Never stop thinking

Outline

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- Parameter Extraction of IQFH and TFH
- Extraction Results
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Transfer Current Definition in HICUM/L0

In HICUM/L0 the modeling of the dc and ac behavior is almost decoupled. To describe the dc high current behavior new model equations and the model parameters IQFH and TFH were introduced in HICUM/L0.

From the low transfer current in HICUM/L0, including the modeling of the knee current and the early effect,

$$i_{tfl} = \frac{i_{tfl}}{q_{pT}} \quad \begin{array}{l} i_{tfl} = \text{ideal forward transfer current} \\ q_{pT} = \text{normalized charge} \end{array}$$

the forward transfer current including the modeling of the high current behavior is calculated using the new high current correction charge Δq_{fh}

$$i_{tf} = \frac{i_{tfl}}{1 + \frac{\Delta q_{fh}}{q_{pt}}} = \frac{i_{tfl}}{q_{pt} + \Delta q_{fh}}$$

Transfer Current Definition in HICUM/L0

The high current correction charge Δq_{fh} is defined as

$$\Delta q_{fh} = \left[w(i_{Tfl})^2 + TFH \frac{i_{Tfl}}{I_{CK}} \right] \frac{i_{Tfl}}{IQFH}$$

I_{CK} = critical current
 w = injection width

with the new model parameters

IQFH=high-injection correction current

THF=high-injection correction factor

Note, that for the right physical meaning the following relations should be obtained

$$IQFH < IQF \quad TFH > T0$$

$T0$ = transit time

IQF = knee current

➔ Through the critical current I_{CK} and the injection width w the charge Δq_{fh} is influenced of the high current ac behavior

Parameter Extraction of IQFH and TFH

Extraction flow


IQFH and TFH should be extracted at one of the last steps of the extraction flow, because the high current dc behavior is influenced of

- the transfer current parameters
- the ac high current behavior

Extraction technique

The effect of the high current correction charge becomes clear in

- the high collector current behavior
- the output characteristics for high current densities (quasi saturation)

