Gummel-Poon Visual Parameter Fitting

-Quick Overview-

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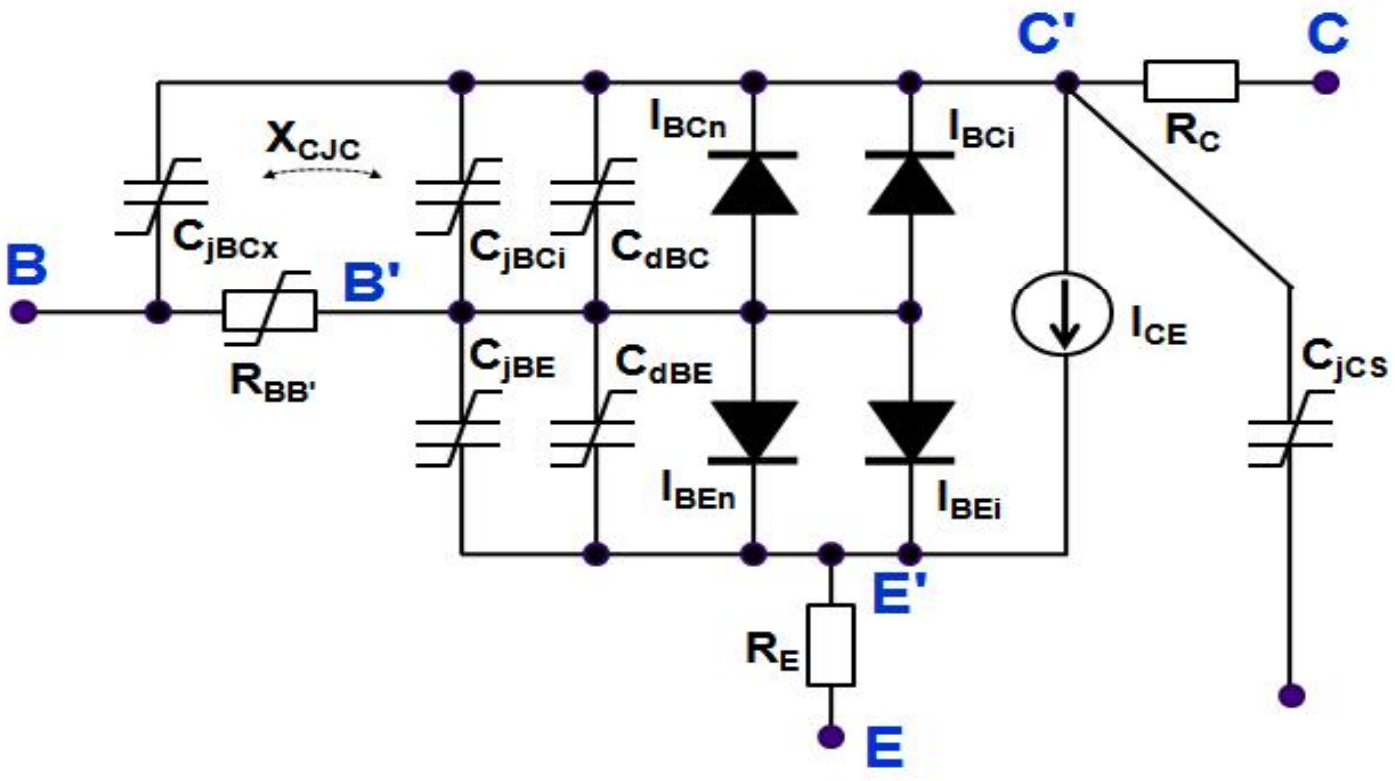
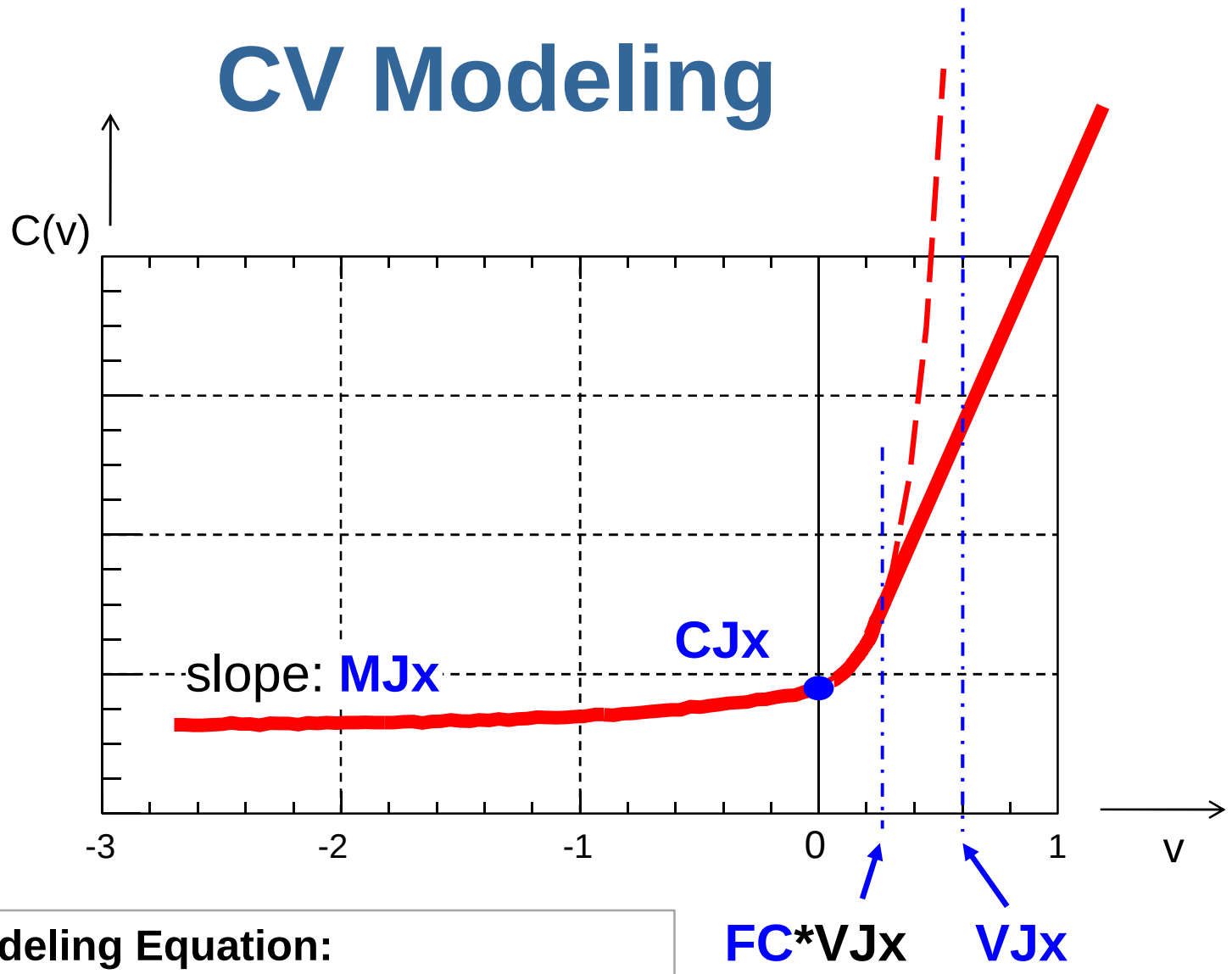
Gummel-Poon Model Schematic



