

Experience using the HiCUM Master Toolkit

■
June 18th 2007

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Agenda

- ☐ **Project Background**
- ☐ **Project Challenges**
- ☐ **Summary of Results**
- ☐ **Feedback on the HMT Tool/issues**
- ☐ **Feedback on New Features**

Project Background

Reason for evaluation:

- Improved high current f_t modeling for SiGe NPNs
- Leverage HMT for geometric scaling

HMT evaluation	
Technology:	RF SiGe NPN – 50GHz, 0.25 μ m
Configurations:	CBEBC, CBEB, CBE
Current compact model:	VBIC (geometry specific models)
Simulation Tool:	spectre

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Project Challenges

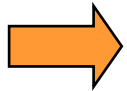
- ❑ Developing expertise in the HiCUM Master Toolkit flow
- ❑ Test structures for technology were not developed with HiCUM geometric scaling in mind.
 - ❑ *Technology has fixed emitter width*
 - ❑ *No test structures with varied width*
 - ❑ *Test structures available include fixed emitter width and 4 different lengths*
 - ❑ *No large arrays available to characterize depletion caps very accurately*
 - ❑ *Tetrode structures with various widths but fixed length*
 - ❑ *Sheet resistance of base link was taken from TCAD simulations as structures were not available for determination of base link resistance*
- ❑ HMT Limitations - not much flexibility for data input
 - ❑ *Bias conditions, sweep orders*
 - ❑ *S parameters must be de-embedded for HMT input*

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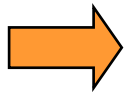
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Summary of Results

- ❑ Fixed emitter widths lead to small perimeter to area variation -> effects accuracy of γ_C and γ_B extractions
- ❑ Use of long tetrode only -> uncorrected, underestimate $RSBi0$ by a factor of 10 – 20%, still gives correct value for $Qp0$
- ❑ Accurate capacitance splitting not possible

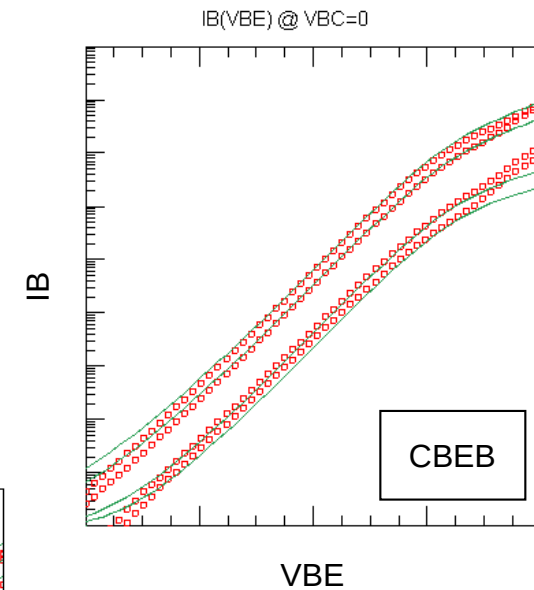
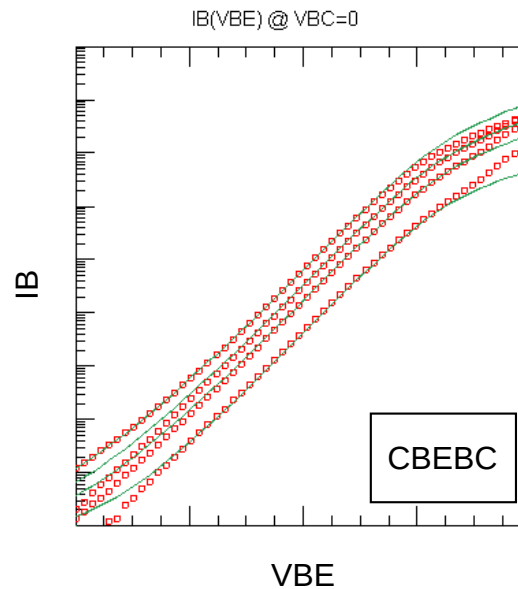
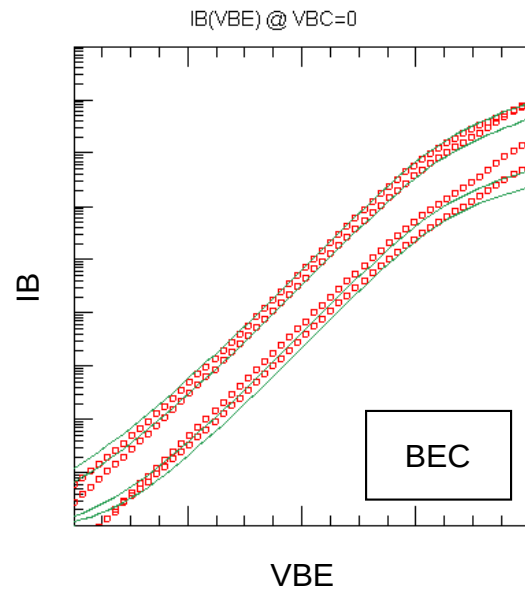