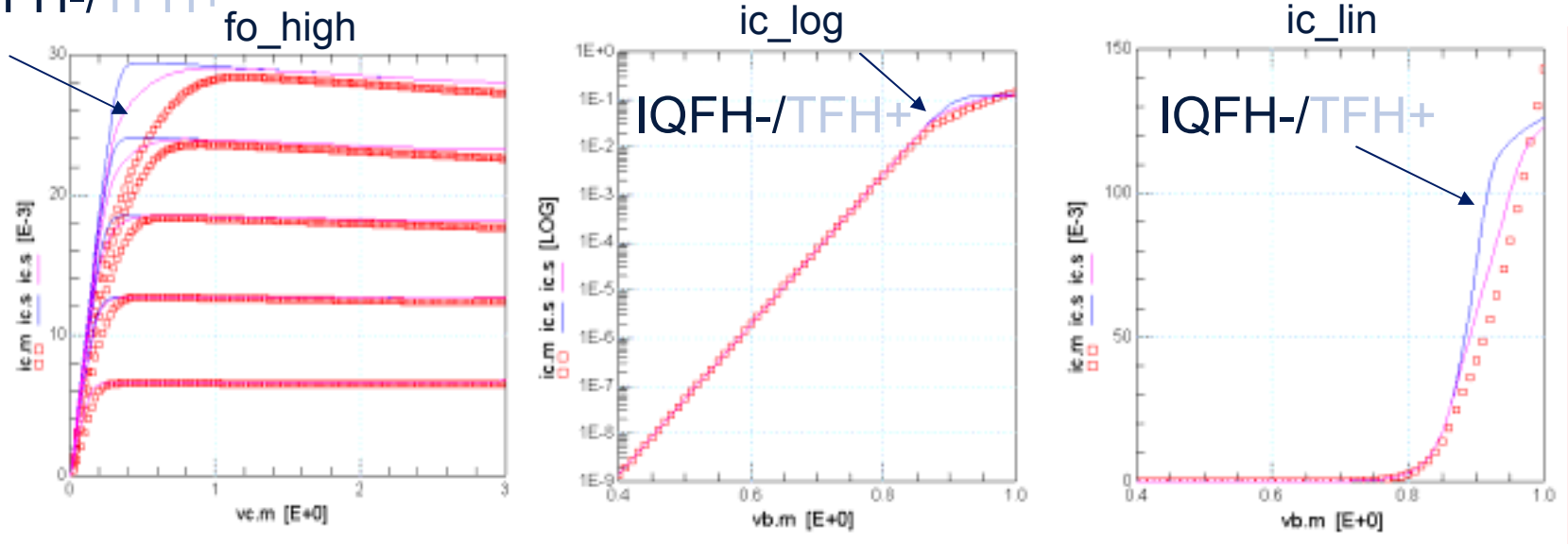


IQFH and TFH can be extracted by fitting the high collector current and the output characteristics after extraction of all other ac and dc model parameters

Parameter Extraction of IQFH and TFH

General influence of TFH and IQFH on the collector current and the output characteristic

IQFH-/TFH+



The influence of TFH is small comparing to IQFH and decreases when IQFH becomes smaller.



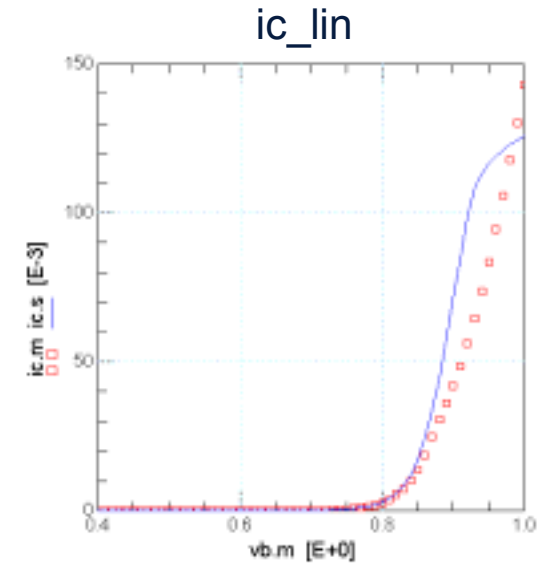
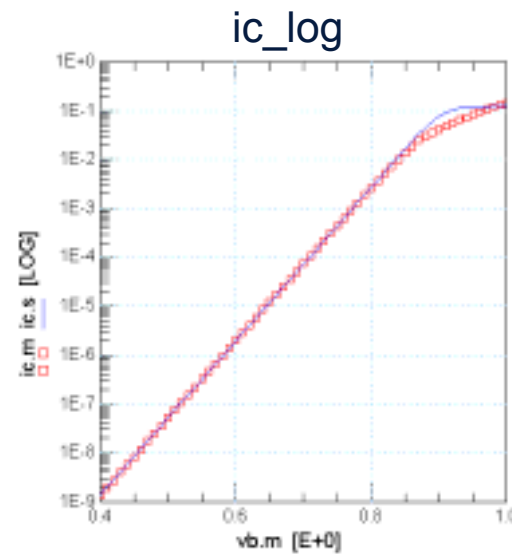
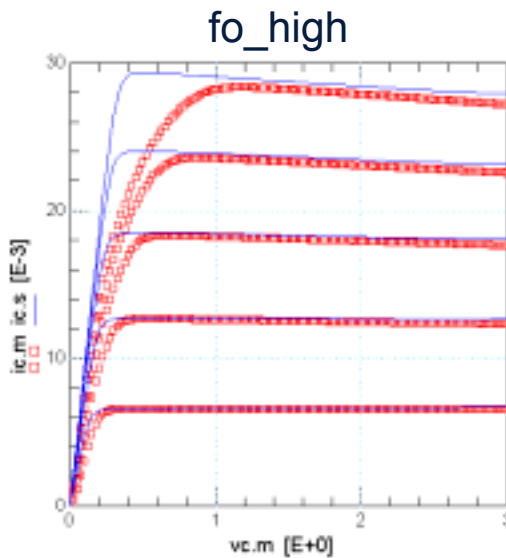
Problem: Almost only IQFH can be used for fitting

Extraction Results

No influence of IQFH and TFH

When $IQFH \rightarrow \infty$ and $TFH \rightarrow 0$ only the low current part of the transfer current is active

