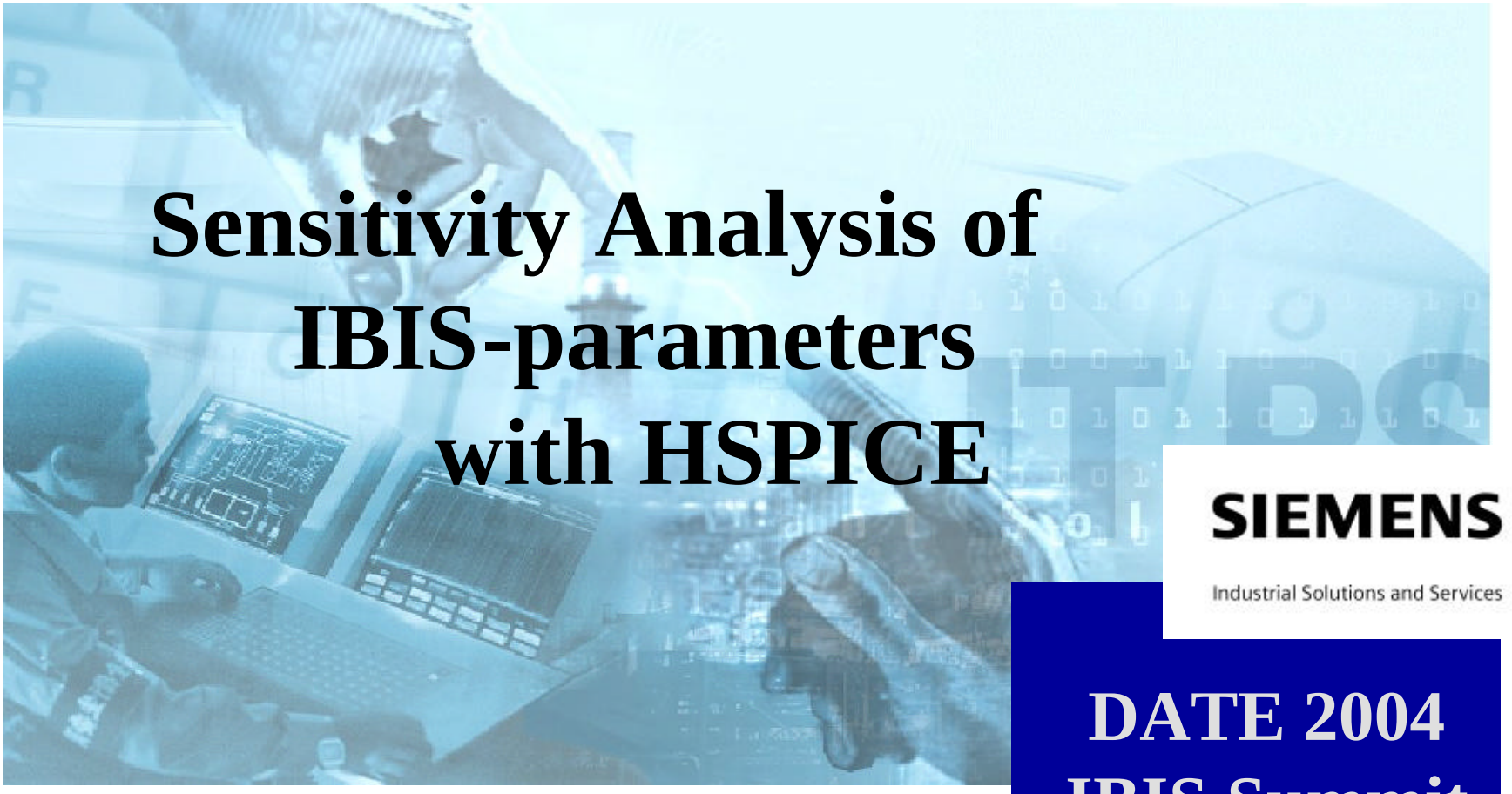

Sensitivity Analysis of IBIS-parameters with HSPICE

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DATE 2004
IBIS Summit Meeting
Paris 2004

Your Success is Our Goal

Manfred Maurer

Email: ***manfred.maurer@siemens.com***

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Overview

- Motivation
- **Sensitivity analysis** main focus of the design process
- Scaling of the **static / dynamic curves** of a **IBIS model**
- Sensitivity analysis with a **IBIS-model**
- Summary

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Motivation

- **Confidence level of the IBIS-Model**
- **Model adjustments to the Golden Waveform**

- **Timing Budget of the design very small**
- **Application different to the IBIS-model conditions**
- **Design robustness has to be evaluated**

?

- **Which <u>parameter variation</u> of the IBIS-model have the greatest impact to the <u>time delay</u> on the PCB**

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Design Methodologies

- **Timing Spreadsheet (Worst-Case and Statistical)**
  - **Uncertainty of Reference Voltage (Vth) and Loads**
  - **Signal integrity / ISI and EMC**
  - **Different Topologies**
  - **Thermal considerations**
- **Design Solution Space = (Electrical + Layout + Thermal) Requirements**
- **➔ Sensitivity Analysis ←**
  - **Initial *Monte Carlo* Analysis ➔ *significance* and *trend* of each variable**
  - **Determine Corner conditions**
  - **Eye Diagrams / fix ISI**
- **Design Guidelines (only) for the actual project**

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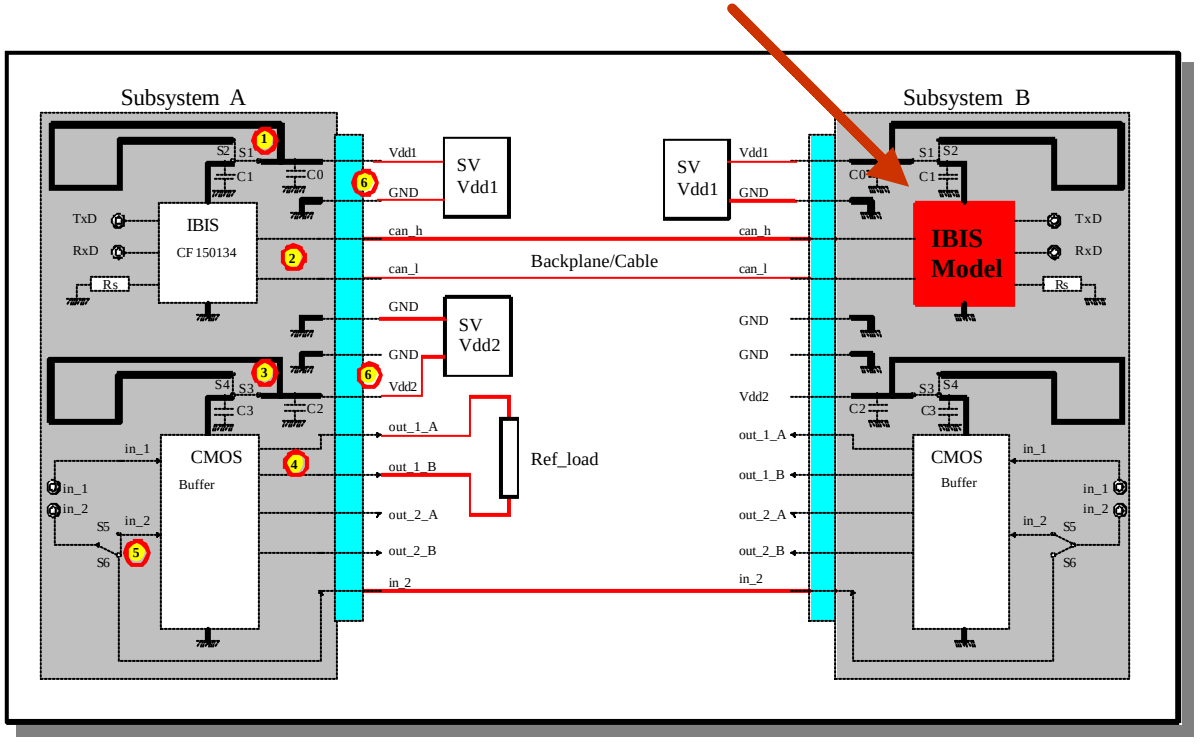
Localization of the actual analysis

