



Avalanche Multiplication Model in HICUM Measurement vs. Simulation at 75GHz SiGe-Transistors

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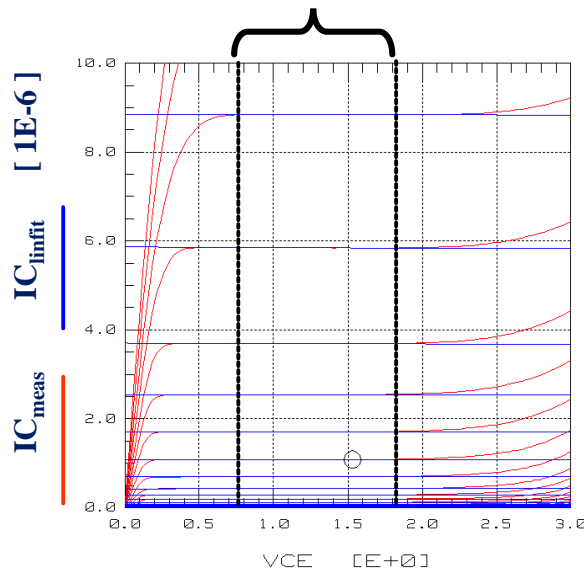
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Motivation

- HICUM's avalanche multiplication model does not account for current dependency of multiplication factor (M-1)

$$IC_{calc} = IC_{linfit} + \Delta IC = IC_{linfit} \cdot \left(1 + \frac{1}{IB} \right) \cdot (M - 1) \cdot IC_{meas} ; \quad IB = const.$$



$$(M - 1) = f_{avl} \cdot V_{bc,eff} \cdot \exp\left(\frac{-q_{avl}}{C_{jci} \cdot V_{bc,eff}} \right)$$

with :

$$V_{bc,eff} = v_{jci} \cdot \left(\frac{C_{jbc}(V_{b'c'})}{C_{jci}} \right)^{\frac{1}{m_{jci}}}$$

- For correct description of (M-1) around fT_{max} a current dependent description of (M-1) is needed !

Extraction of Multiplication Factor (M-1). Measured vs. Calculated (M-1) for Different Collector Currents.

Extraction of the avalanche multiplication term M-1(IC) and it's collector current dependency.

