Micron's IBIS Model Quality Process

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Overview

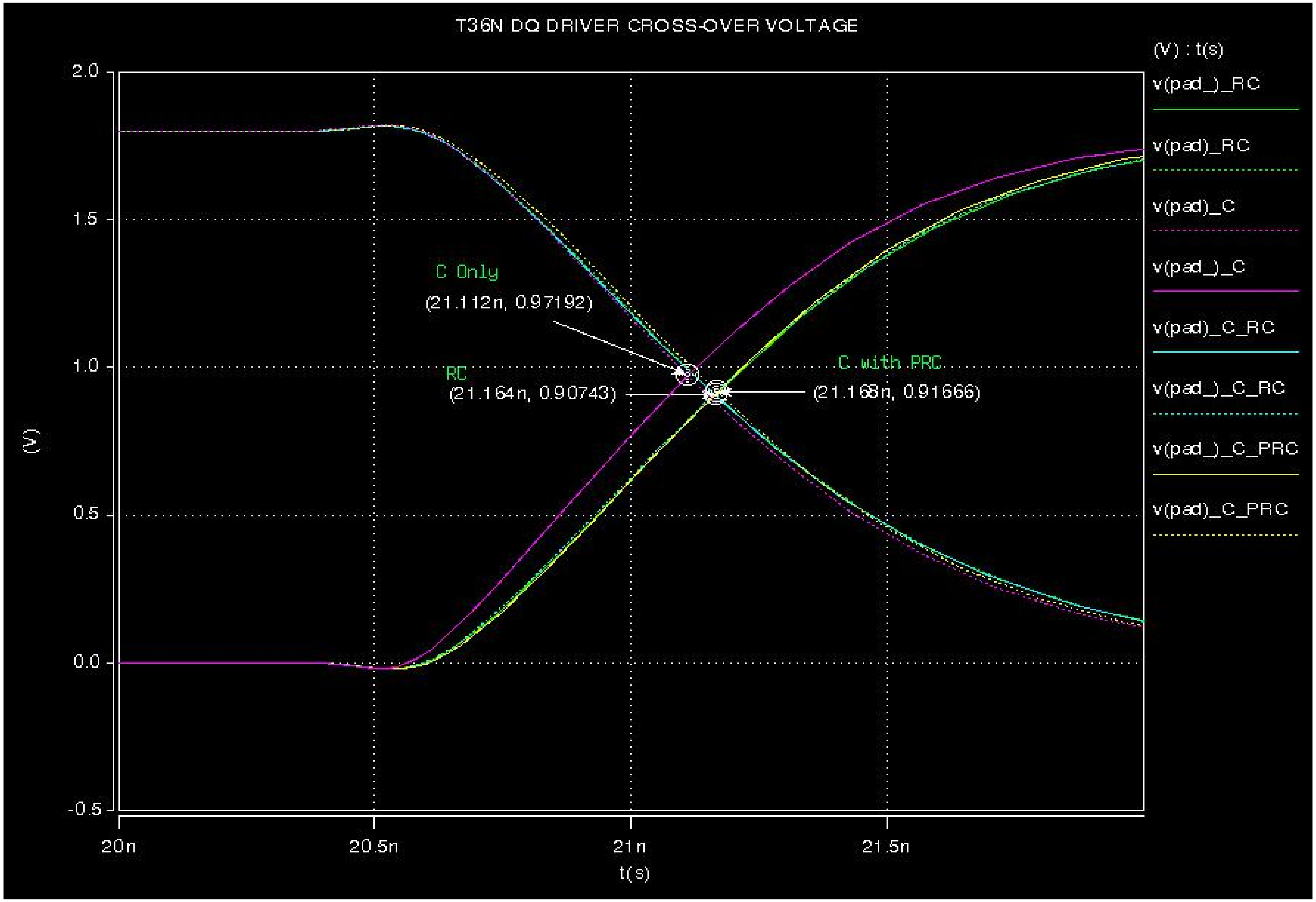
- Micron builds in quality checks into each step of the model creation process
  - Spice netlist creation
  - IBIS creation process
- Quality Report documentation for customers
- Conclusions