Focus of investigation



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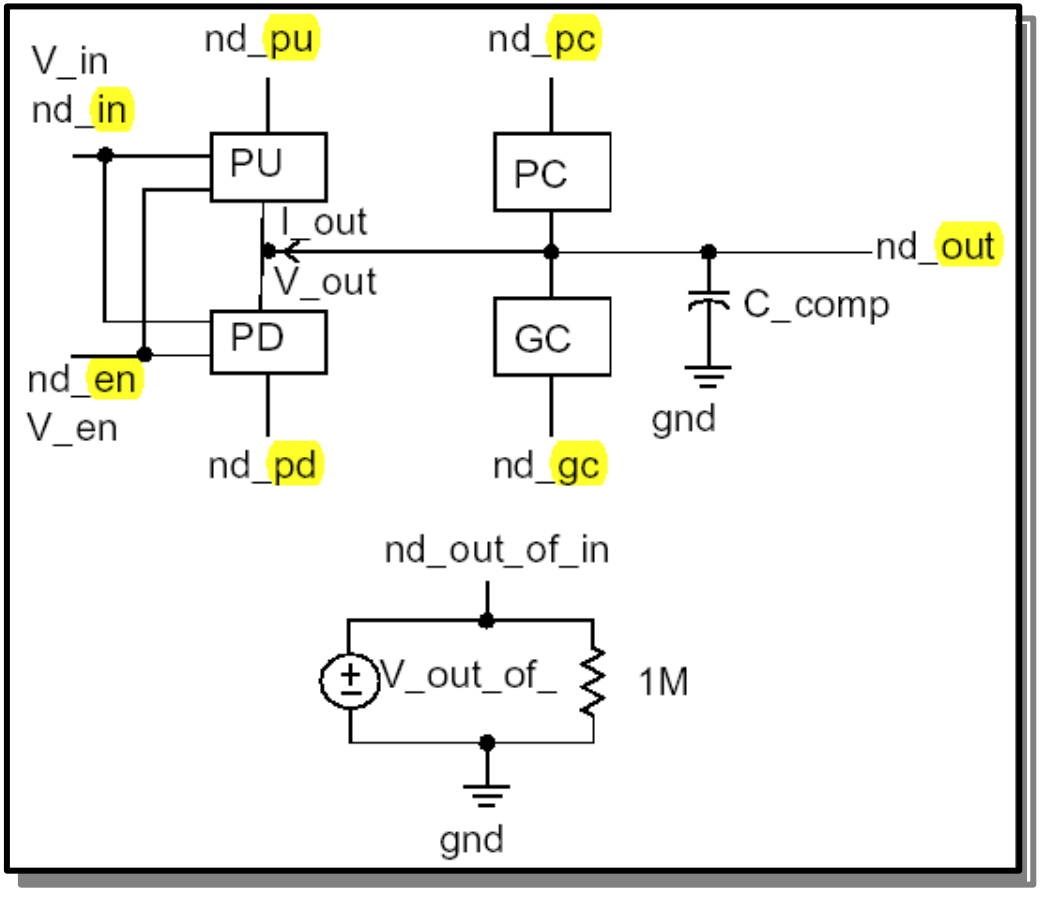
Input-Output Buffer (HSPICE)



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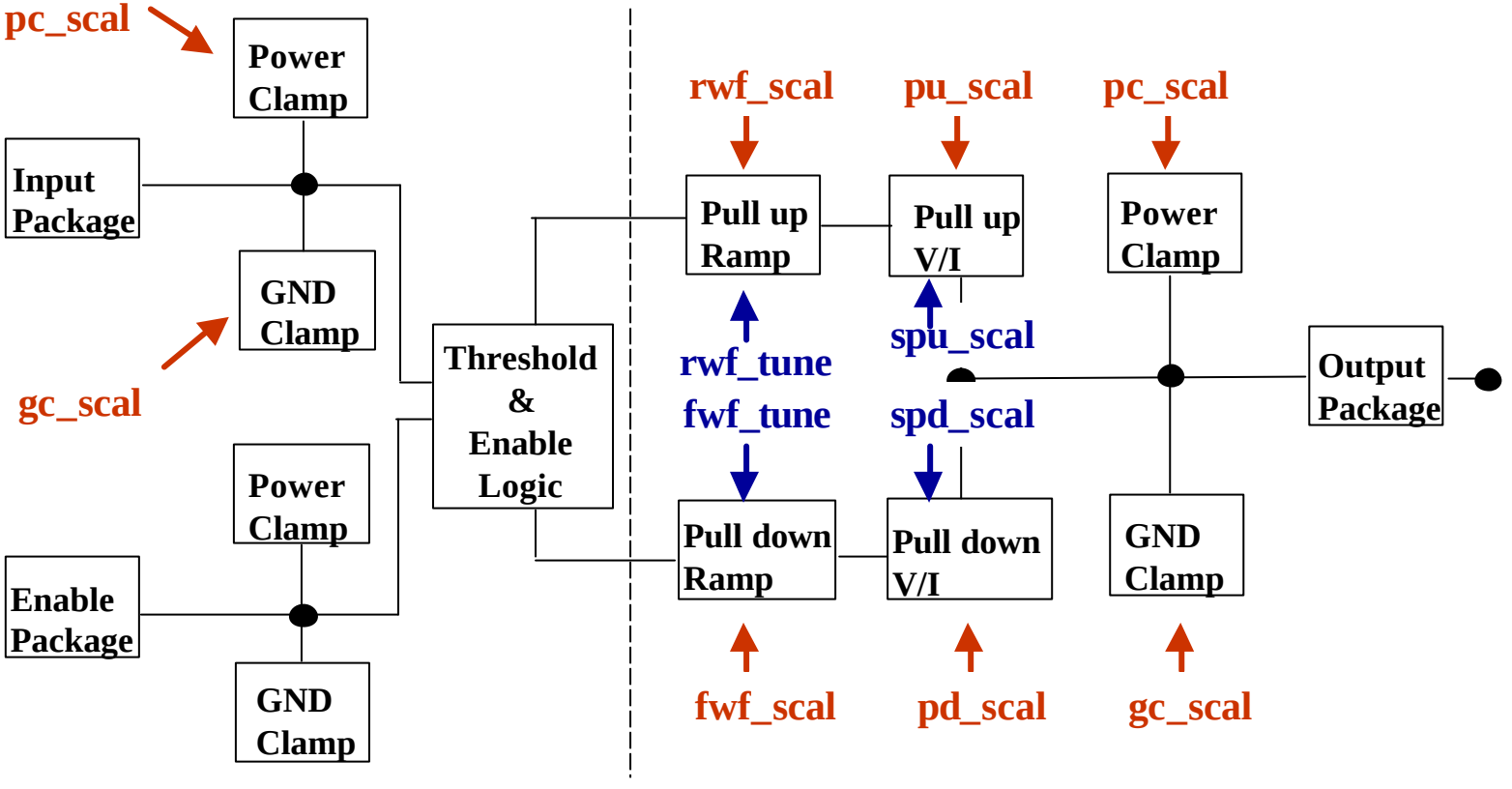
Scaling / tuning possibilities (HSPICE)