The lack of data will lead to some limitations!

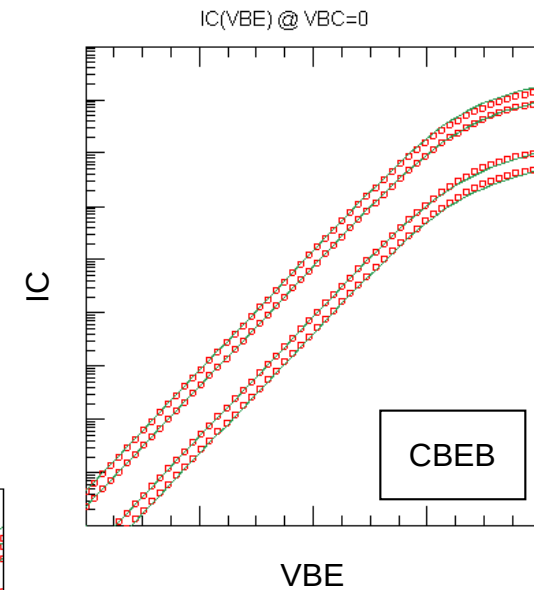
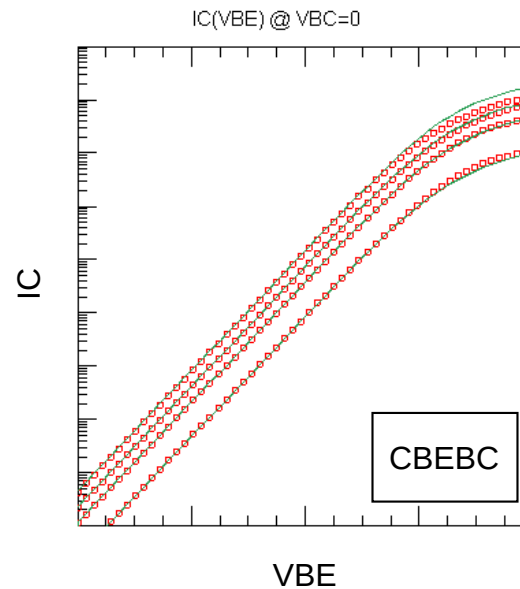
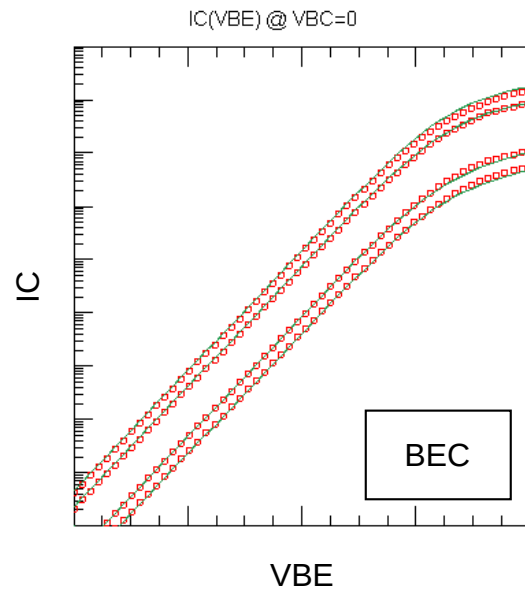


Opportunity to encounter potential issues before a new test chip design is launched!