$IQF=460.8m$ $T0=1.985p$



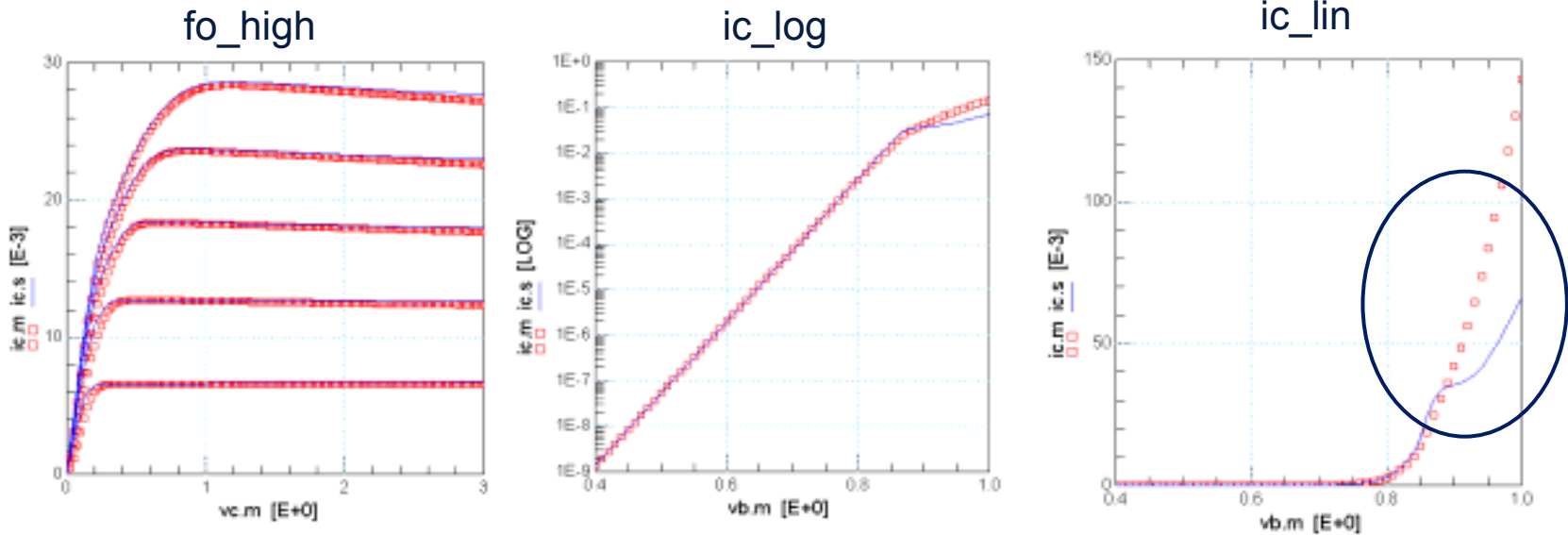
Without using the high current correction parameters a sufficient fitting of the high collector current and the quasi saturation is not possible

Extraction Results

Best fit for the output characteristic (fo high)