Spice netlist creation

- Multiple pre-driver stages are included - critical timing paths unmodified
- Standard Parasitic Format (SPF) netlists are created for circuits with completed layouts
- SPF includes two flavors
  - C only – Capacitance of all layout structures included
  - RC – Resistance and Capacitance included
  - RC is more accurate but creates unreasonably large netlists
  - C only with additional PRC elements on critical nets can approach accuracy of RC netlist but be much smaller

Spice Netlist: SPF Format Effect on Vox

In this example, PRC elements were needed to properly model the effect of long, imbalanced metal lines between the pre-driver logic and pre-driver stages.

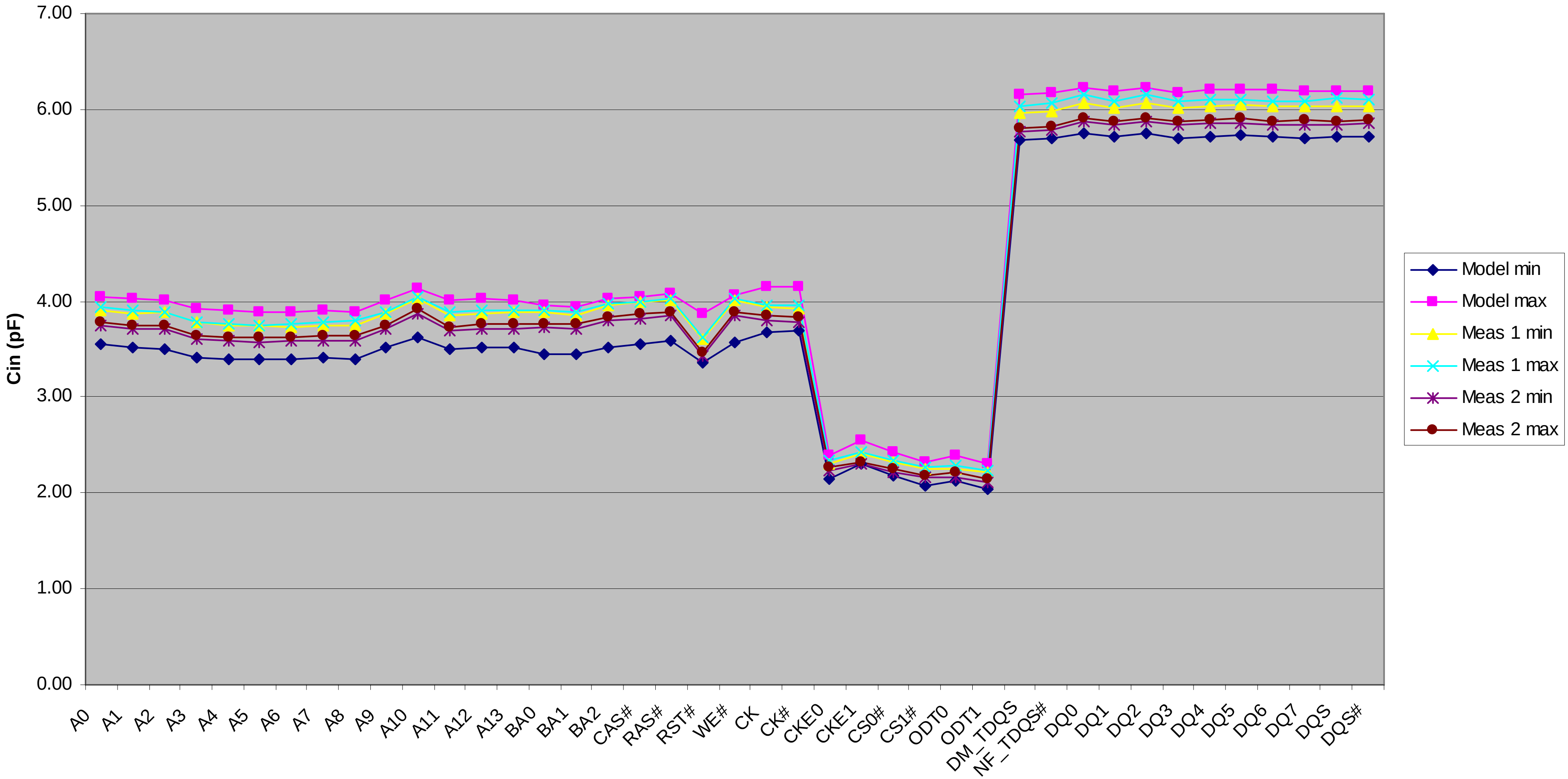


Quality ☑: Correct Vox level