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HSPICE Syntax of an I/O-Buffer

```
B_IO nd_pu nd_pd nd_out nd_in nd_en V_out_of_in [nd_pc nd_gc]
+ file='file_name' model='model_name'
+ [typ={typ|min|max|fast|slow}] [power={on|off}]
+ [buffer={3|input_output}]
+ [xv_pu=state_pu] [xv_pd=state_pd]
+ [interpol={1|2}]
+ [ramp_fwf={2|1|0}] [ramp_rwf={2|1|0}]
+ [fwf_tune=fwf_tune_value] [rwf_tune=rwf_tune_value]
+ [nowarn]
+ [c_com_pu=c_com_pu_value]
+ [c_com_pd=c_com_pd_value]
+ [c_com_pc=c_com_pc_value]
+ [c_com_gc=c_com_gc_value]
+ [pu_scal=pu_scal_value]
+ [pd_scal=pd_scal_value]
+ [pc_scal=pc_scal_value]
+ [gc_scal=gc_scal_value]
+ [rwf_scal=rwf_scal_value]
+ [fwf_scal=fwf_scal_value]
+ [spu_scal=spu_scal_value]
+ [spd_scal=spd_scal_value]
```

← If ramp=0|1 ➔RAMP adjustment

← C_comp distribution between nodes

← PU / PD + PC / GC scaling

← Rising WF / Falling WF scaling

← If power=off ➔ adjustment of the PU/PD curves

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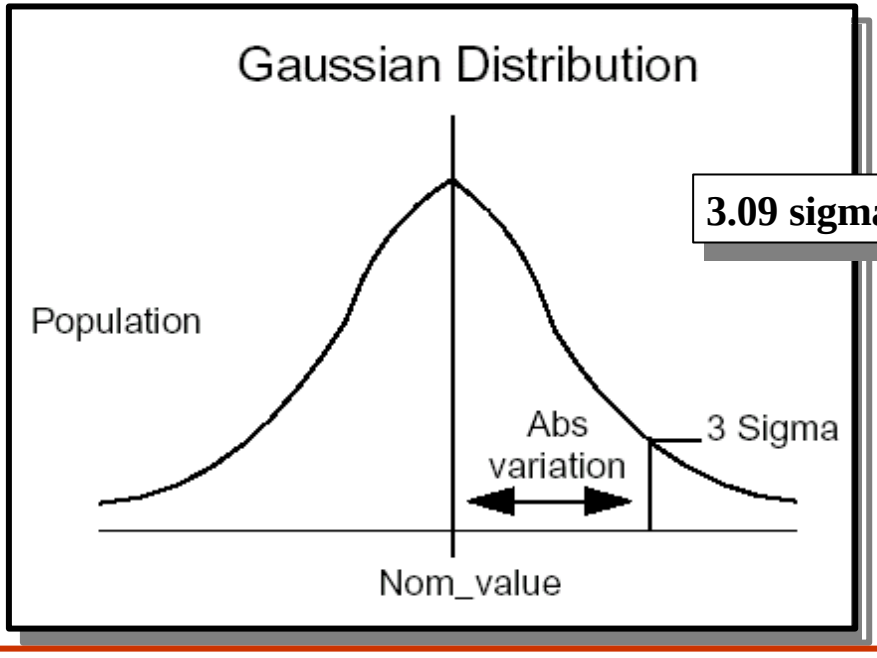
Definition of the Distribution Function



3.09 sigma ➔ 99.8%

```
.PARAM xx=GAUSS(nominal_val, rel_variation, sigma <,
+ multiplier>)
```

Rel_variation=Abs_variation/Nom_value

Timing reference - Scaled and Reference buffer

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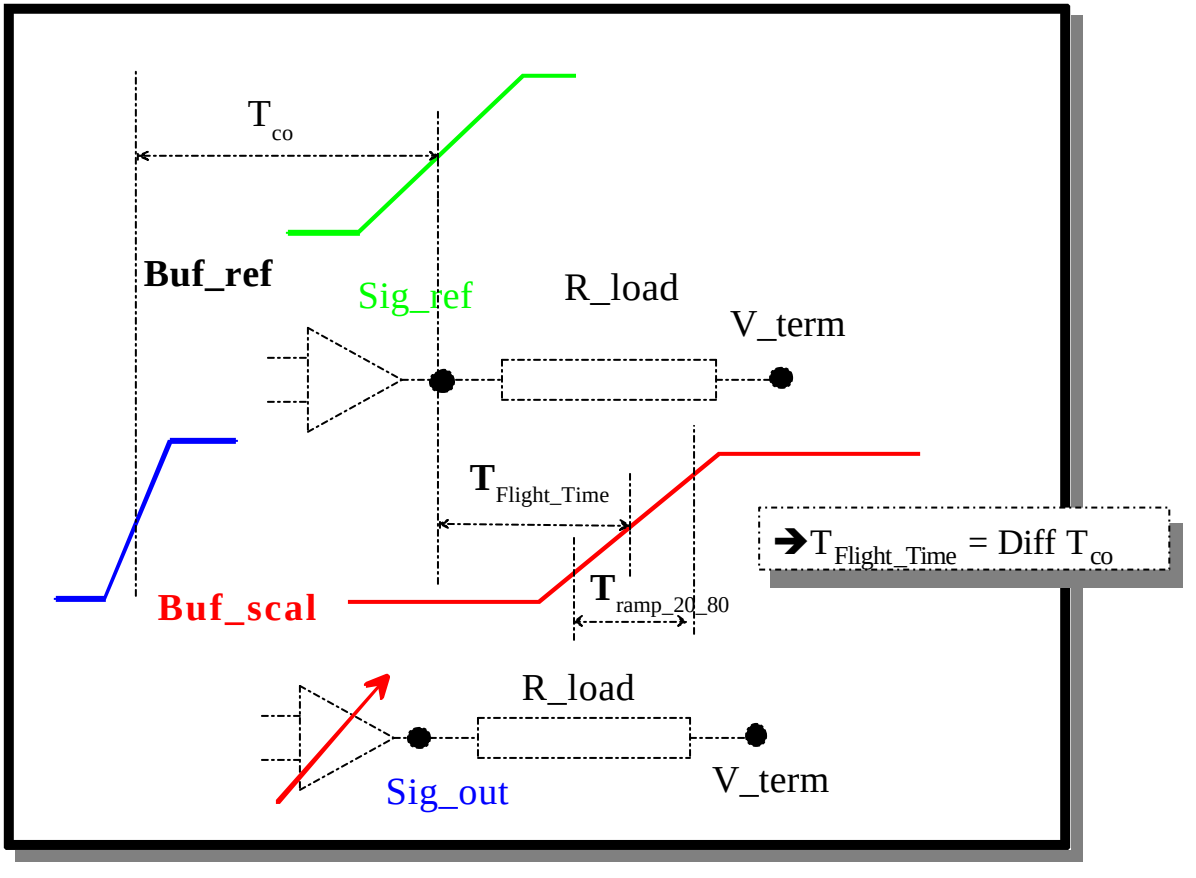

