

Design ID: **Z01A**

Description: **8Gb DDR4 SDRAM**

Marketing device name(s): **MT40A2G4WE, MT40A1G8WE, MT40A512M16HA, MT40A2G4Z01A, MT40A1G8Z01A, MT40A512M16Z01A**

Valid speed grades: **DDR4-1600, DDR4-1866, DDR4-2133, DDR4-2400, DDR4-2666, DDR4-2933, DDR4-3200**

Zip filename: **z01a\_auto\_ibis.zip**

IBIS filename (Version 5.0): **z01a\_ait.ibs, z01a\_aat.ibs, z01a\_aut.ibs** File rev: **2.1**

HSPICE filename: **z01a\_auto\_hspice.zip** File rev: **2.3**

EBD filename (if applicable): File rev:

Die revision: **B**

Date: **February 7, 2018**

Datasheet Link (from micron.com):

[https://www.micron.com/~media/documents/products/datasheet/dram/ddr4/8gb\\_auto\\_ddr4\\_dram.pdf](https://www.micron.com/~media/documents/products/datasheet/dram/ddr4/8gb_auto_ddr4_dram.pdf)

E-mail [modelsupport@micron.com](mailto:modelsupport@micron.com) for questions regarding Quality Report.

## Device Parameters

VDDQ Slow: **1.14V** Typical: **1.20V** Fast: **1.26V**

VDD Slow: **1.14V** Typical: **1.20V** Fast: **1.26V**

Junction Temperature (Industrial) Slow: **110C** Typical: **50C** Fast: **-40C**

Junction Temperature (Automotive) Slow: **120C** Typical: **50C** Fast: **-40C**

Junction Temperature (Ultra-high) Slow: **140C** Typical: **50C** Fast: **-40C**

VDDQ/VSSQ Decoupling Capacitance (Approximate value at 10MHz) – Full Die: **10.65nF**

Included in HSPICE DQ/DQS/DM models? **Yes** Amount per DQ/DQS/DM model: **484pF**

Included in IBIS DQ/DQS/DM models? **No, must be included with separate Spice subcircuit (.ckt files) found in the zip file.**

VDDQ/VSSQ Decoupling Capacitance ESR – Full Die: **45mohm**

VDDQ/VSSQ Decoupling Capacitance ESR – per DQ model: **1ohm**

## **IBIS Quality Summary**

1. ☒ Include the IBIS Quality Specification 2.0 Overall IBIS Quality level. For details on IBIS Quality, reference the quality specification and quality checklist on IBIS quality webpage [http://www.ibis.org/quality\\_wip/checklist.html](http://www.ibis.org/quality_wip/checklist.html).

**Overall IBIS Quality Level: IQ3MSX**

**Exceptions: V-t length in Version 5.0 model is excessive due to inclusion of [Composite Current] I-t data.**

2. ☒ Include the filename of the IBIS Quality Checklist that accompanies this report.