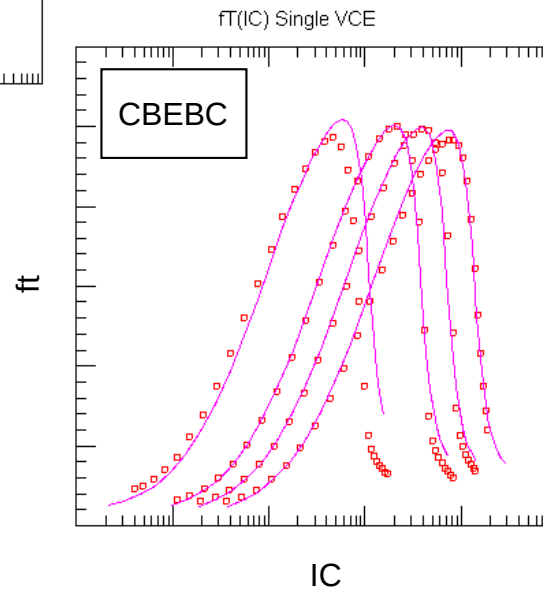
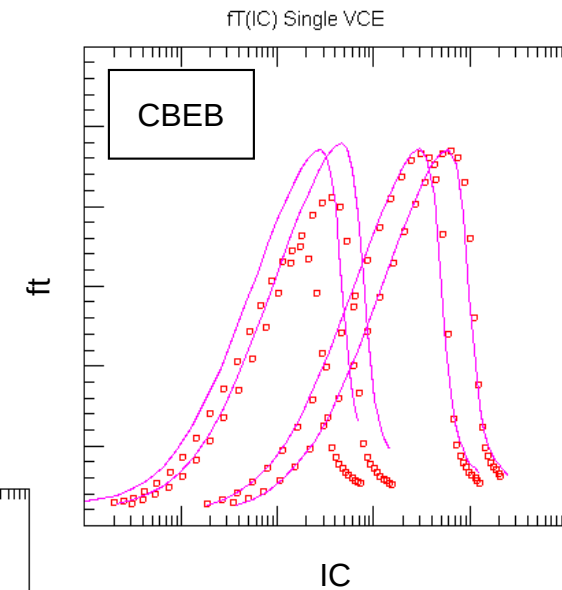
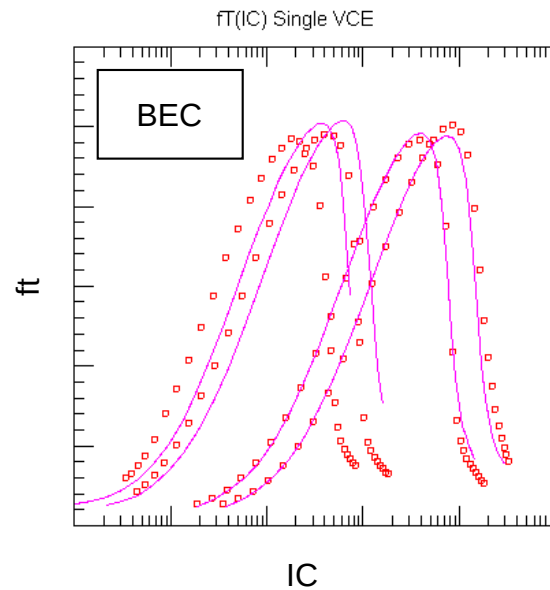
Summary of Results - IB