Determining C_comp min/max

C_model_min = C_package + C_comp_min

C_model_max = C_package + C_comp_max



Quality ☑: Correct C_package and C_comp

Correlating I-V curves to Measurements

- Must match exact Process/Voltage/Temp conditions between Spice simulation and Measurement
- Process model adjustment example
  - Process corners set by parameter range: -1=Slow, 0=Typical, 1=Fast
  - IDSN model corners (uA/um) (for specific Vds and Vgs voltage setting)

    Slow: 359.0 Typical: 399.8 Fast: 450.9

    Silicon Measurement: 397.3, Adjusted 6.1% towards Slow (-0.061)
  - IDSP model corners (uA/um)

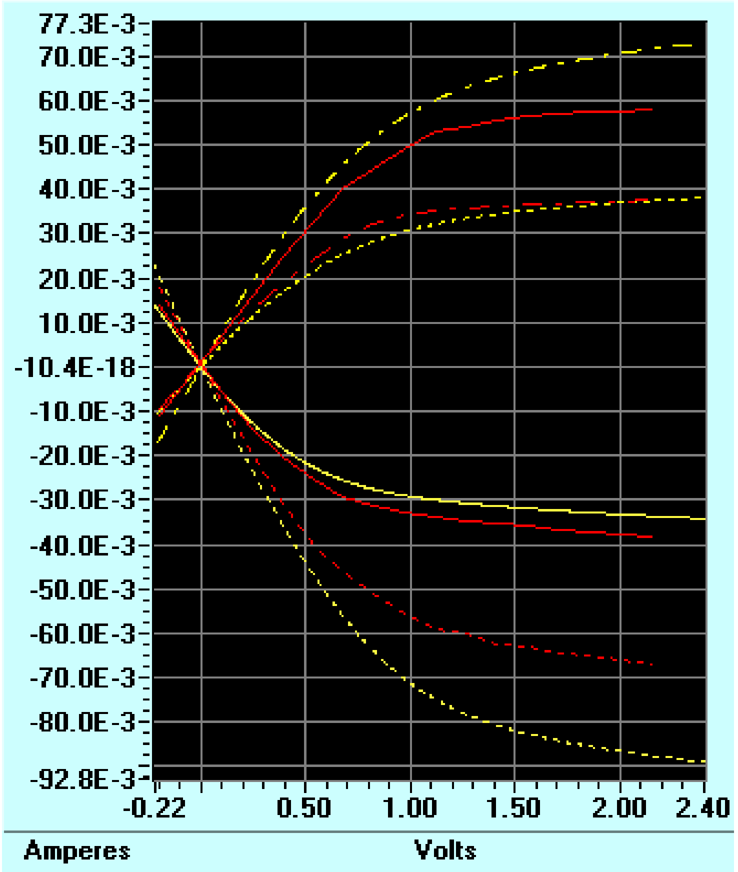
    Slow: 173.1 Typical: 203.7 Fast: 242.1

    Silicon Measurement: 194.1 , Adjusted 31.5% towards Slow (-0.315)