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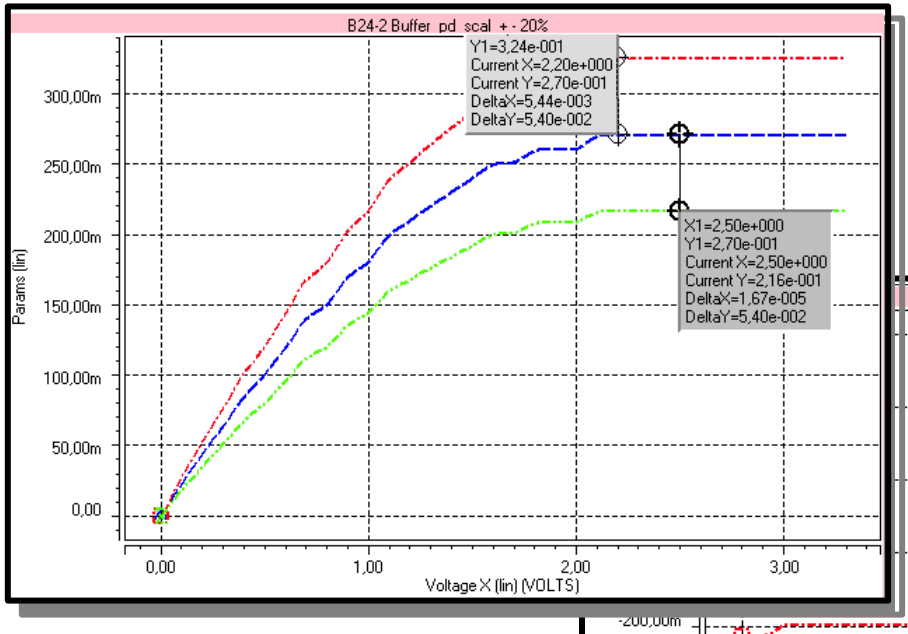
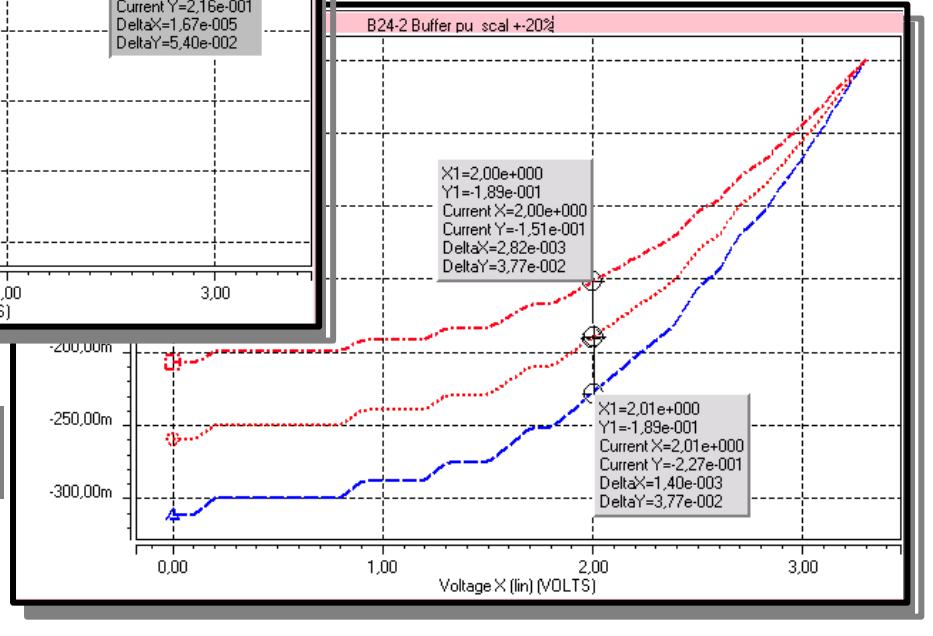
Scaling of the static curves



$$I_{PU}^{scal} = pu\_scal * I_{typ}$$



$$I_{PD}^{scal} = pd\_scal * I_{typ}$$

Wafeform scaling rwf_scal / fwf_scal

0.85 / 3 sigma from typical

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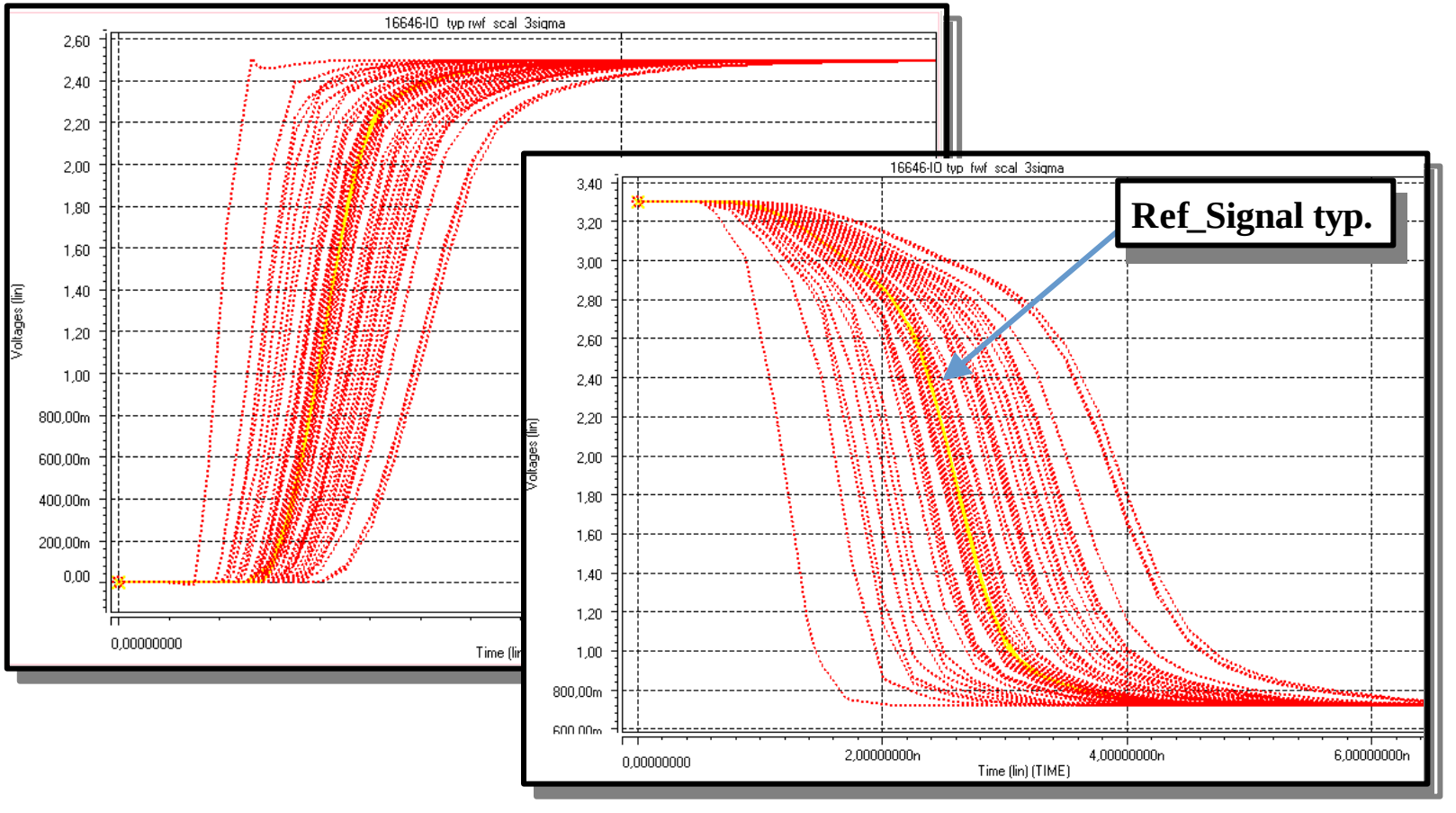