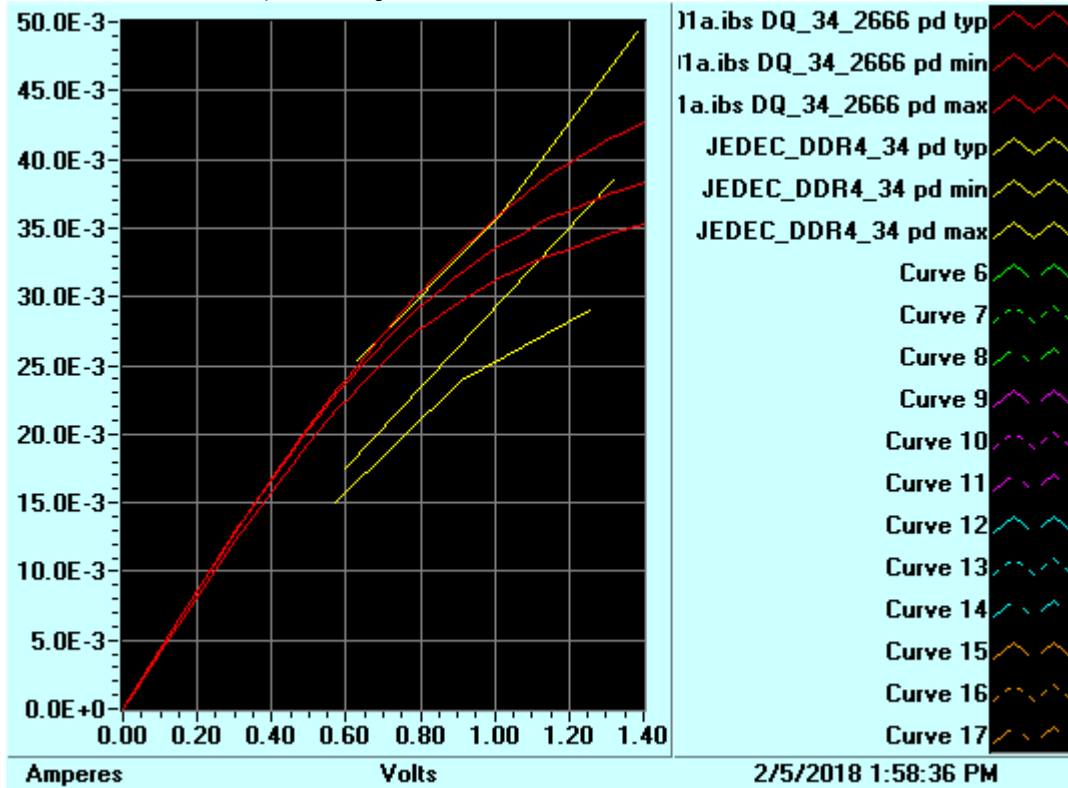
**Filename: z01a\_auto\_ibis\_quality\_checklist.xls**

## **IBIS Model Correlation: Datasheet**

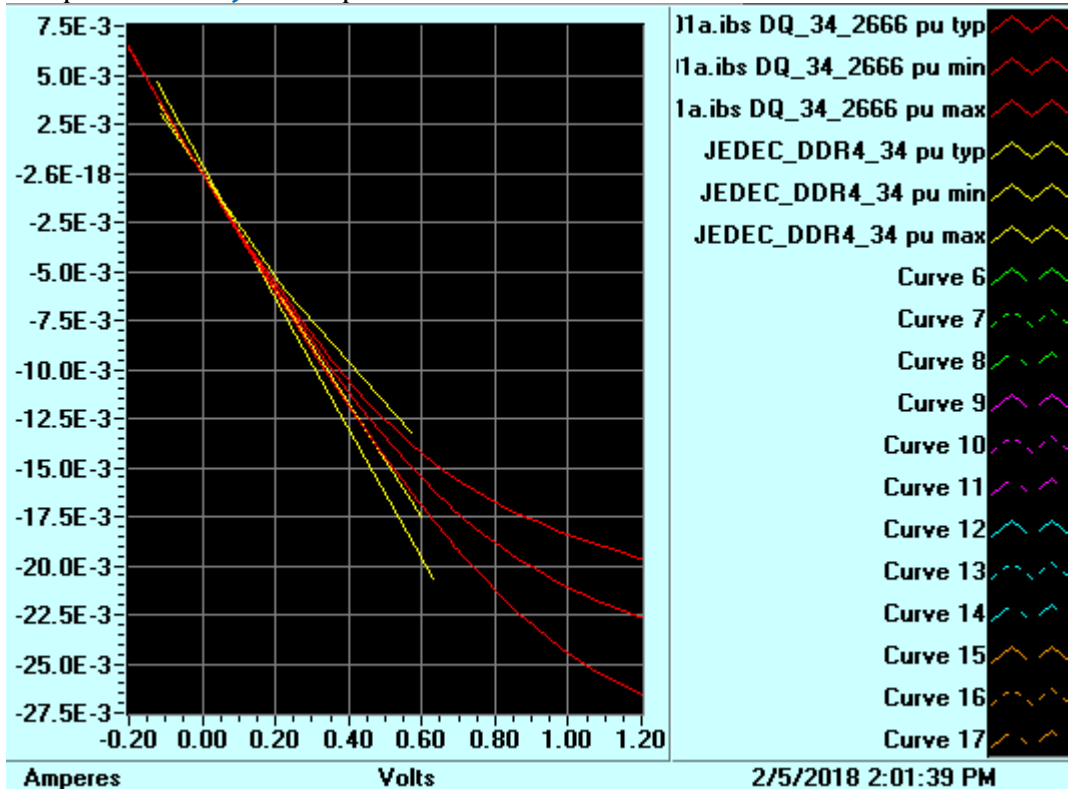
1. ☒ For Output or I/O model compare datasheet IOH/IOL data with IBIS pullup/pulldown data.