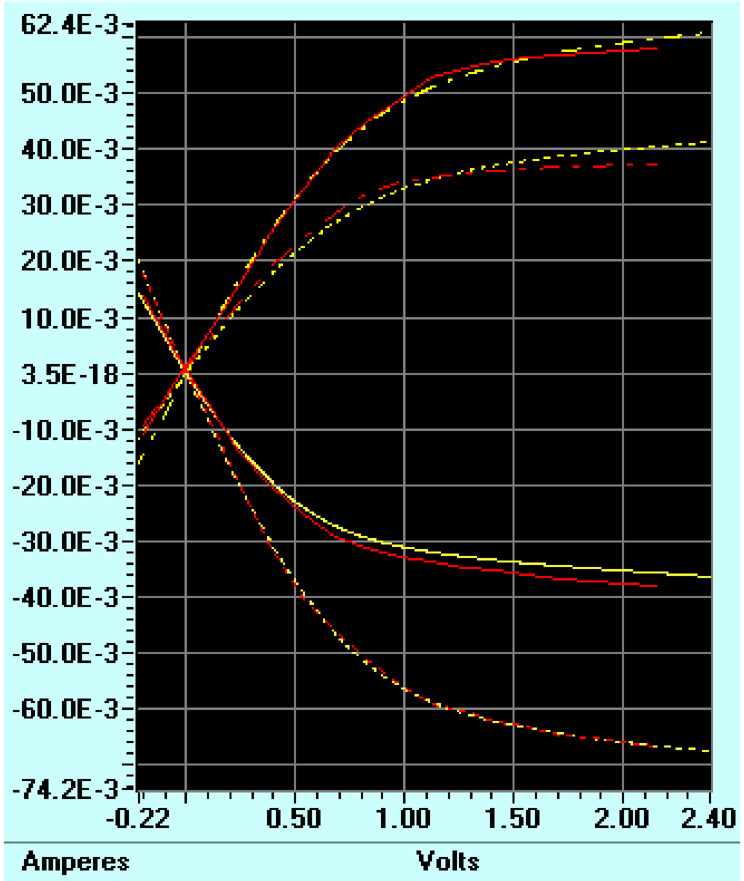
Correlating I-V curves to Measurements

- Model = yellow, Measurement = red

Before PVT Adjustment



After PVT Adjustment



Quality ☑: I–V curves match measurements

Model Quality

- Model Creation Checklists
  - Spice model development

    ☑: Transistor model libraries setup and correlated to speed grades

    ☑: Correct power supply decoupling included in netlists

    ☑: Variable capacitance added to PAD node for proper C_comp variation

    ☑: Clamp diode currents adjusted through bulk node resistance

    ☑: All control signal combinations function properly

Model Quality

- Model Creation Checklists
  - IBIS model development
    - ☑: Run IBISCHK – explain any warnings
    - ☑: Component names and Pin lists agree with the datasheet
    - ☑: Input model parameters match the datasheet
    - ☑: I/O model parameters match the datasheet
    - ☑: V-t curves time correlated and on/off time relationships valid
    - ☑: Combined Submodel curves show proper ODT voltage midpoint termination and resistance

Quality Reports

- IBIS Open Forum – IBIS Quality Task Group
  - Released the IBIS Quality Specification, Rev 1.0, 3/31/04
  - Currently working on an updated release
- Micron follows the IQ Spec, but releases a detailed report with each model
  - Compares model to specification data
  - Compares model to measurement data
  - Compares IBIS model to HSPICE model

Quality Reports - Introduction

IBIS/HSPICE Model Quality Report

Design ID: T35M
Description: 128Mb Mobile DDR SDRAM
Marketing device name(s): MT46H8M16LFBF, MT46H4M32LFB5, MT46H8M16LFT35M, MT46H4M32LFT35M
Valid Speed Grades: -75 (266), -6 (333), -54 (370), -5 (400)
Zip File Name: t35m_ibis.zip, t35m_it_ibis.zip
IBIS File name: t35m.ibs, t35m_it.ibs File rev: 2.0, 2.0
HSPICE File name: t35m_hspice.zip File rev: 2.0
EBD file name (if applicable): File rev:
Die Rev: K
Date: October 8, 2008
Datasheet Link:
http://download.micron.com/pdf/datasheets/dram/mobile/128mb_mobile_ddr_sdram_t35m.pdf