IQFH was decreased to get the best fit for the output characteristic

IQFH=28.30 m TFH=3.0 p



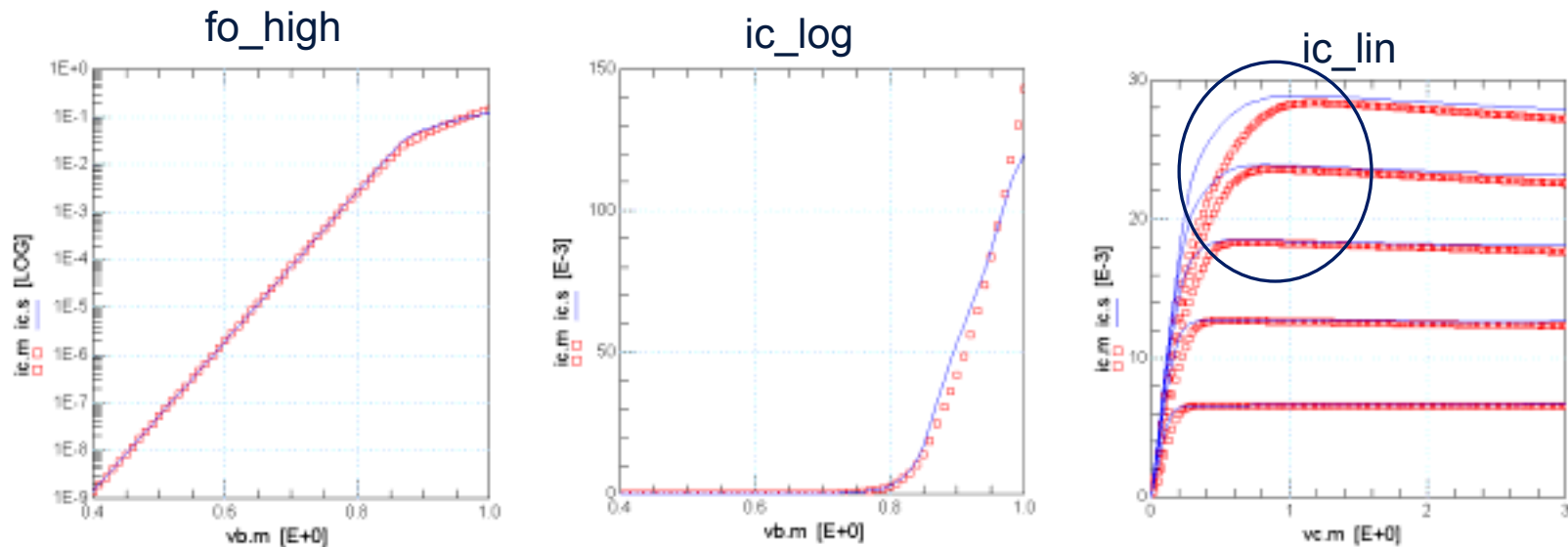
Problem: For the best fit of the output characteristics the collector current gets a bend.

Extraction Results

Best possible fit for the high collector current behavior

To avoid the bend in the collector current IQFH had to be increased

IQFH=73.75 m TFH=3.0 p



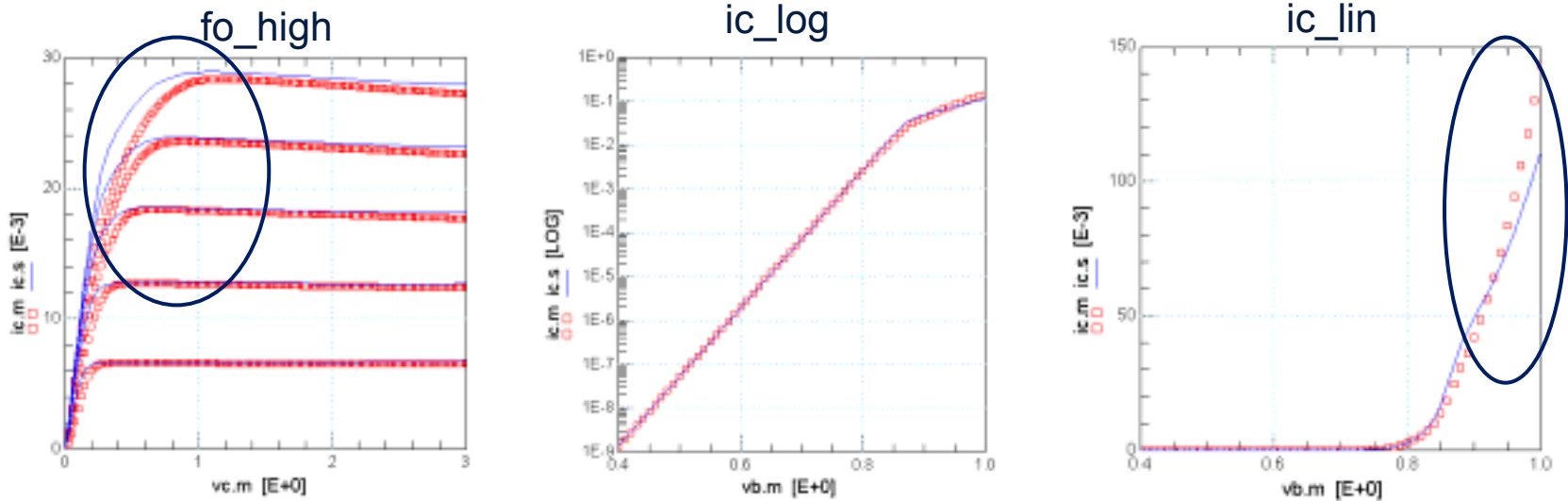
For the best possible fit of the high collector current behavior, the fitting for the quasi saturation is not sufficient.