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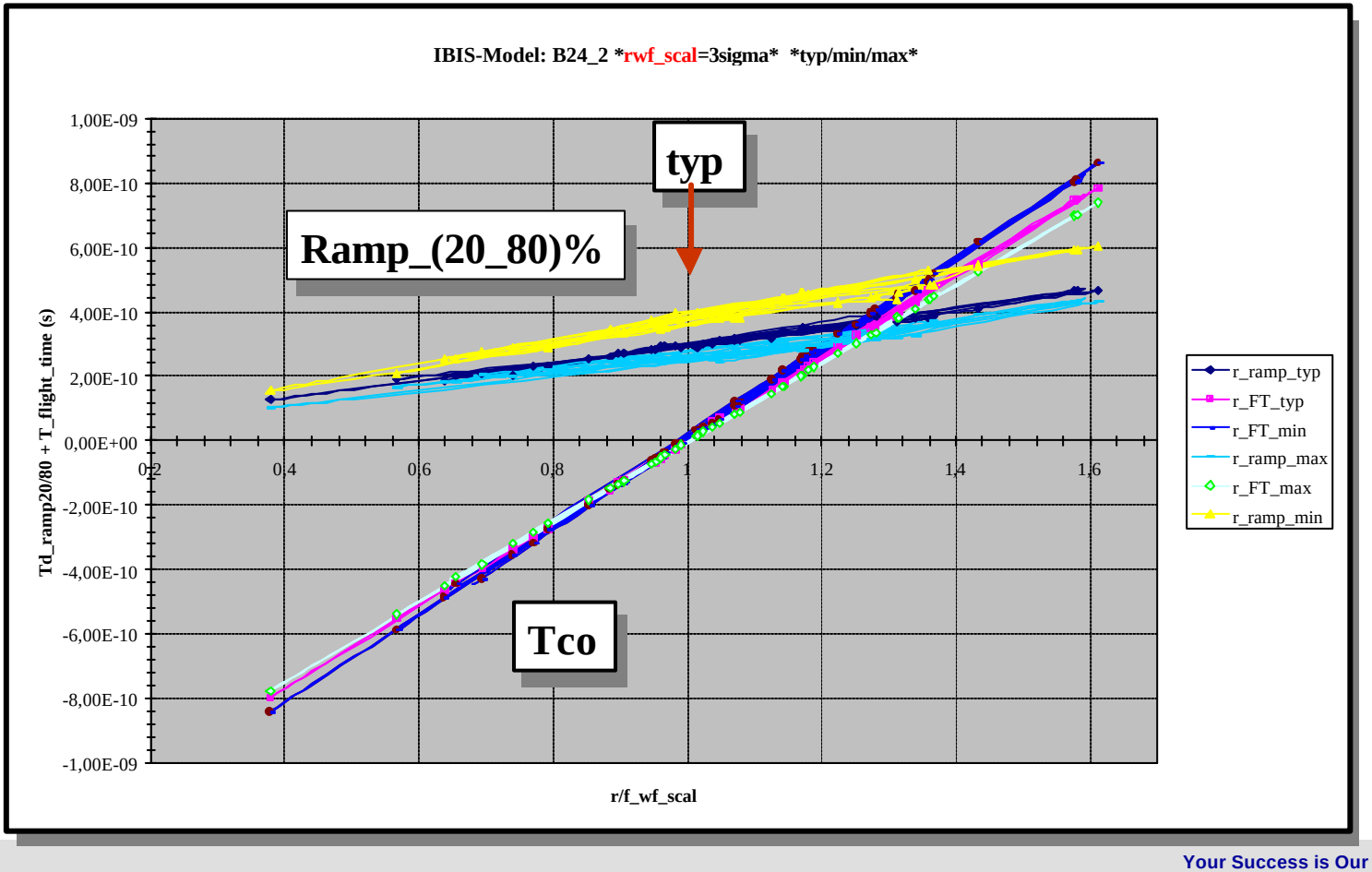
rwf_scal ➔ Rising Waveform