CV Modeling



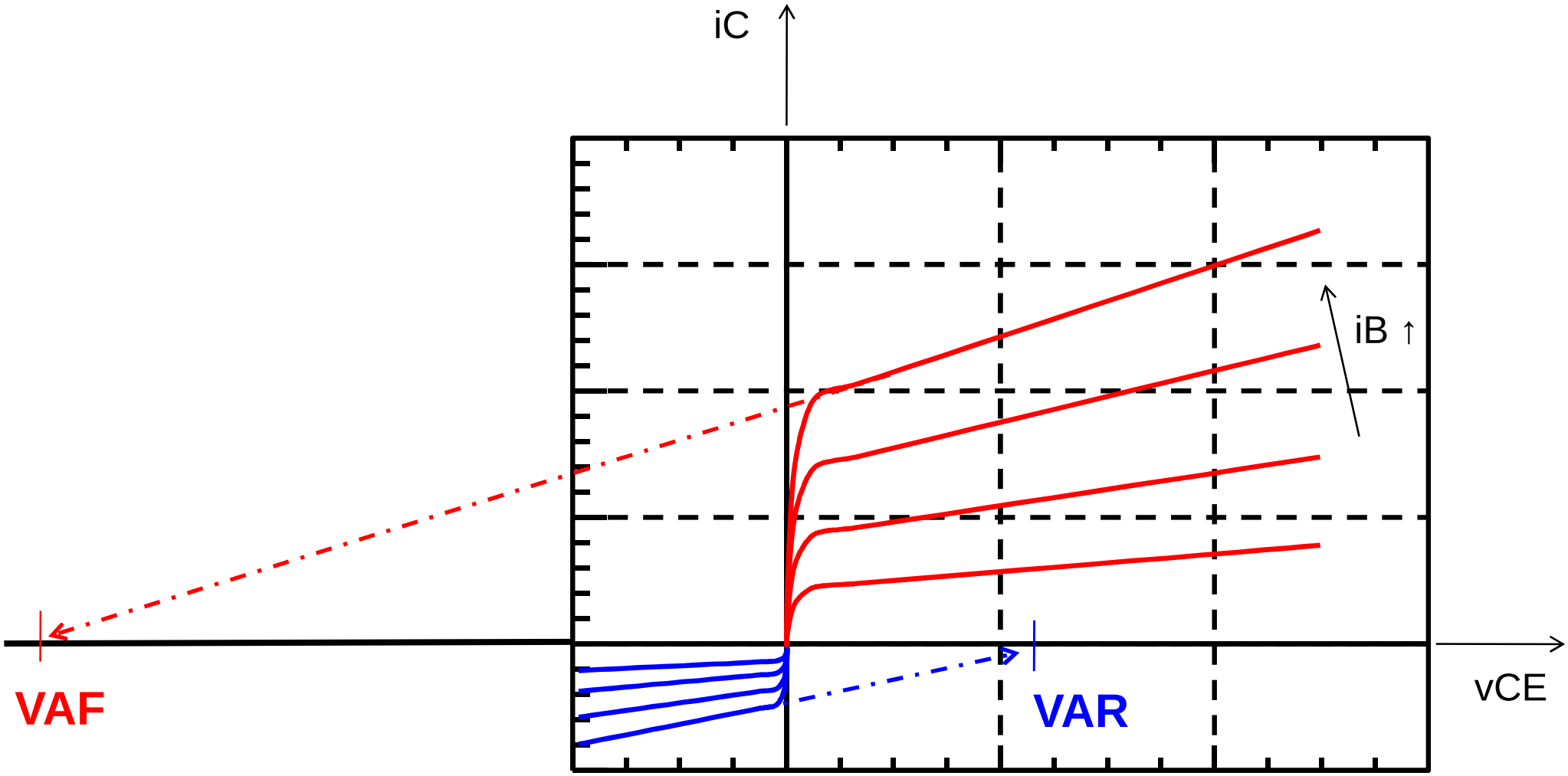
CV Modeling Equation:

$$C(v) = \frac{CJx}{\left(1 - \frac{v}{VJx}\right)^{MJx}}$$

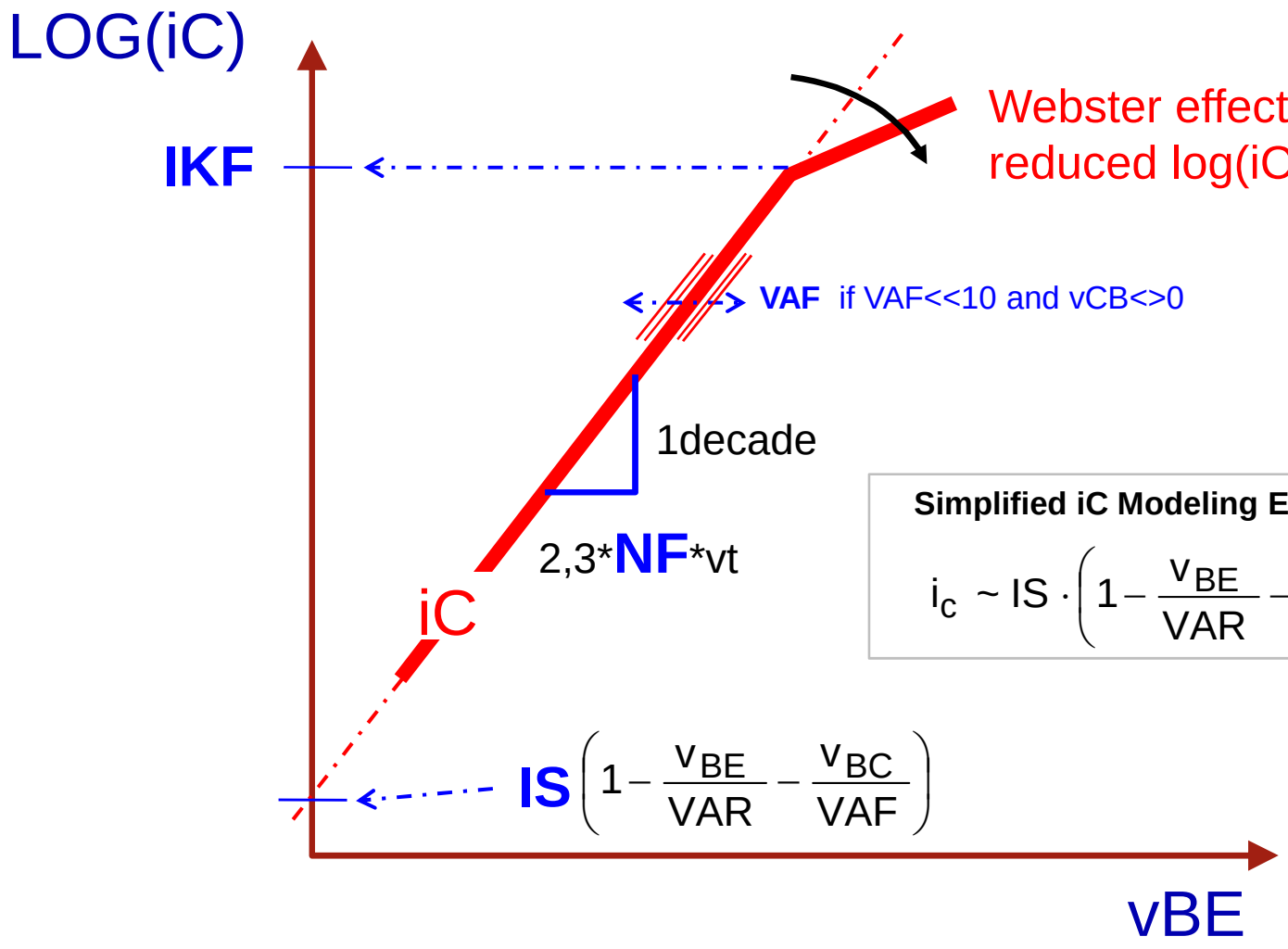
with
x=E for CBE
x=C for CBC
x=X for CCS