a. Model name: **DQ\_34\_2666**

i. Pulldown I-V versus **JEDEC** specification

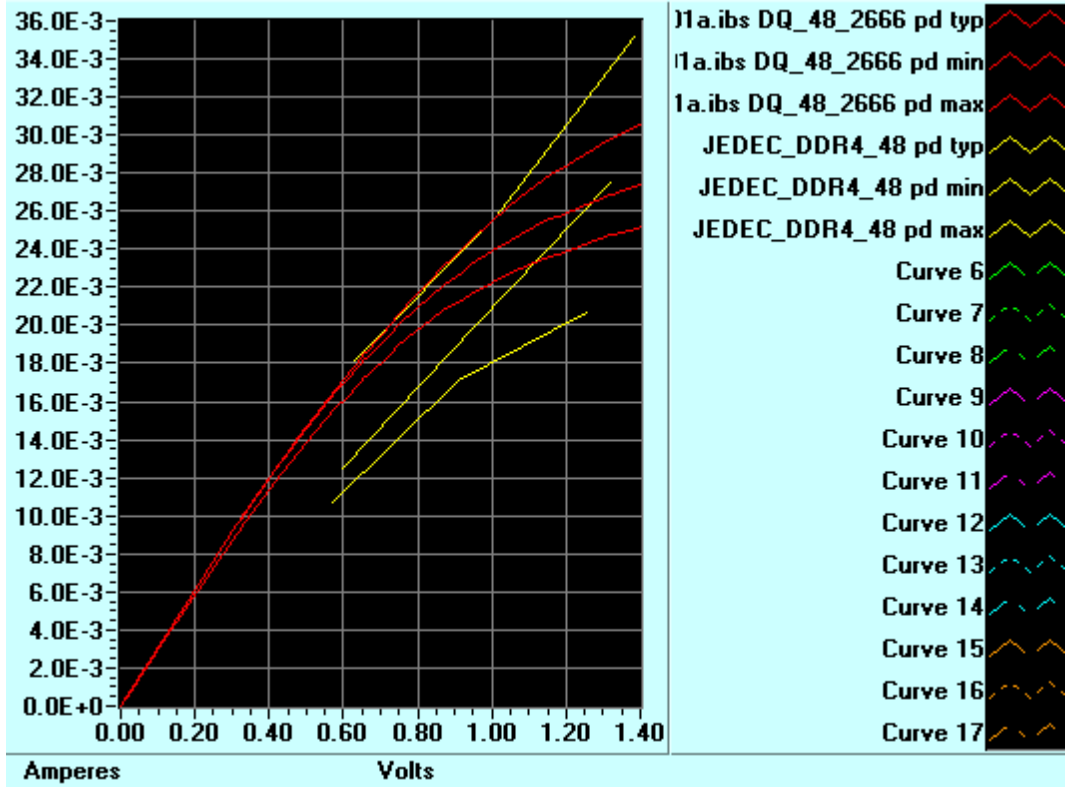


ii. Pullup I-V versus **JEDEC** specification

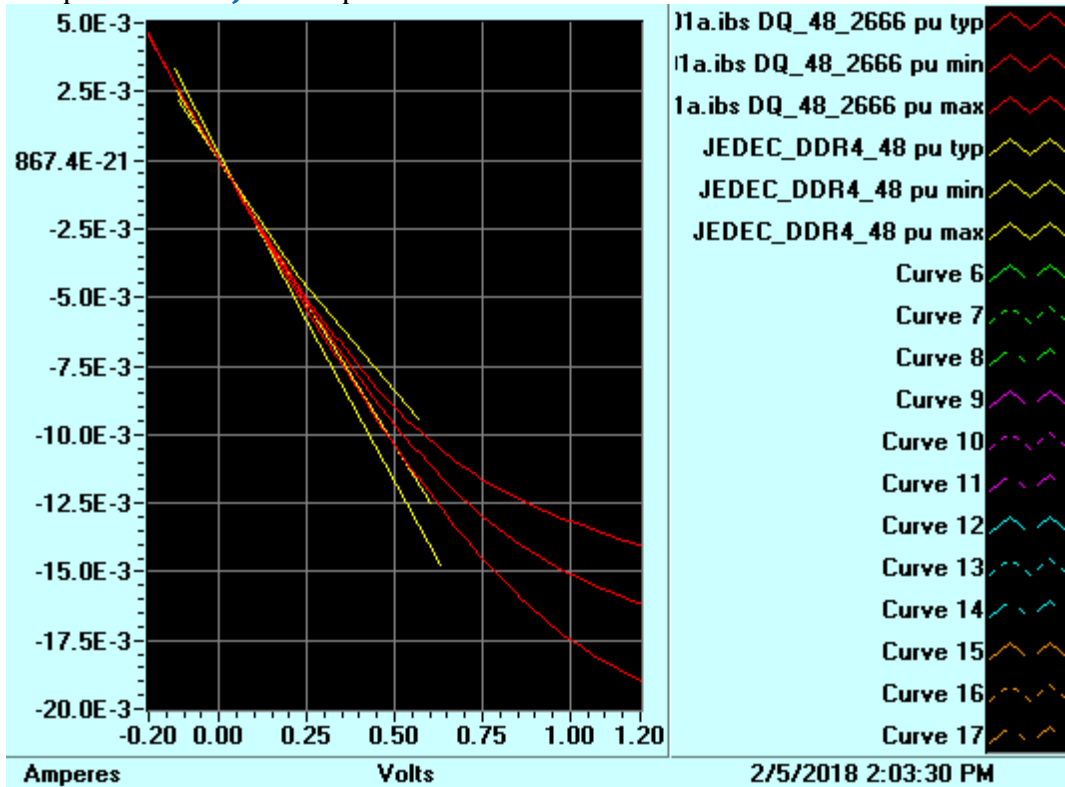


b. Model name: **DQ\_48\_2666**

i. Pulldown I-V versus **JEDEC** specification



ii. Pullup I-V versus **JEDEC** specification



2. ☒ Compare C\_comp with datasheet Input Capacitance. Provide C\_comp comparison table for all models and for all package combinations (i.e. x4, x8 and x16).

Component name: **Bare die**

|              | C_comp IBIS (pF) |      | Cin Datasheet (pF) |      |
|--------------|------------------|------|--------------------|------|
|              | min              | max  | min                | max  |
| <b>DQ</b>    | 0.87             | 0.97 | 0.70               | 1.40 |
| <b>INPUT</b> | 0.42             | 0.52 | 0.20               | 0.80 |
| <b>CLK</b>   | 0.41             | 0.51 | 0.20               | 0.80 |
| <b>CTRL</b>  | 0.38             | 0.48 | 0.20               | 0.80 |
| <b>ALERT</b> | 0.76             | 0.86 | 0.50               | 1.50 |

3. ☒ Compare package impedance and time delay with datasheet specifications. Provide comparison table for all package combinations.

Component name: **MT40A1G8WE, MT40A2G4WE (78-Ball, x4/x8)**

|                | Z_pkg IBIS ( $\Omega$ ) |      | Z_pkg Datasheet ( $\Omega$ ) |     | Td_pkg IBIS (ps) |      | Td_pkg Datasheet (ps) |     |
|----------------|-------------------------|------|------------------------------|-----|------------------|------|-----------------------|-----|
|                | min                     | max  | min                          | max | min              | max  | min                   | max |
| <b>IO</b>      | 55.2                    | 60.3 | 50                           | 85  | 25.5             | 30.2 | 14                    | 37  |
| <b>ADD/CMD</b> | 55.5                    | 69.5 | 55                           | 90  | 20.6             | 28.7 | 14                    | 36  |
| <b>CTRL</b>    | 56.5                    | 70.1 | 55                           | 90  | 19.5             | 28.0 | 14                    | 36  |
| <b>CLK</b>     | 60.0                    | 63.7 | 60                           | 90  | 30.0             | 30.3 | 14                    | 34  |
| <b>ALERT</b>   | 67.3                    | 67.3 | 40                           | 100 | 33.2             | 33.2 | 20                    | 55  |