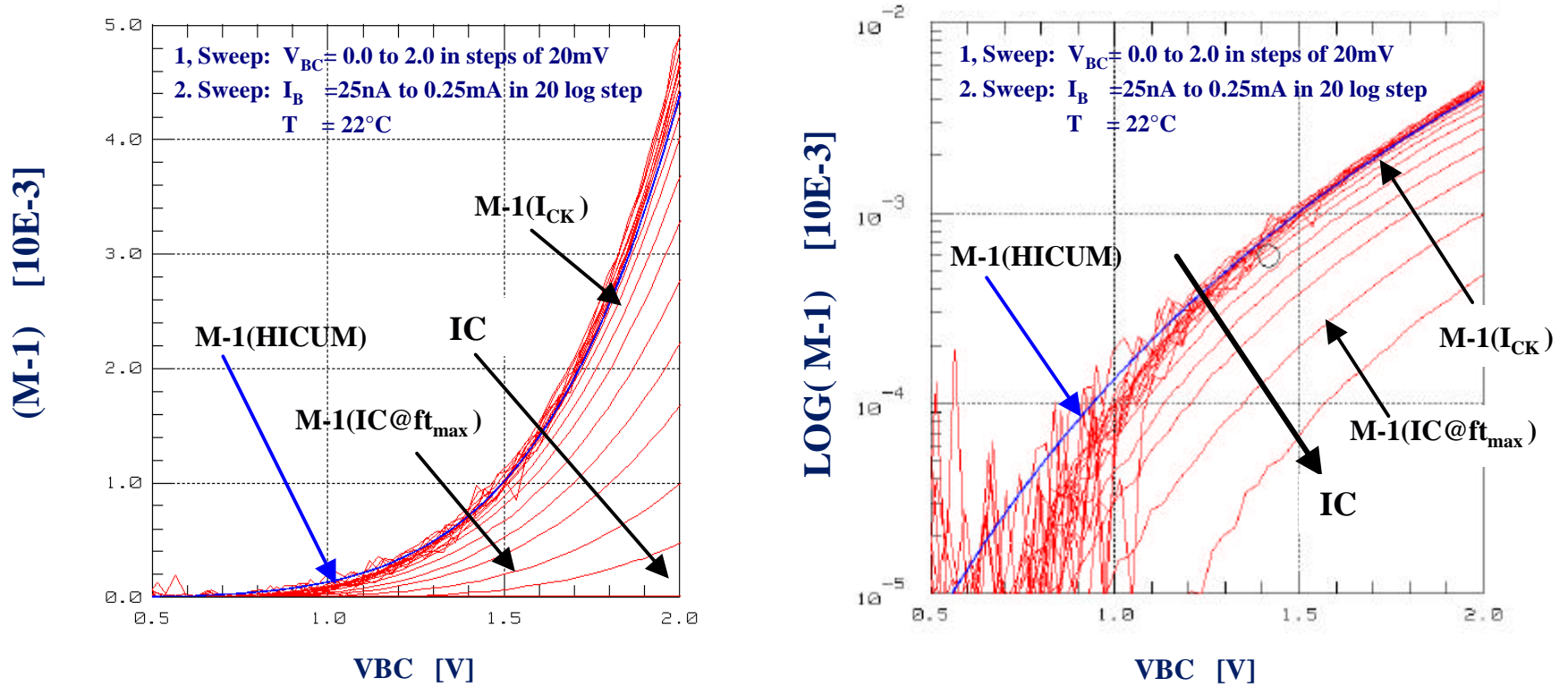


Fig. 1: Extraction of the multiplication factor (M-1) from measured output characteristics. The **red** curves represents M-1, extracted from measured output characteristics from a 75GHz transistor (B7HFC, N1042C2). The **blue** curves is M-1 calculated from the avalanche multiplication equations used in HICUM V2.1. On the **left side** linear representation of M-1 is presented and on the **right side** logarithmic representation of M-1 vs. VBC-bias is presented for different $I_B = \text{const}$ injection levels. Here clearly can be seen that measured (M-1) decreases with increasing collector current I_C when collector current I_C exceeds a critical collector currents $I_{CK}(V_{BE}, V_{CE})$. HICUM's avalanche multiplication model is only valid for low collector current $I_C \leq I_{CK}$. Reason: HICUM V2.1 does not consider the current dependency of M-1 when I_C becomes greater than I_{CK} .

Calculation of Forward Output Characteristics using HICUM's Avalanche Multiplication Model.

Calculation of $I_C(V_{CE})$ using the Avalanche Multiplication Model from HICUM

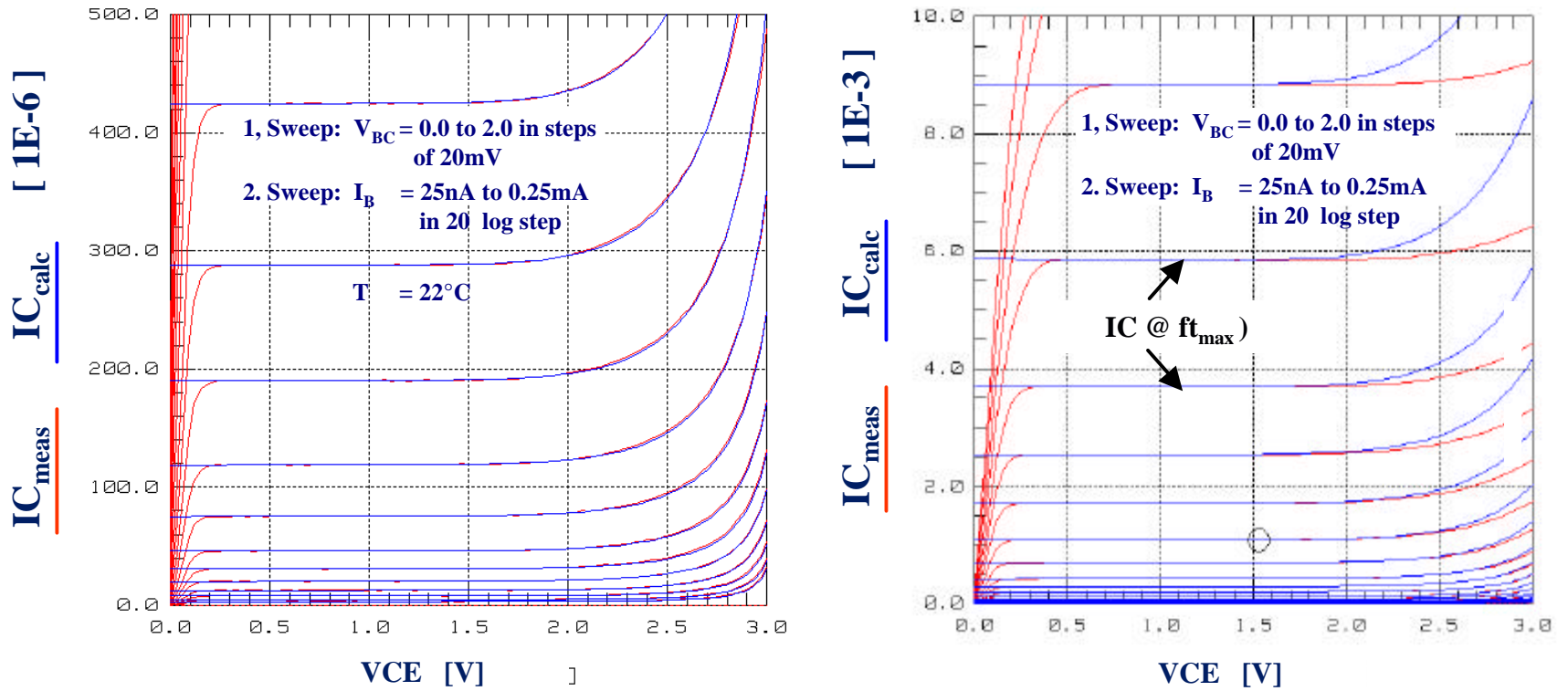


Fig. 2: Measured vs. calculated output characteristics $I_C(V_{CE}, I_B)$. **Red** curves: Measured output characteristics $I_C(V_{CE}, I_B)$ from a 75GHz transistor (B7HFC, N1042C2). The **blue** curves are calculated $I_{C_{calc}}$ -current progression using linear line extrapolation to $V_{CE} > 1.5V$ and using the avalanche multiplication equations used in HICUM V2.1. On the left side output characteristics $I_C(V_{CE}, I_B)$ at low current densities are plotted and on the right side the output characteristics $I_C(V_{CE}, I_B)$ for high current densities are presented. Here it can be seen clearly that with increasing collector current I_C the avalanche multiplication decreases. HICUM's avalanche multiplication model is only valid for low/medium collector current $I_C \leq I_{CK}$ because it does not consider the current dependency of avalanche multiplication when I_C becomes greater than I_{CK} .