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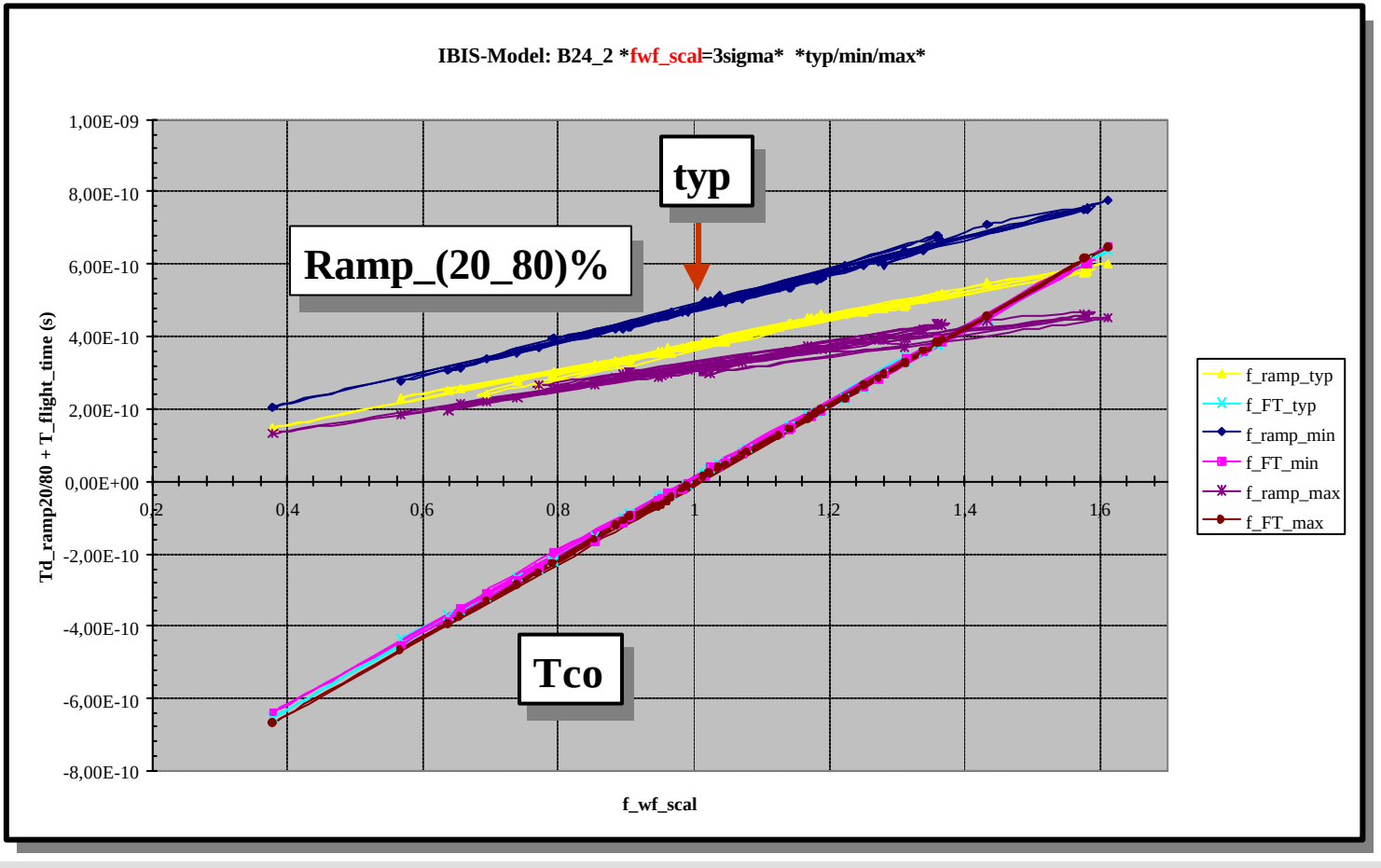
fwf_scal ➔ Falling Waveform



Sensitivity analysis on a 4 RAM topology

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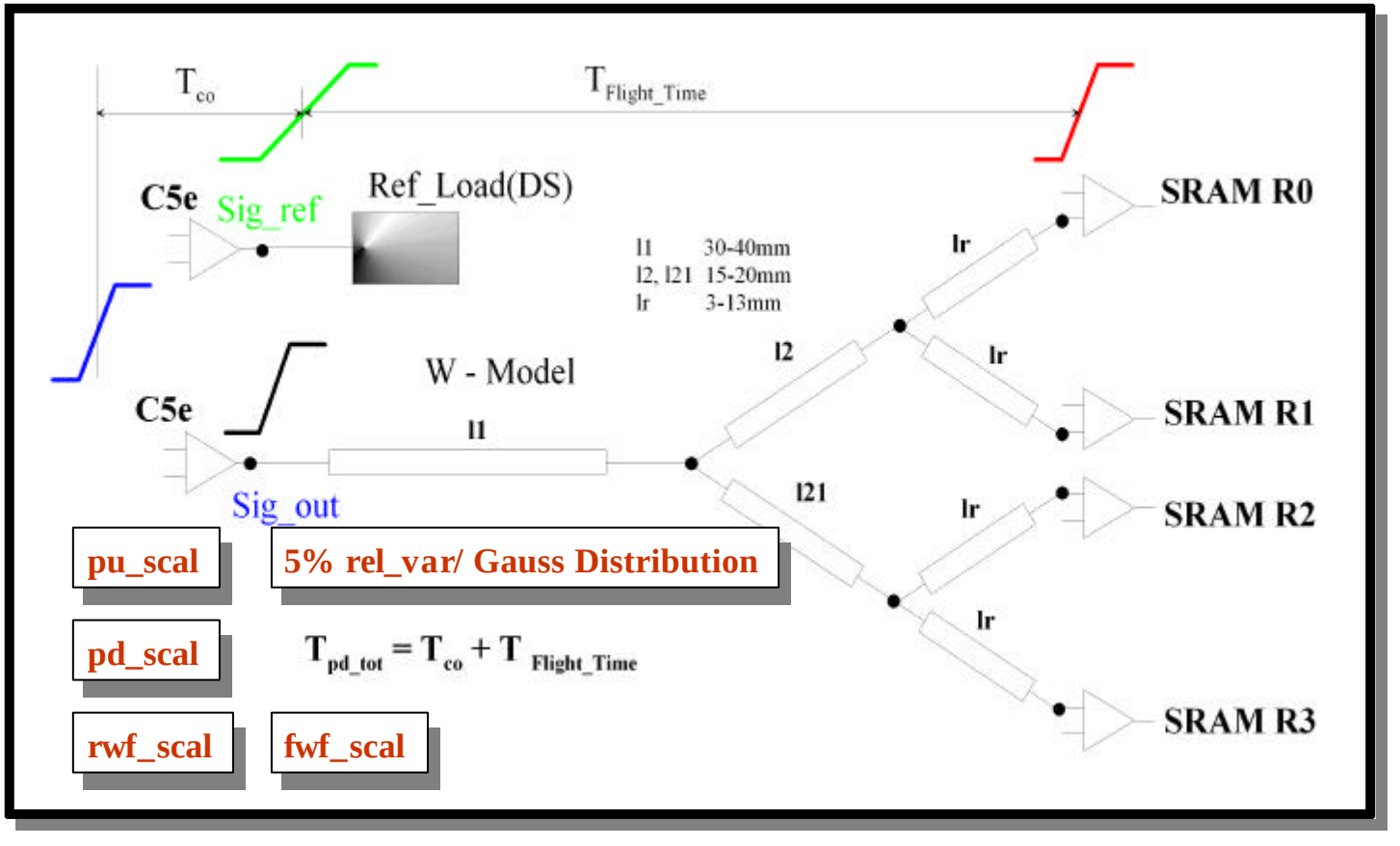