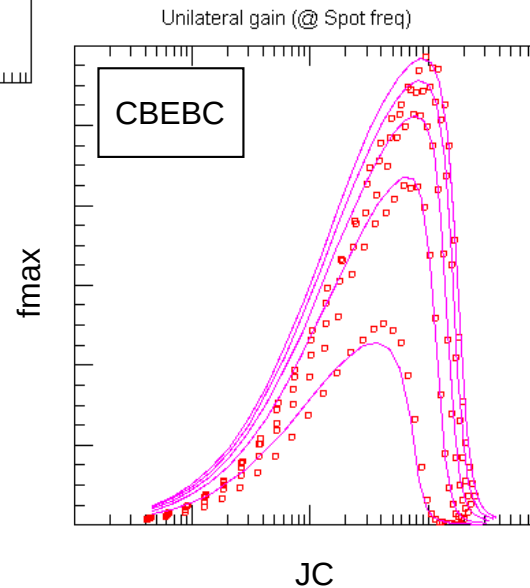
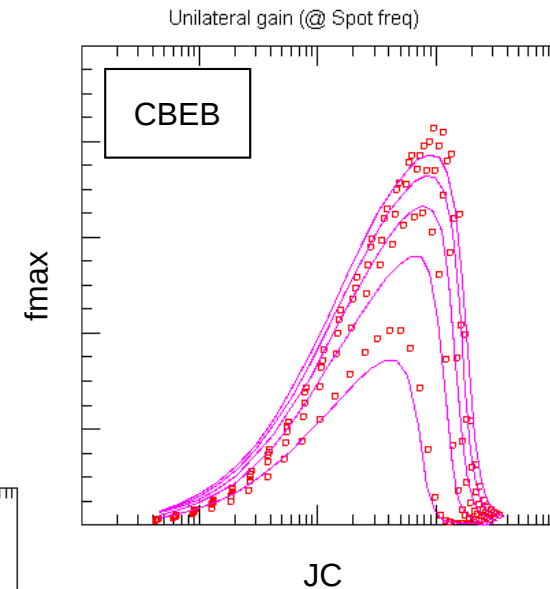
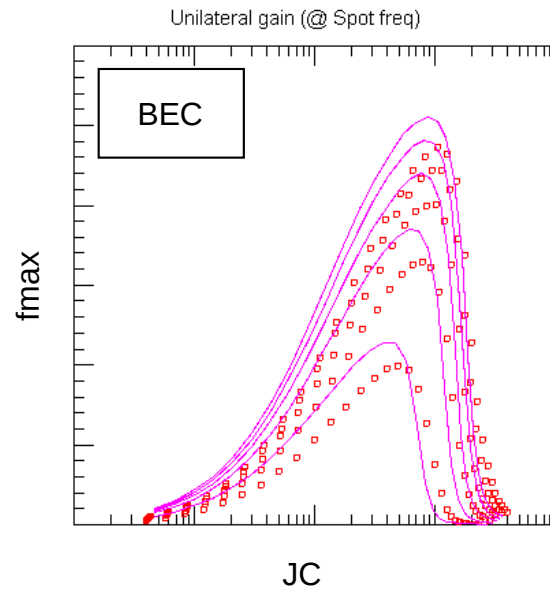
Summary of Results - IC



Summary of Results - ft



Summary of Results - f_{max}



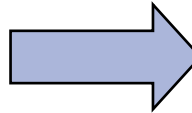
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Feedback on HMT Tool/issues(1)

- ❑ Circuit deck syntax incompatibility with spectre native format

```
define backend (C B E S)  
C:CBEBE B E C=1e-20  
C:CBCBE B C C=1e-20  
HMT_FT:X1 C B E S  
end backend
```