Non-Linear DC Modeling

DC Early Effect Modeling



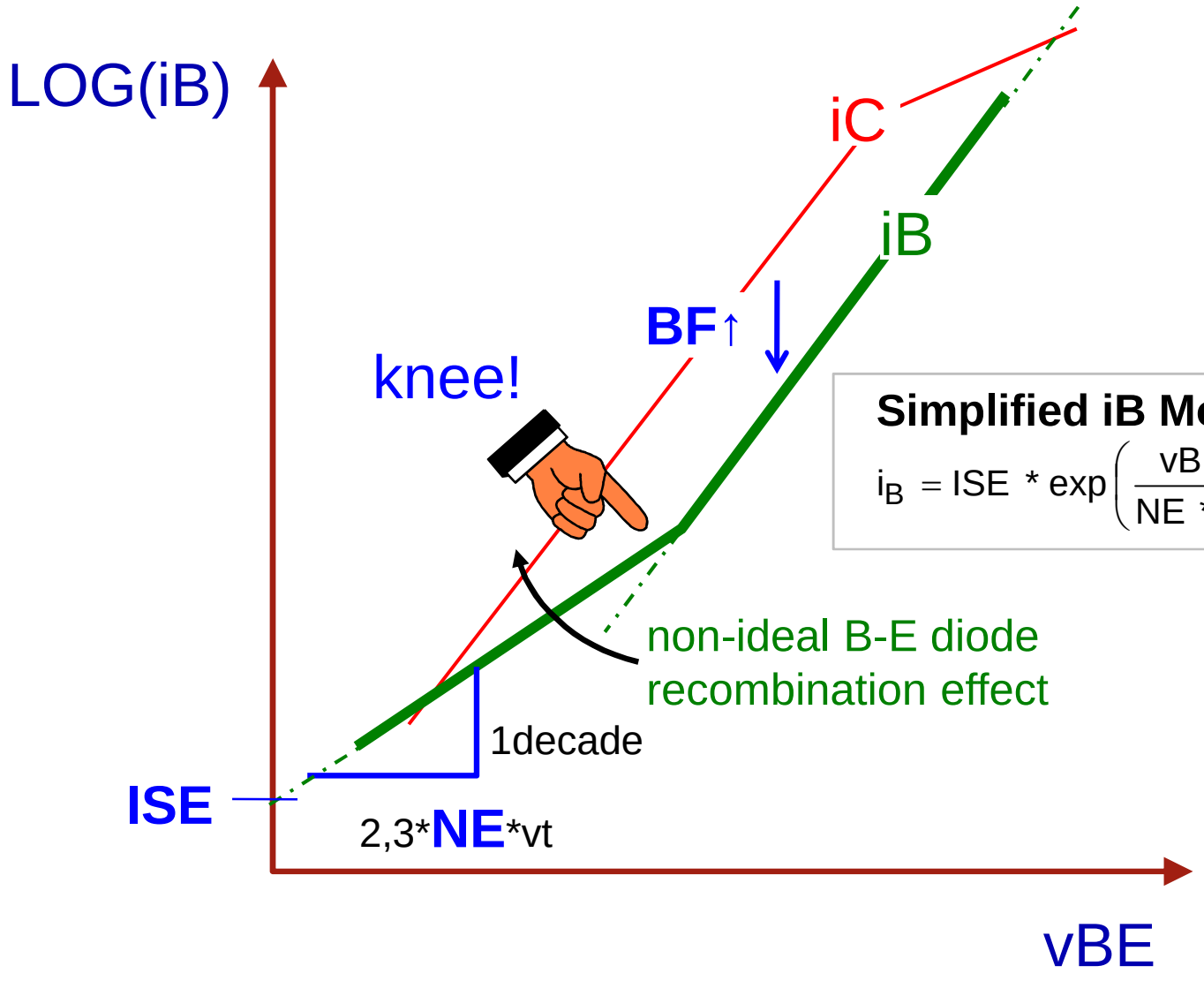
iC-vBE Gummel-Plot Modeling



Simplified iC Modeling Equation w/o Webster Effect:

$$i_c \sim IS \cdot \left(1 - \frac{v_{BE}}{VAR} - \frac{v_{BC}}{VAF}\right) * \exp\left(\frac{v_{BE}}{NF * vt}\right)$$