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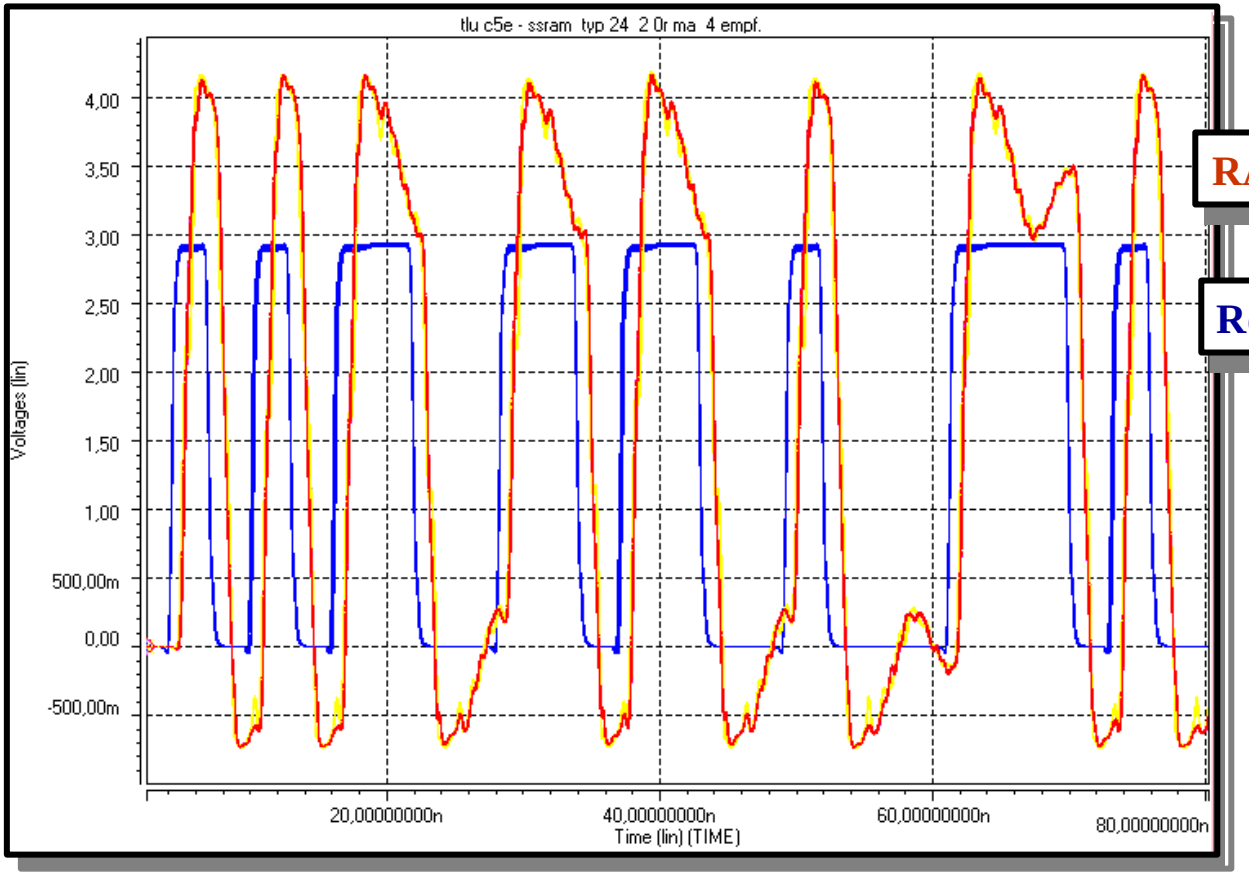
Signal Integrity (SI) and ISI ➔ FT



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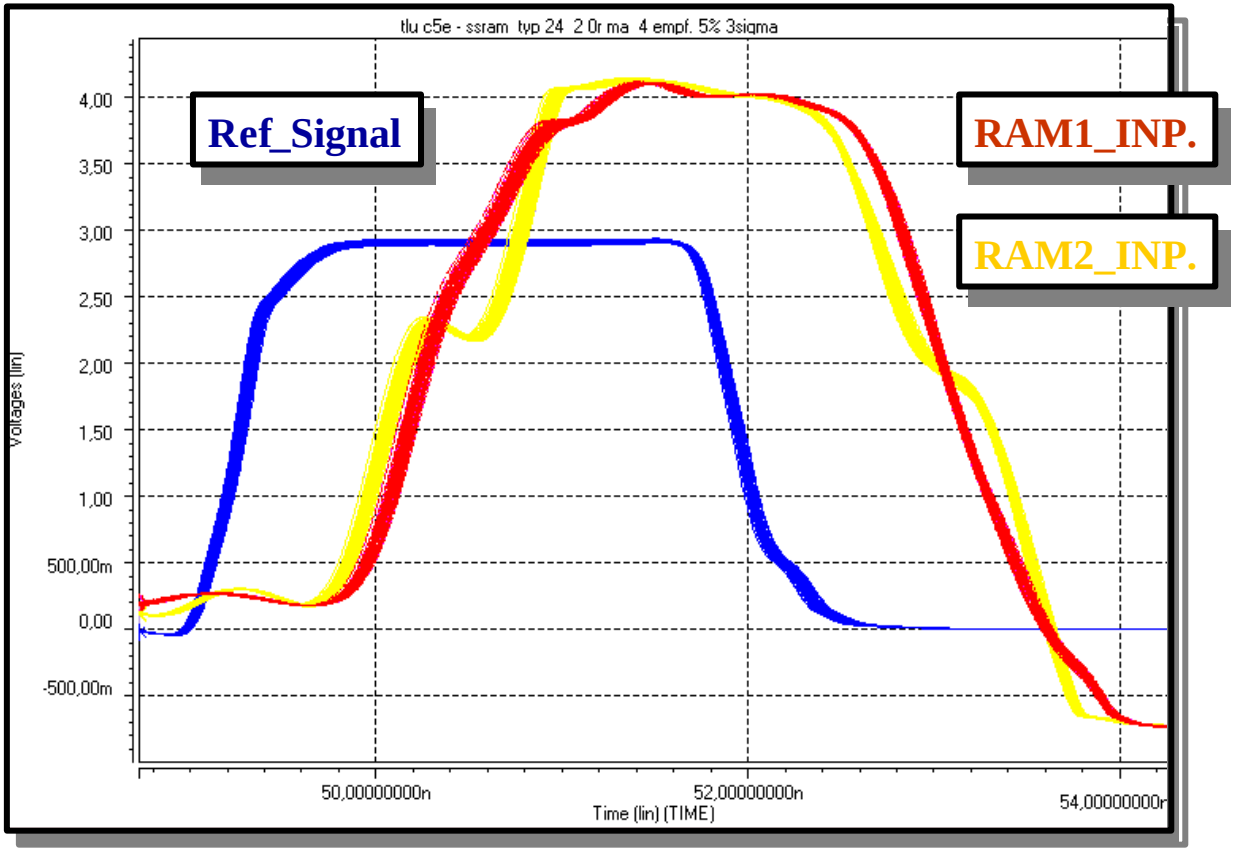
Signal integrity (SI) and ISI (Zoom)