E-mail at modelsupport@micron.com for questions regarding Quality Report

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Device Parameters

VDDQ – Slow: 1.70 Typical: 1.80 Fast: 1.95
VDD – Slow: 1.70 Typical: 1.80 Fast: 1.95
Junction Temperature (Commercial) - Slow: 85 Typical: 40 Fast: 0
Junction Temperature (Industrial) - Slow: 100 Typical: 40 Fast: -40
VDDQ/VSSQ Decoupling Capacitance: 2.76nF
Included in HSPICE DQ/DQS models? yes Amount per DQ/DQS model: 76.66pF
VDDQ/VSSQ Decoupling Capacitance Series Resistance: 1 ohm

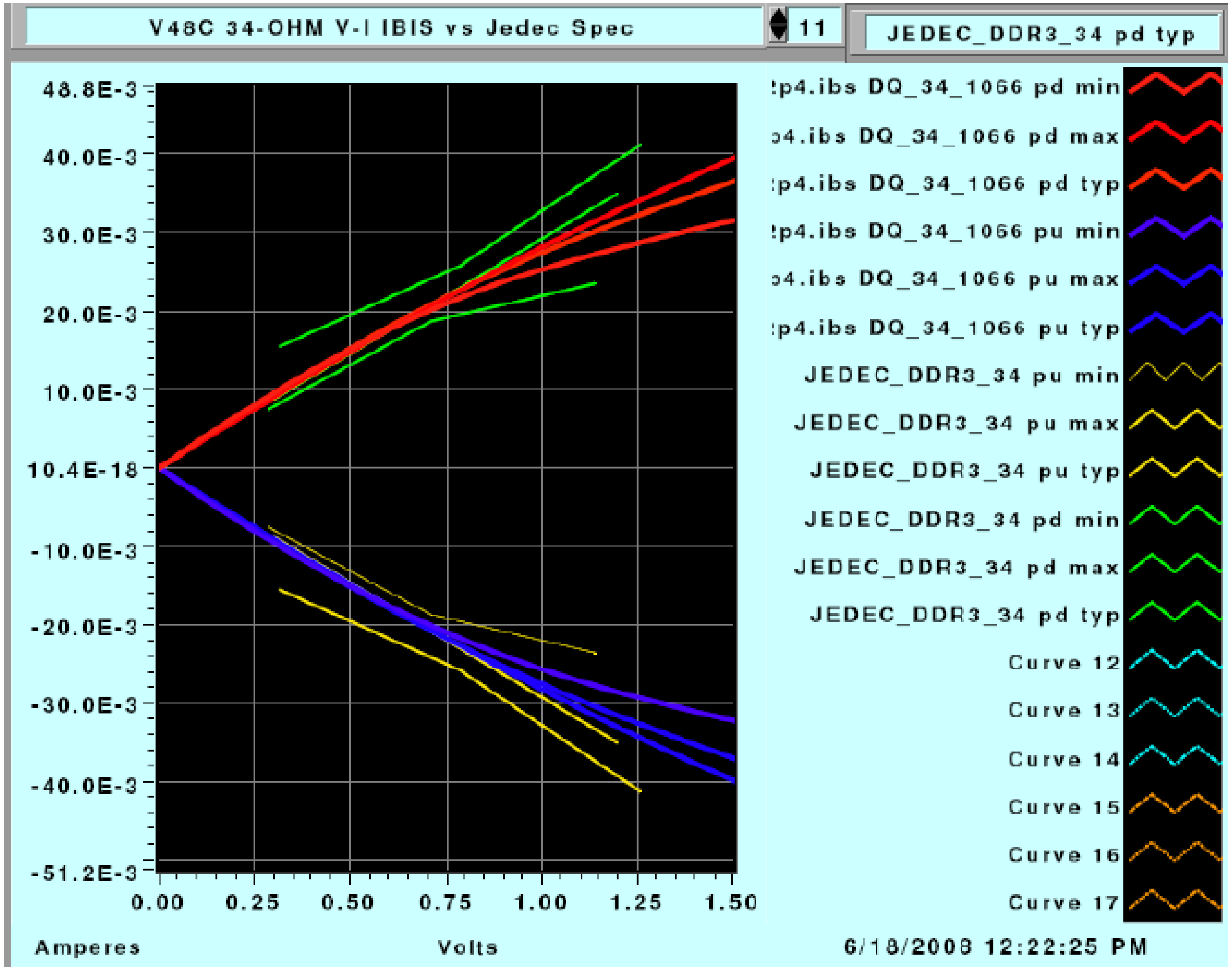
Quality Reports – IQ Summary

- IBIS Quality Summary included based on IQ 1.0 specification
- Report will detail IQ 1.1 spec once released
- IBIS model does not include full IQ Summary, but instead states:

|IQ SUMMARY Overall Quality of component and models Level 2b

|See Micron IBIS Model Quality Report for full IQ SUMMARY

Quality Reports – IOH/IOL vs. Spec



Quality Reports – C_comp, ODT & Slew Rates vs. Specification

C_comp

		IBIS		Datasheet (DDR3-1600)	
		Min	max	min	max
DQ	C_comp	1.55pF	1.94pF		
	C package	0.20pF	0.26pF		
	C_total	1.75pF	2.2pF	1.5pF	2.3pF
INPUT	C_comp	0.6pF	0.91pF		
	C package	0.17pF	0.36pF		
	C_total	0.77pF	1.27pF	0.75pF	1.3pF
CLK	C_comp	0.76pF	0.99pF		
	C package	0.20pF	0.21pF		
	C_total	0.96pF	1.20pF	0.8pF	1.4pF

ODT

	TYP	MIN	MAX
Vinl (V)	0.575	0.5375	0.6125
Vinh(V)	0.925	0.8875	0.9625
Iinl (A)	-0.0073	-0.0068	-0.00793
Iinh (A)	0.007425	0.00615	0.00789
Rtt (Model)	23.77	22.12	27.03
Rtt (datasheet-in units of ZQ/12)	1.00	0.90	1.60
Rtt (datasheet)	20.00	18.00	32.00