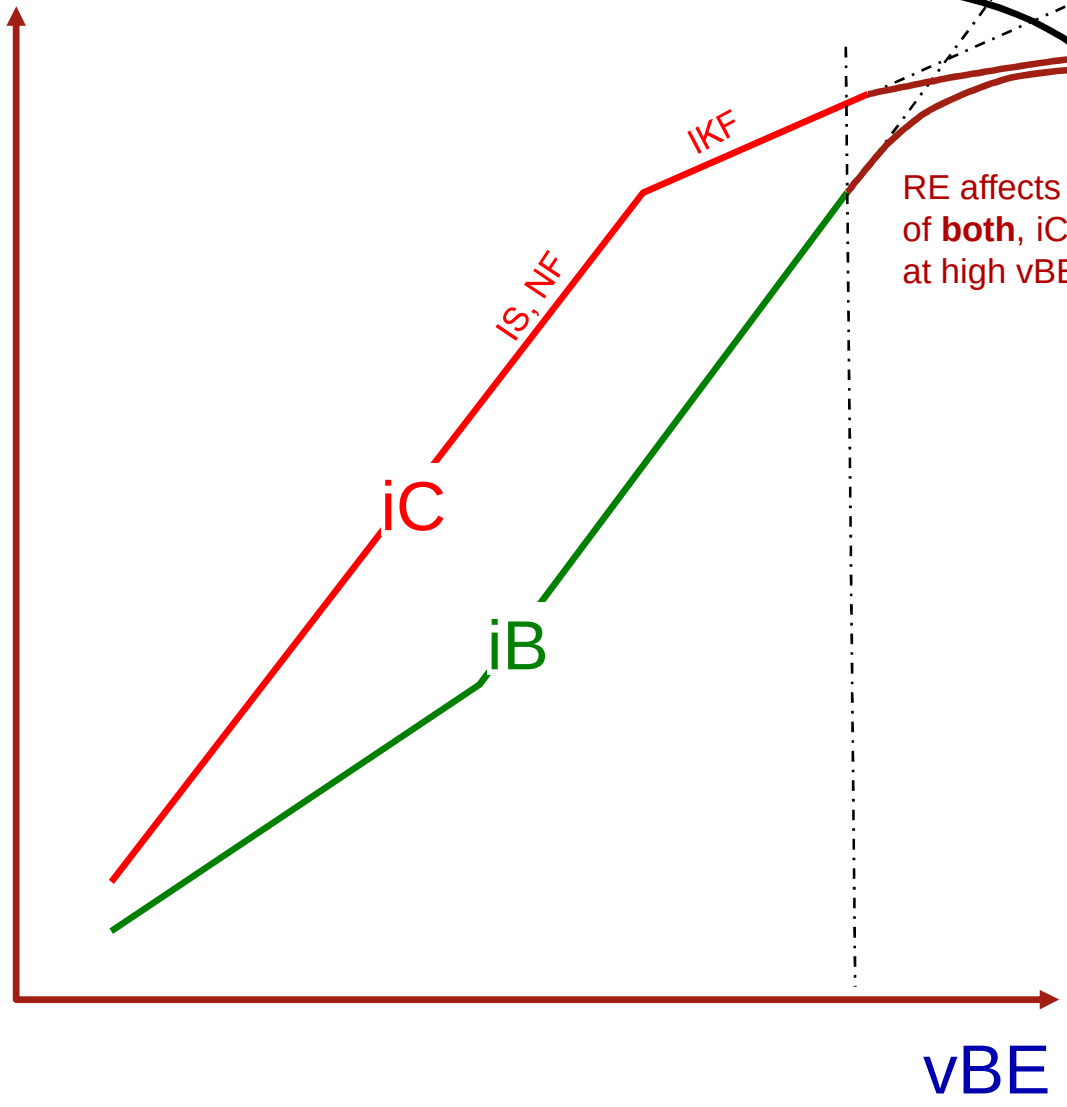
iB-vBE Gummel-Plot Modeling



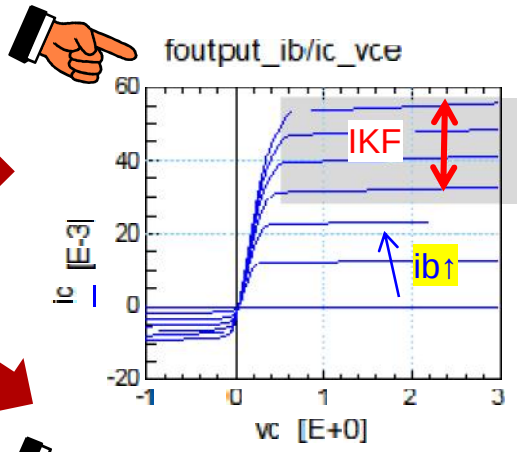
Simplified iB Modeling Equation:

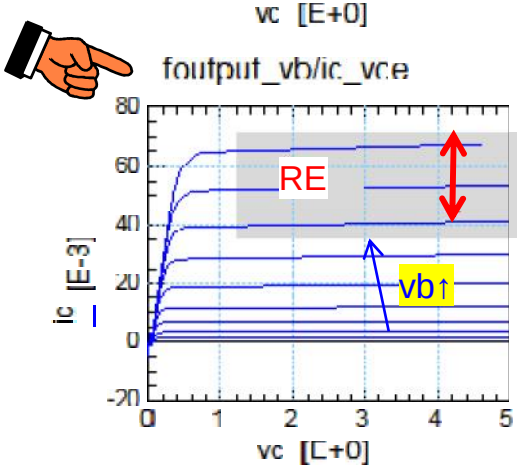
$$i_B = ISE * \exp\left(\frac{vBE}{NE * vt}\right) + \frac{IS}{BF} * \exp\left(\frac{vBE}{NF * vt}\right)$$