Extraction Results

Compromise

For the final parameter set a compromise had to be found

IQFH=56.64 m TFH=3.0 p



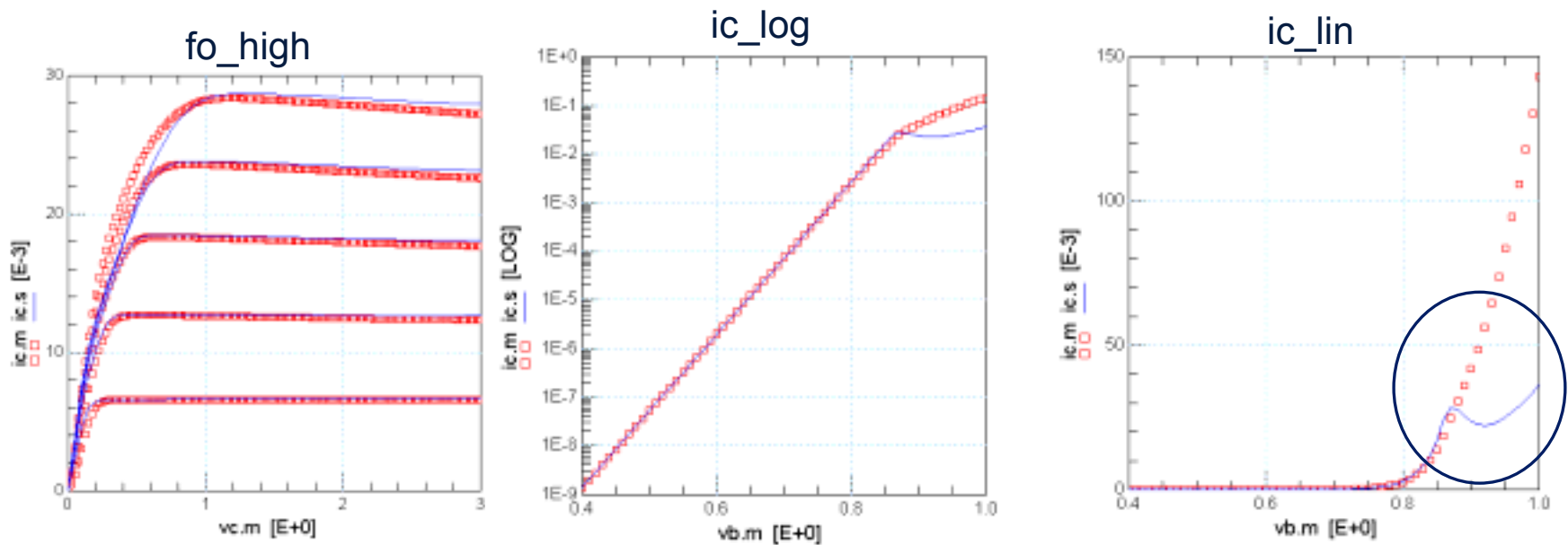
The compromise is not sufficient for modeling the quasisaturation nor the high current behavior. But it is important, that the collector current does not have a bend or a negative slope.

Extraction results

Worste case for the collector current

By decreasing IQFH additionally the collector current gets a negative slope

IQFH=14.96 m TFH=3.0 p



The negative slope is not physical and has to be avoided. Probably, the model equations has to be modified.

Summary

- For decoupling the ac and dc behavior the new model parameters IQFH and TFH were introduced in HICUM/L0
- IQFH and TFH can be extracted by fitting the high collector current and the output characteristics after extraction of all other ac and dc model parameters
- The influence of TFH is very small, that is why only IQFH can be used to fit the characteristics
- Fitting the output characteristics by decreasing IQFH effects a bend at high collector currents
- In the worst case the collector current gets a negative slope. This has to be avoided. Probably, the model equation has to be modified