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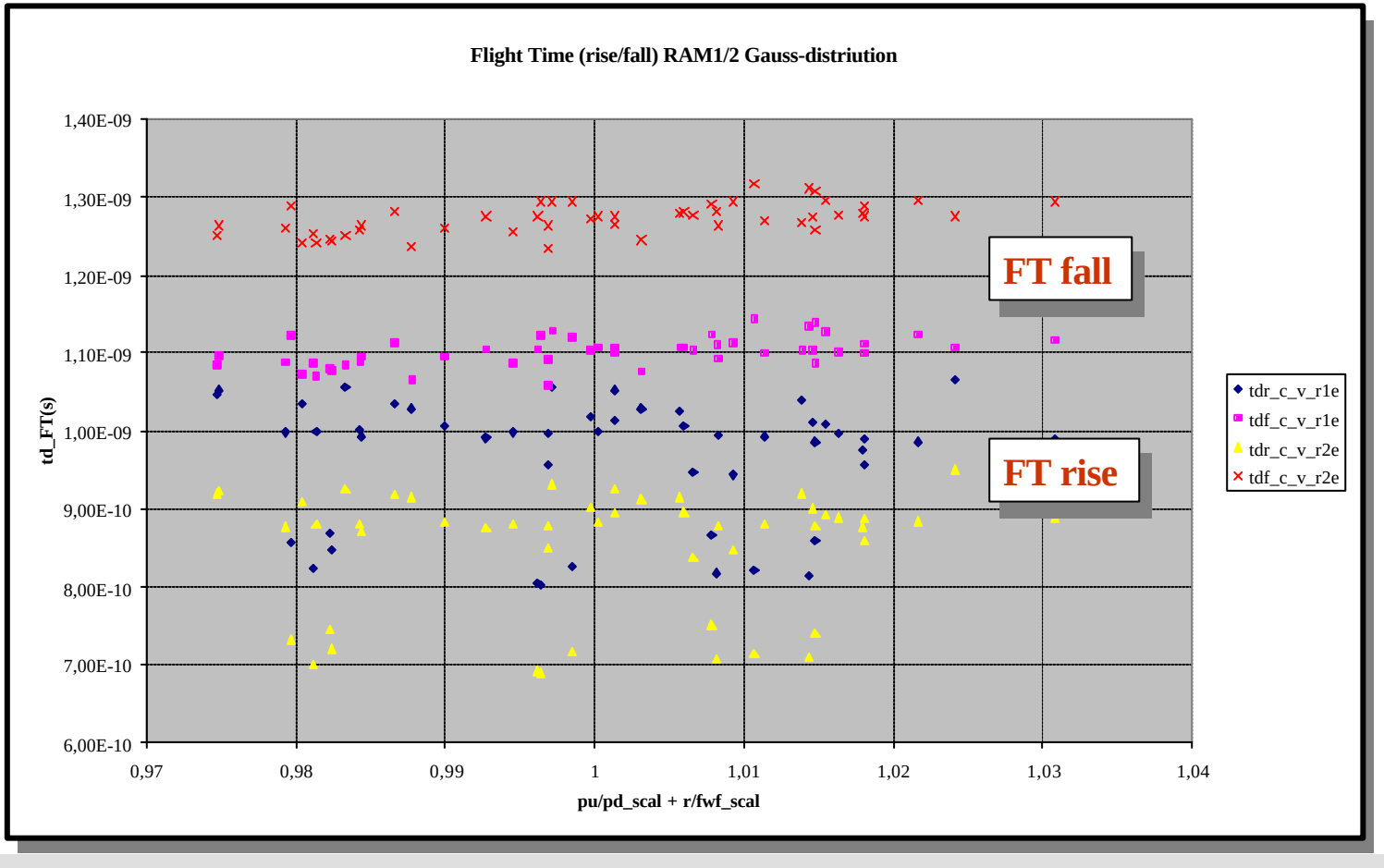
Flight Time of the RAM1&2



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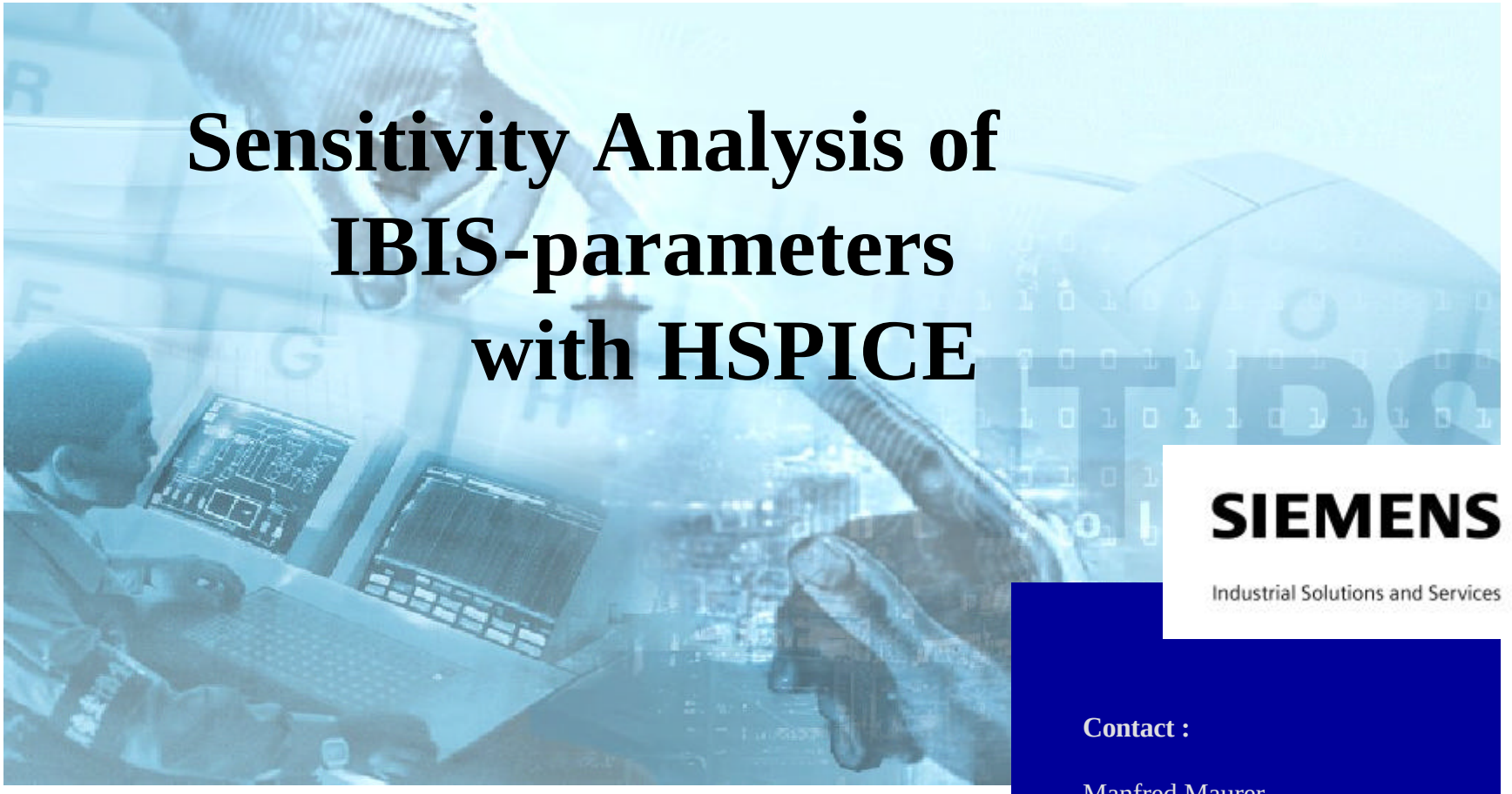
Summary

- The analysed model parameter are **simulator specific**,
  not IBIS model intrinsic
- The HSPICE **B-element** ➔ external controlled parameters for model scaling
  - **Pu/pd** parameter ➔**direct** control of the static current
    (parameter+10% ➔ +10%I)
  - **WF**-parameter ➔**no** fix correlation to the ramp, **nor** the Tco / FT
    (IBIS-model specific)
- With a **typical IBIS** model ➔ **sensitivity analysis** are possible
- **Robustness** of a design can be quantified by the parameters of the B-element



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Thank you very much for your attention.

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