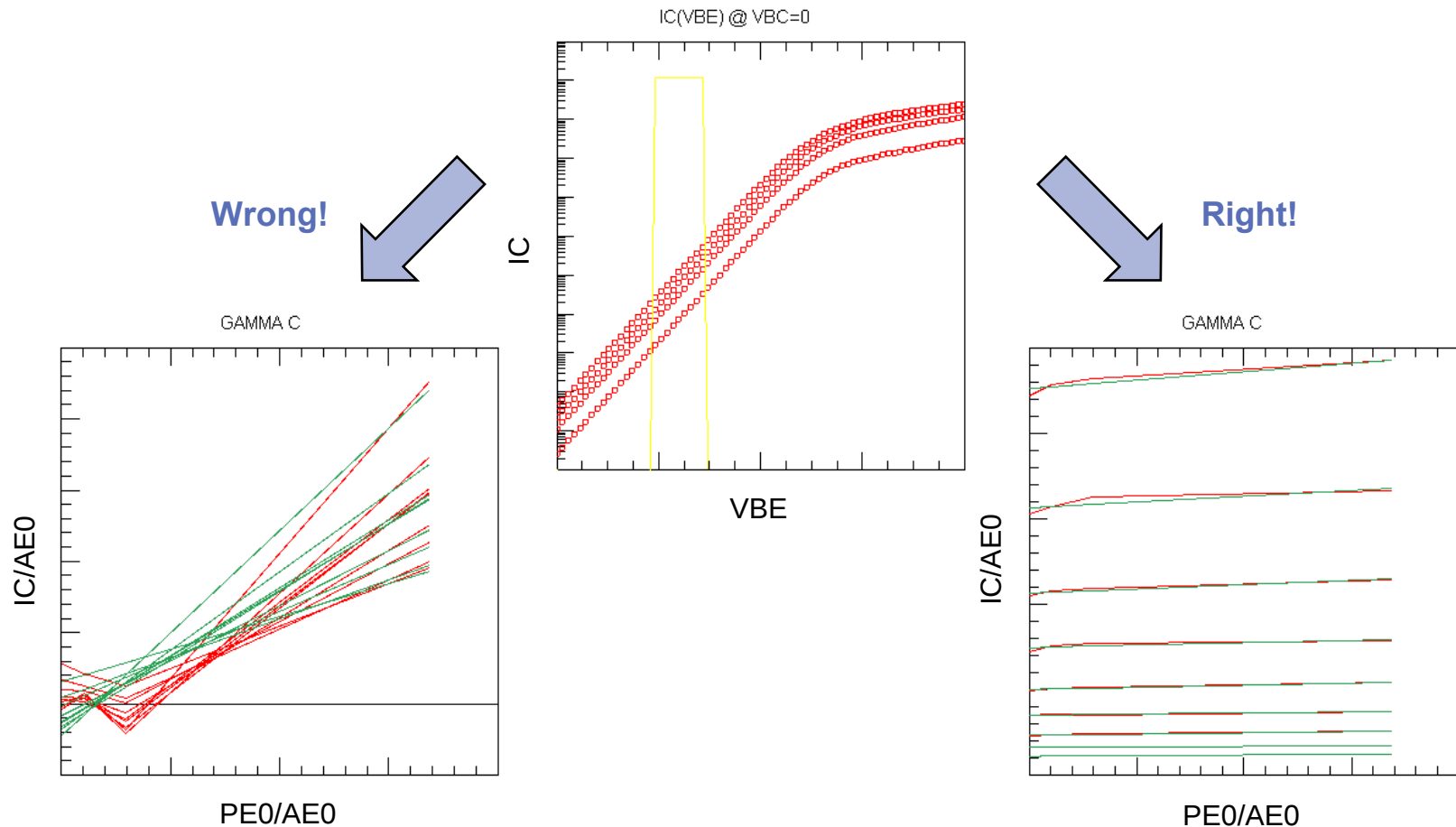


```
subckt backend (C B E S)  
CBEBE B E capacitor C=1e-20  
CBCBE B C capacitor C=1e-20  
X1 C B E S HMT_FT  
ends
```

- ❑ Load data: subcircuit in HMT_XX/DATA is updated with ADS syntax (the default), ICCAP automatically runs syntax parser -> error message
- ❑ Simulation: subcircuit is automatically replaced by HMT with spectre syntax. ICCAP makes automatic check for subcircuit parameters -> error message

Feedback on HMT Tool/issues(2)

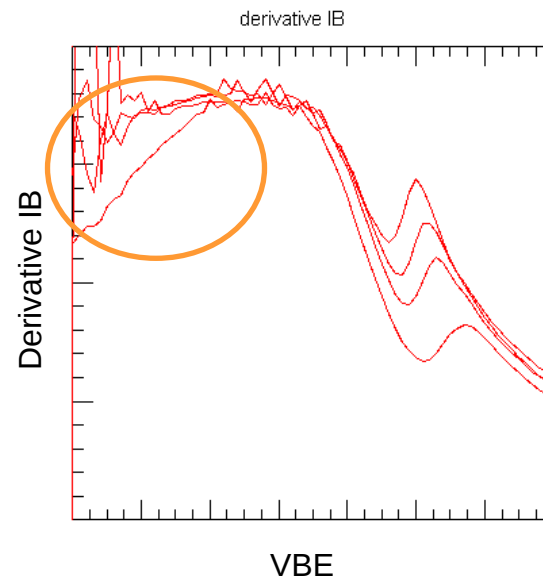
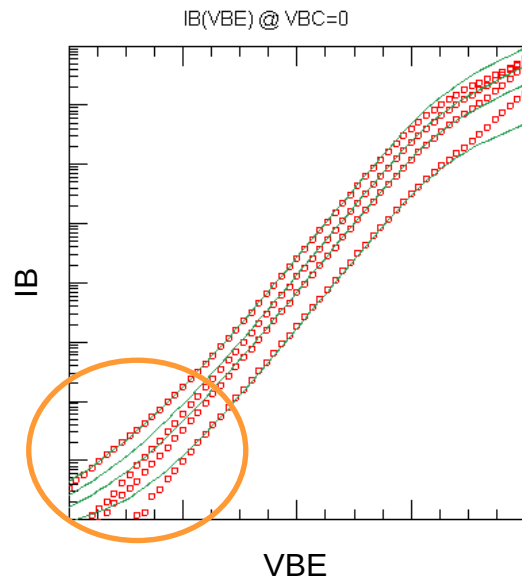
- ❑ Extraction of γ_C and γ_B doesn't work, field table values are not set correctly