Understanding the High-Bias Effects in the Gummel-Plot



RE affects the slope of **both**, iC and iB at high vBE bias

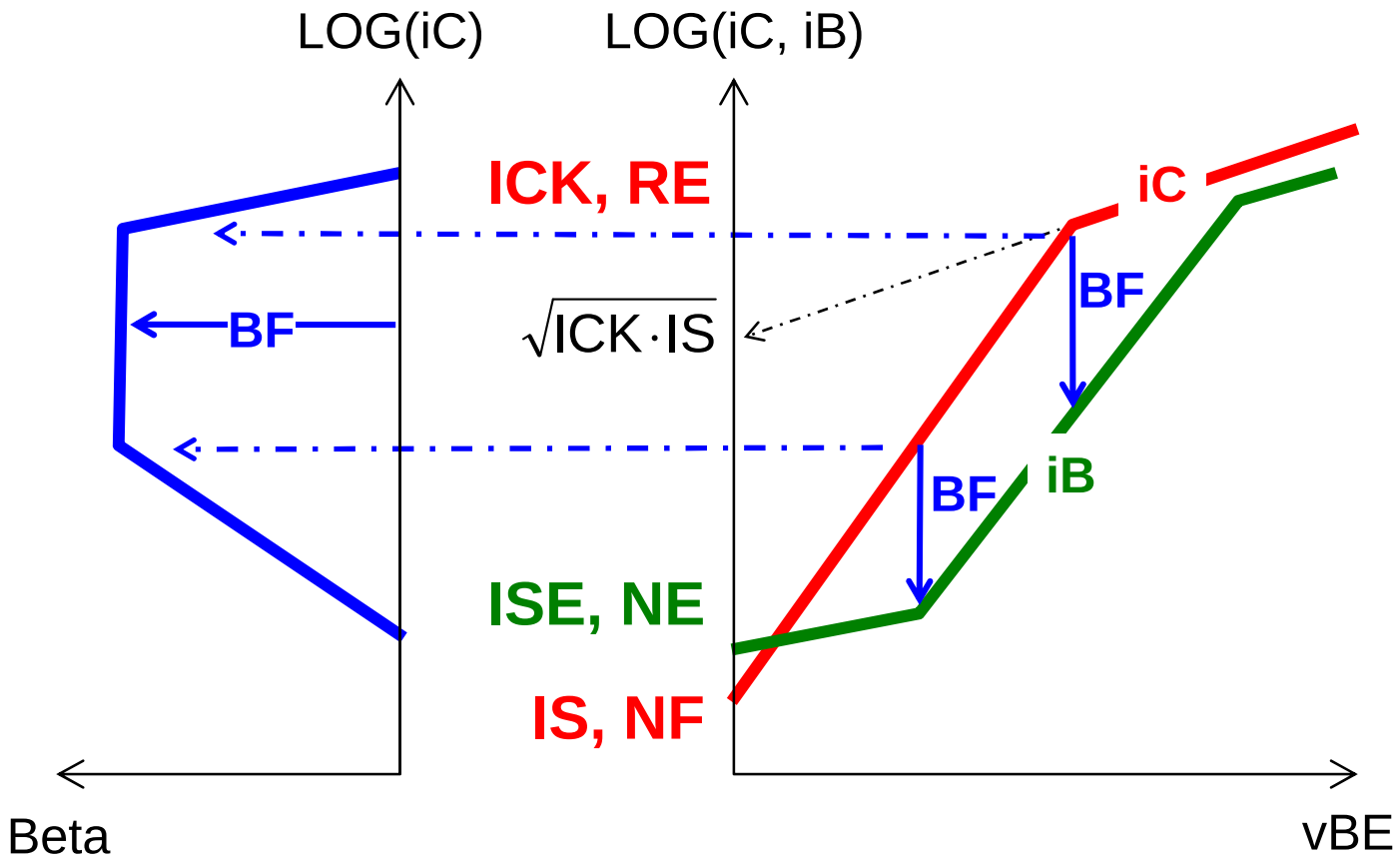




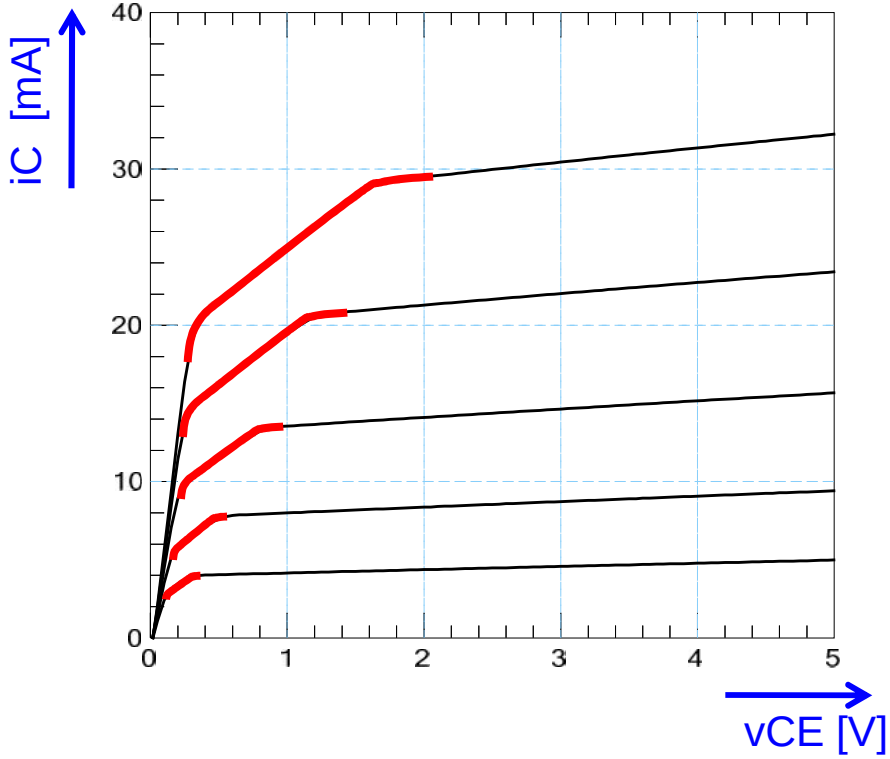
Best Practice:

- fit IKF in the Plot foutput(vc, ib)
- and RE in foutput(vc, vb)