Slew Rates

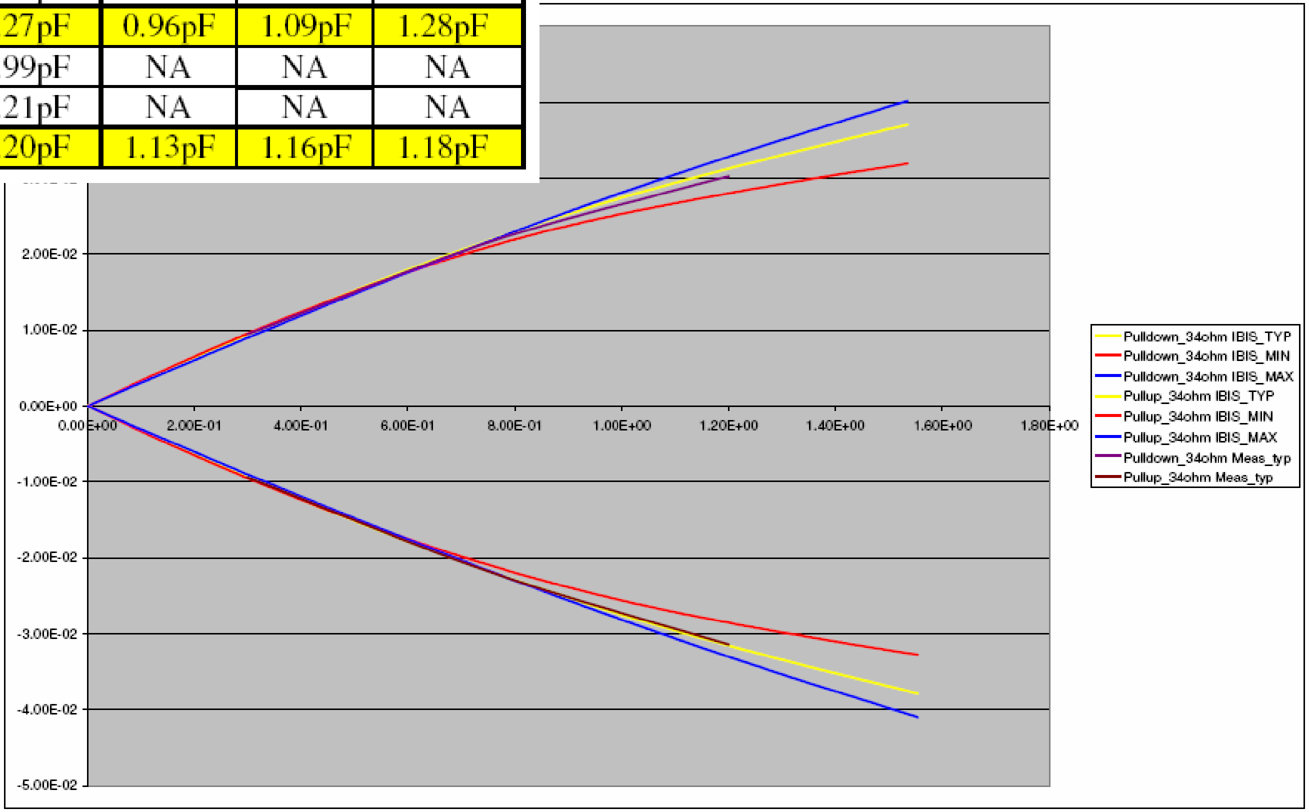
		Simulation			Datasheet	
Model	Slew Rate (V/ns)	min	Typ	max	min	max
DQ_34_1066	Rising	2.27	2.84	3.88	2.5	5
	Falling	3.24	4.03	5.17	2.5	5
DQ_34_1333	Rising	3.15	3.25	4.31	3	5
	Falling	4.72	4.9	6.63	3	5
DQ_34_1600	Rising	3.83	3.87	3.92	3	5
	Falling	4.25	4.45	6	3	5

Quality Reports – C_comp & IOH/IOL vs. Measurement

C_comp

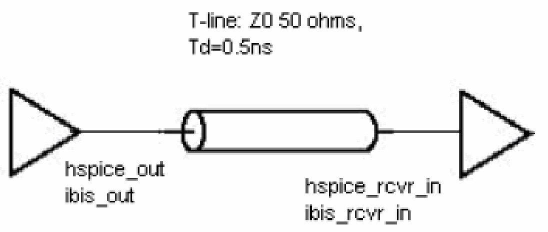
		IBIS			Measured		
		Min	Typ	max	min	typ	max
DQ	C_comp	1.55pF	1.72pF	1.94pF	NA	NA	NA
	C package	0.20pF	0.22pF	0.26pF	NA	NA	NA
	C_total	1.75pF	2.02pF	2.2pF	1.90pF	2.01pF	2.20pF
INPUT	C_comp	0.6pF	0.77pF	0.91pF	NA	NA	NA
	C package	0.17pF	0.25pF	0.36pF	NA	NA	NA
	C_total	0.77pF	1.31pF	1.27pF	0.96pF	1.09pF	1.28pF
CLK	C_comp	0.76pF	0.87pF	0.99pF	NA	NA	NA
	C package	0.20pF	0.21pF	0.21pF	NA	NA	NA
	C_total	0.96pF	1.29pF	1.20pF	1.13pF	1.16pF	1.18pF