Feedback on HMT Tool/issues(3)

More flexibility is desired

- Support for different plots would require change in HMT code -> difficult
- Example: IB and first order derivative of IB to identify non-ideality range



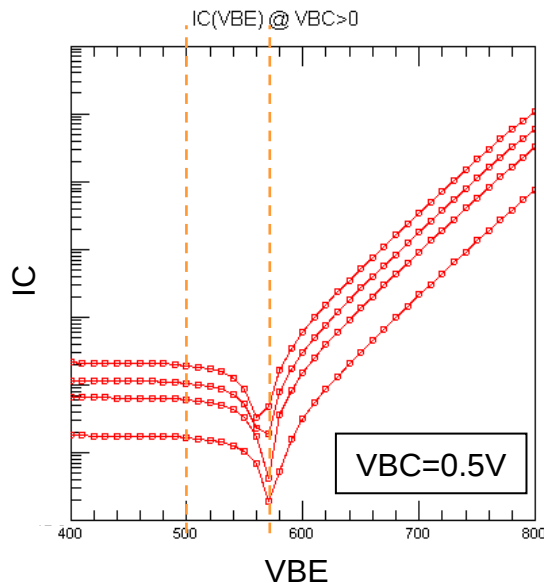
- Biasing and sweep orders for input data are fixed, de-embedding outside the tool
- Additional extraction steps, e.g. to extract reverse characteristics

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Feedback on new features(1)

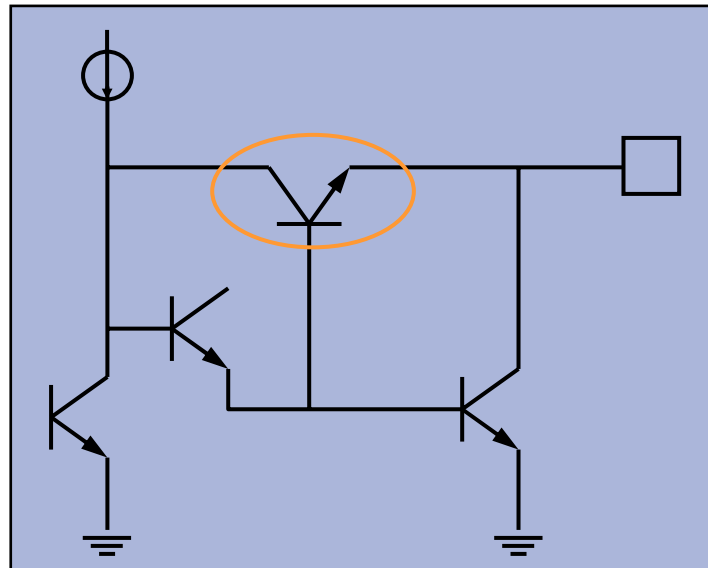
- ❑ Feedback from National's Analog designers - an accurate model of reverse characteristics is important, because:
 - ❑ *BJT must operate very close to saturation, gets more important as supply voltages shrink*
 - ❑ *Saturation considered as superposition of forward active and reverse active*



- ❑ *Measurement precision issue for IBC extraction*
- ❑ *Shift in V_{BE}*

Feedback on new features(2)

- ❑ An accurate model of reverse characteristics is important, because:
 - ❑ *To minimize current flow in overdrive, subcircuits are employed by designers (saturation limit circuits)*
 - ❑ *Require use of a sensing transistor to go into reverse active mode when sensed output stage device approaches saturation*



Feedback on new features(3)

- ❑ Integration of scaling equations into Cadence design environment, so that discrete model cards do not need to be generated
 - ❑ *Equations could be passed into netlist directly?*

- ❑ Plan to evaluate on Complementary Vertical PNP transistors
 - ❑ *Anyone else has extraction experience using HMT on CVPNPs?*

- ❑ HiCUM Workshop planned in North America?