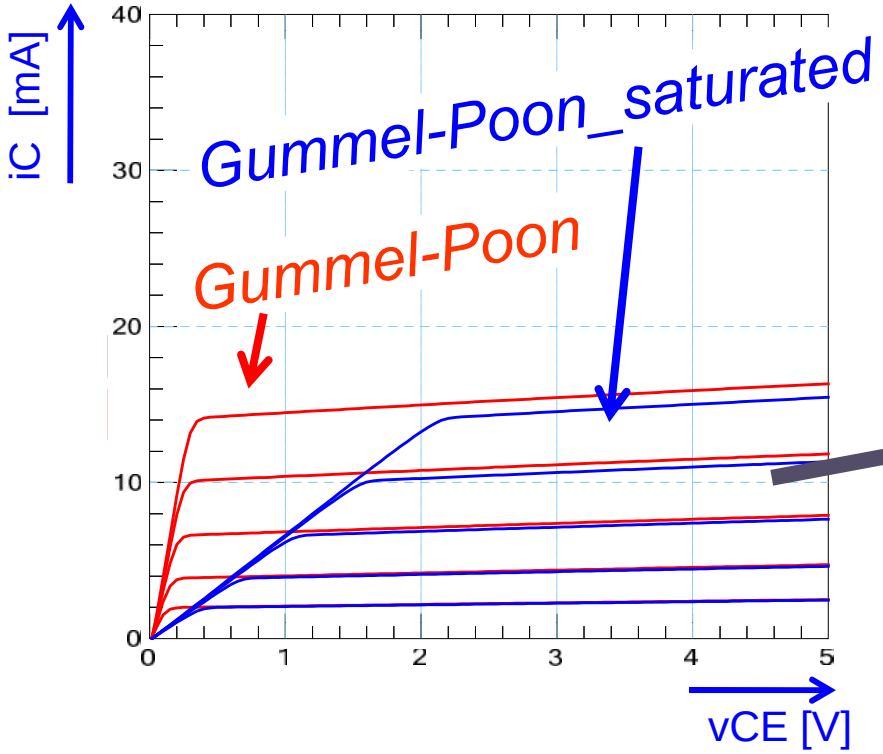
Beta-Plot ↔ Gummel-Plot

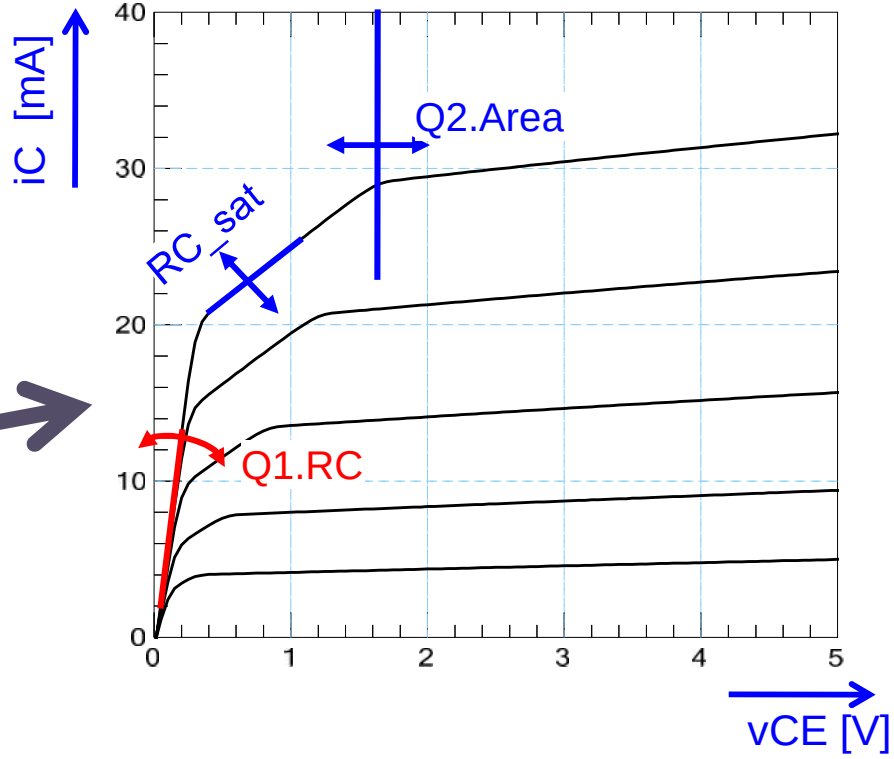


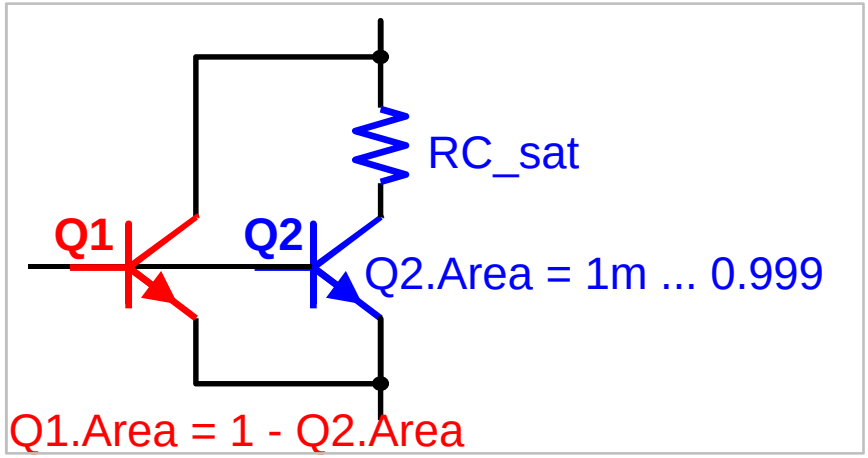
Modeling the ic_vce Quasi-Saturation-Effect by a cascaded Gummel-Poon Subcircuit ...