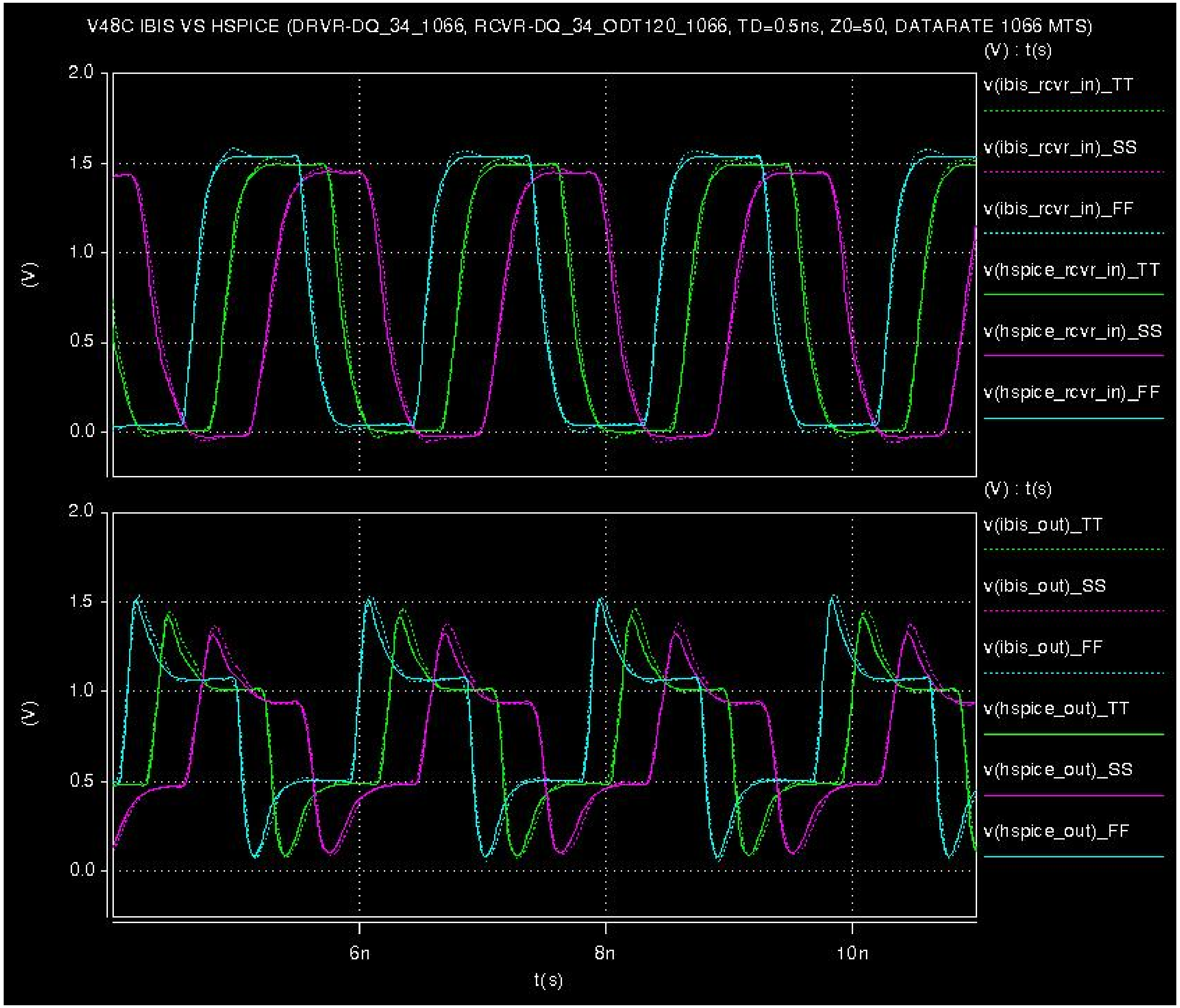
IOH/IOL



Quality Reports – IBIS vs. HSPICE

Test load





Conclusions

- Model users demand quality models
- IBIS Quality Committee work is essential for standardizing quality levels and methods
- IBIS Quality checklists work to maintain quality standards
- Quality Reports go above and beyond checklists to document thorough model checking
- Demand Quality models from vendors!
  - Show them examples of quality models.

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