Improved Quasi-Saturation Modeling with Cascaded Gummel-Poon

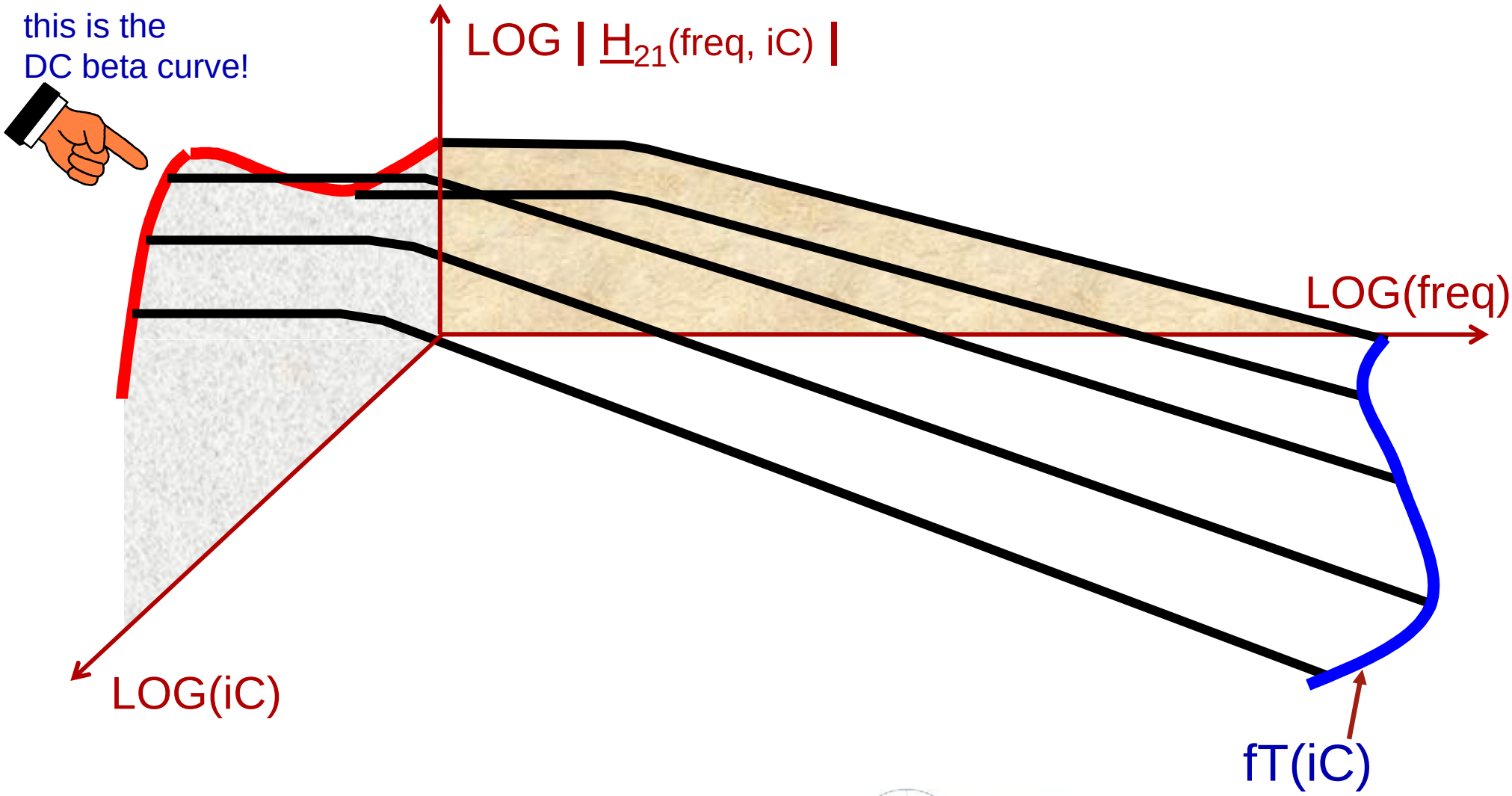




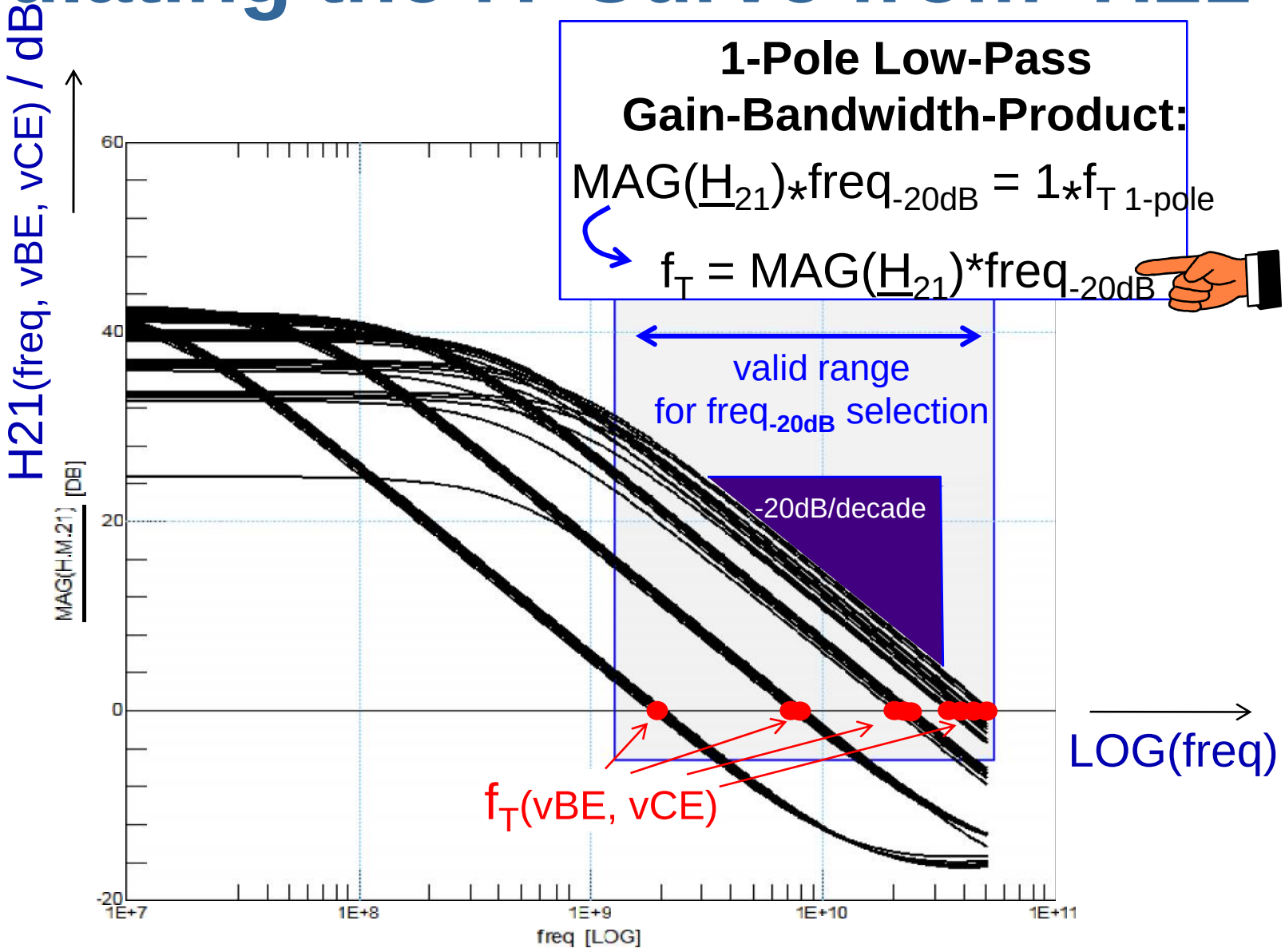


S-Parameter Modeling

Beta, H21 and Transit Freq. fT



Calculating the fT Curve from H21



Transit Time (Diffusion Capacitors)

- The *Diffusion Capacitors* are determined by the charges

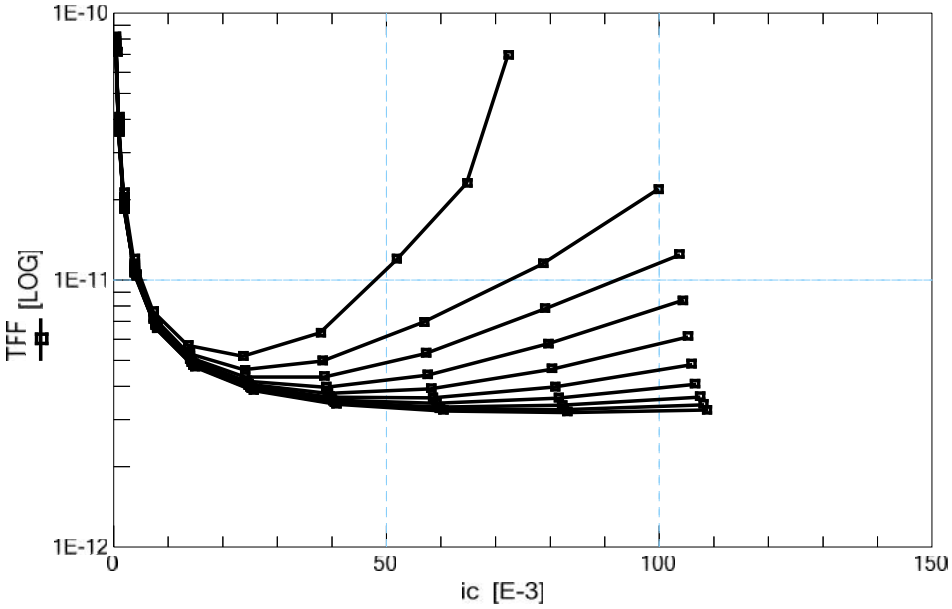
$$Q_{be} = TFF \cdot I_F \qquad Q_{bc} = TR \cdot I_R$$

- The *Forward Transit Time*

  $TFF \sim 1/f_{T\_forward}$

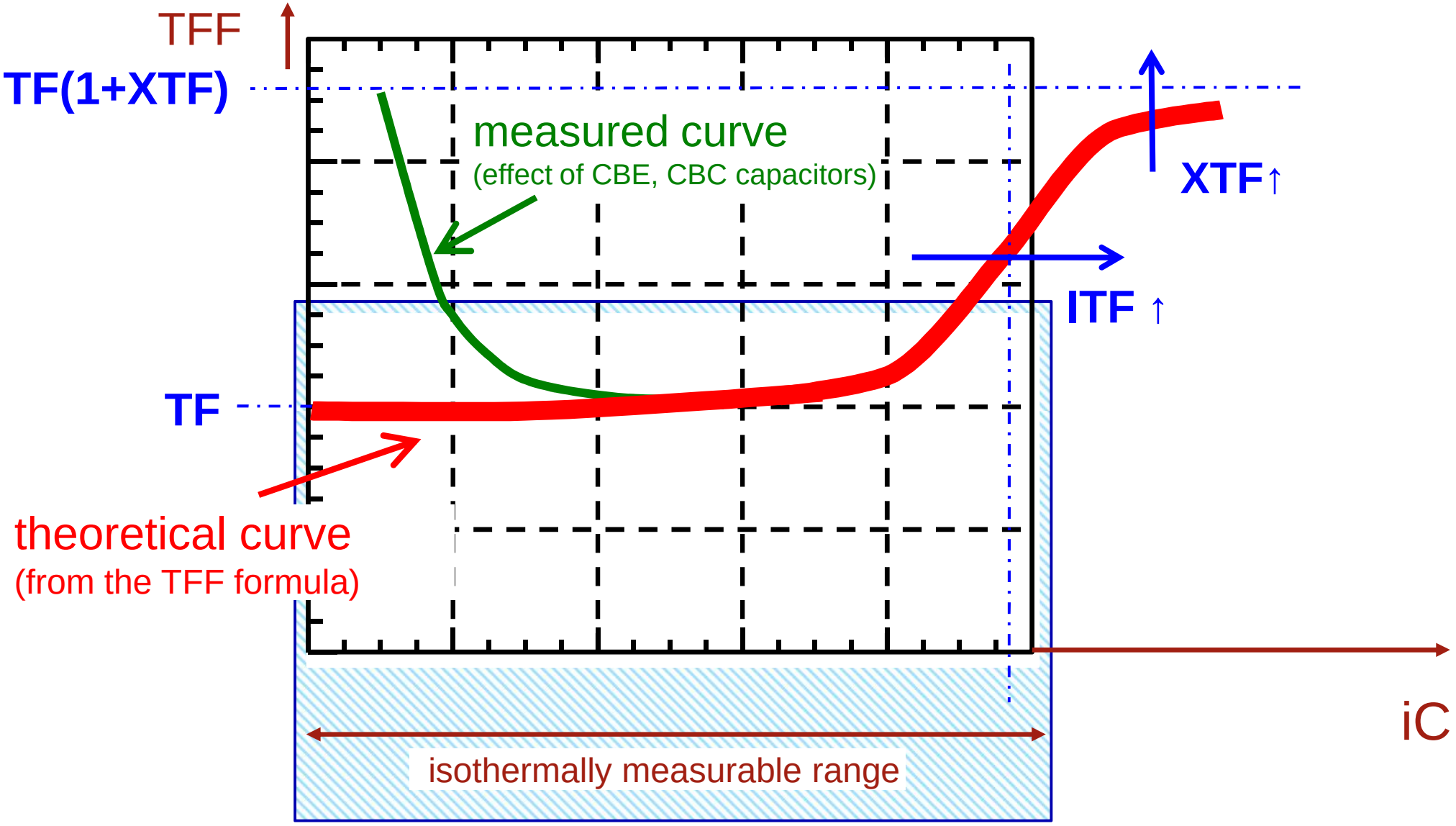
  is empirically described by:

$$TFF = TF \cdot \left[1 + XTF \cdot \left(\frac{I_F}{I_F + ITF} \right)^2 \cdot e^{\frac{v_{bc}}{1.44 \cdot VTF}} \right]$$



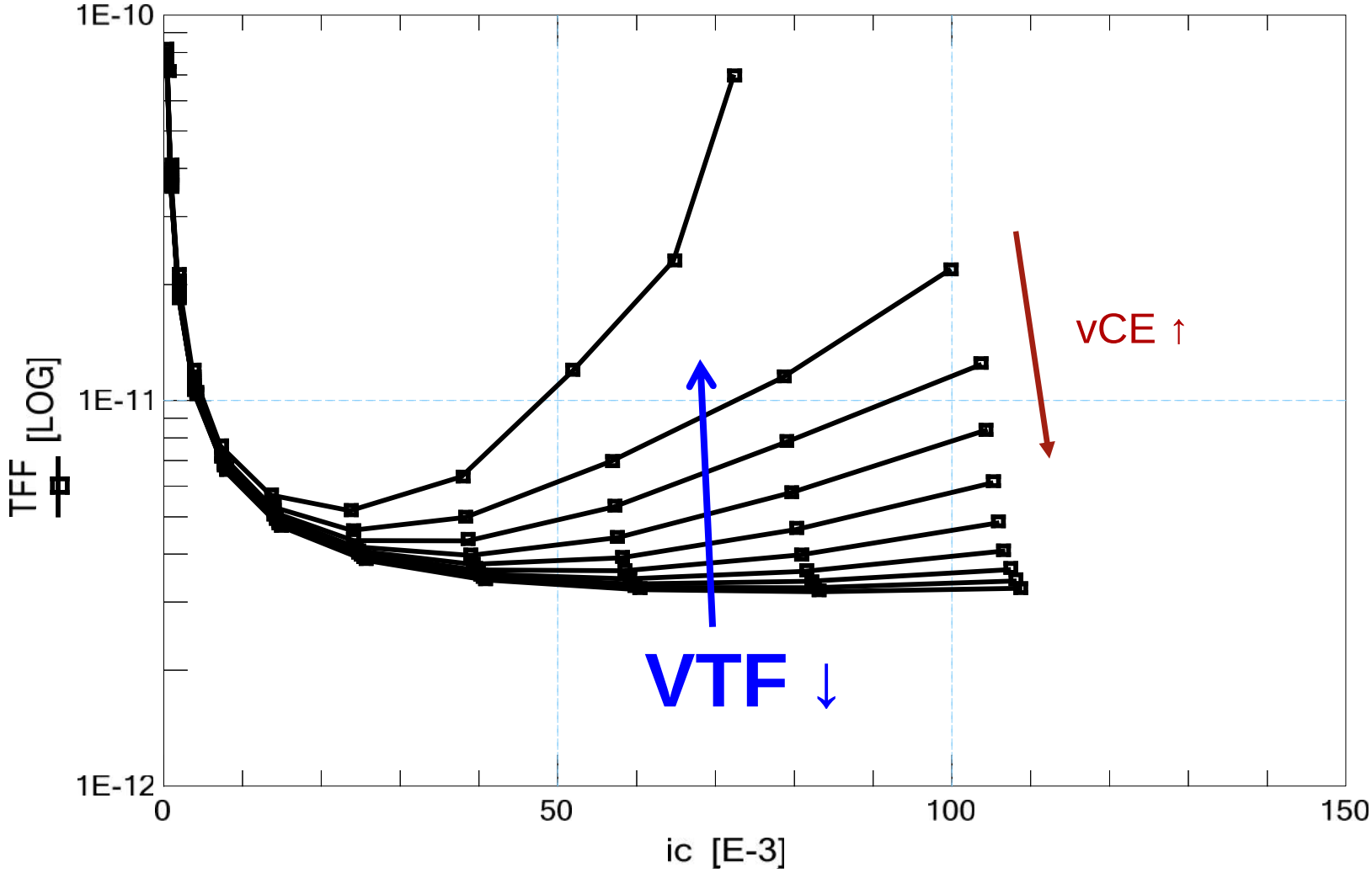
- The *Reverse Transit Time* TR is modeled as a constant

Modeling the Transit Time TFF = $1/f_T$



Transit Time Collector Voltage Dependency:

Parameter VTF



Appendix

GP-Model: Default Model Parameters

Note: Using Default Parameter Values switches-off the Parameter Effect
- do not confuse with *Typical Parameters* -

Parameter	Default
DC Forward	
IS	0.1f
NF	1
BF	100
ISE	0
NE	1,5
IKF **	∞
DC Reverse	
NR	1
BR	1
ISC	0
NC	2
IKR **	∞
Early Modeling *	
VAF	∞
VAR	∞

Parameter	Default
Space Charge Capacitances	
CJE	0
VJE	0,75
MJE	0,33
CJC	0
VJC	0,75
MJC	0,33
XCJC	1
CJS	0
VJS	0,75
MJS	0,33
FC	0,5

Parameter	Default
Resistances	
RE	0
RC	0
RBM	RB
RB	0
IRB	∞
Delay Time (Transit Time) ***	
TF	0
XTF	0
ITF	0
VTF	∞
TR	0
Excess Phase	
PTF	0
Temperature	
TNOM	27
EG	1,11
XTI	3
XTB	0

NOTE: The 'Integral Base Charge Relation' of the Gummel-Poon model covers:

* Early Effect (the slope in the DC Output Characteristic ic-vce)

** Webster Effect (reduction of the Collector Current at high biasing)

*** Kirk Effect (increased Transit Time at high Collector currents)

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