Component name: **MT40A512M16JY (96-Ball, x16)**

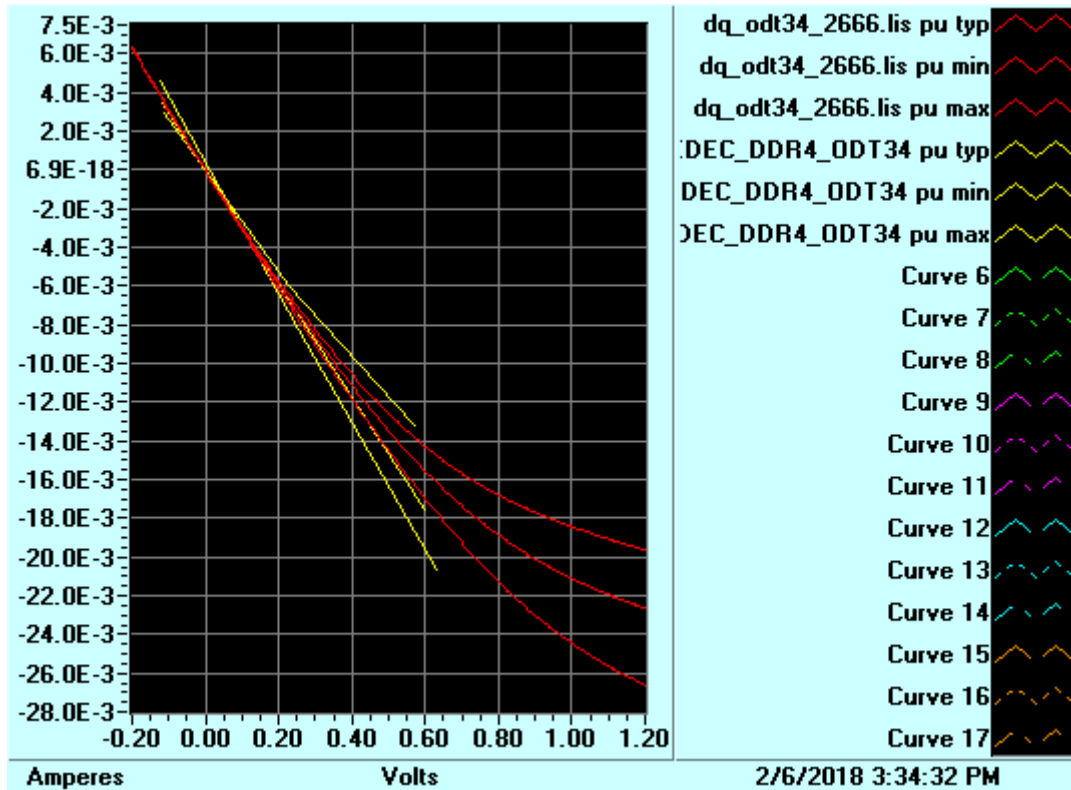
|                | Z_pkg IBIS ( $\Omega$ ) |      | Z_pkg Datasheet ( $\Omega$ ) |     | Td_pkg IBIS (ps) |      | Td_pkg Datasheet (ps) |     |
|----------------|-------------------------|------|------------------------------|-----|------------------|------|-----------------------|-----|
|                | min                     | max  | min                          | max | min              | max  | min                   | max |
| <b>IO</b>      | 54.5                    | 63.2 | 50                           | 85  | 22.2             | 26.1 | 14                    | 37  |
| <b>ADD/CMD</b> | 54.7                    | 69.1 | 55                           | 90  | 19.0             | 27.4 | 14                    | 36  |
| <b>CTRL</b>    | 58.9                    | 67.8 | 55                           | 90  | 20.8             | 24.2 | 14                    | 36  |
| <b>CLK</b>     | 62.0                    | 63.6 | 60                           | 90  | 23.1             | 23.7 | 14                    | 34  |
| <b>ALERT</b>   | 64.7                    | 64.7 | 40                           | 100 | 32.8             | 32.8 | 20                    | 55  |

4. ☒ If slew rate specifications (rise/fall slew) are available from the datasheet, complete Spice simulations to generate slew rate data and provide a comparison table.

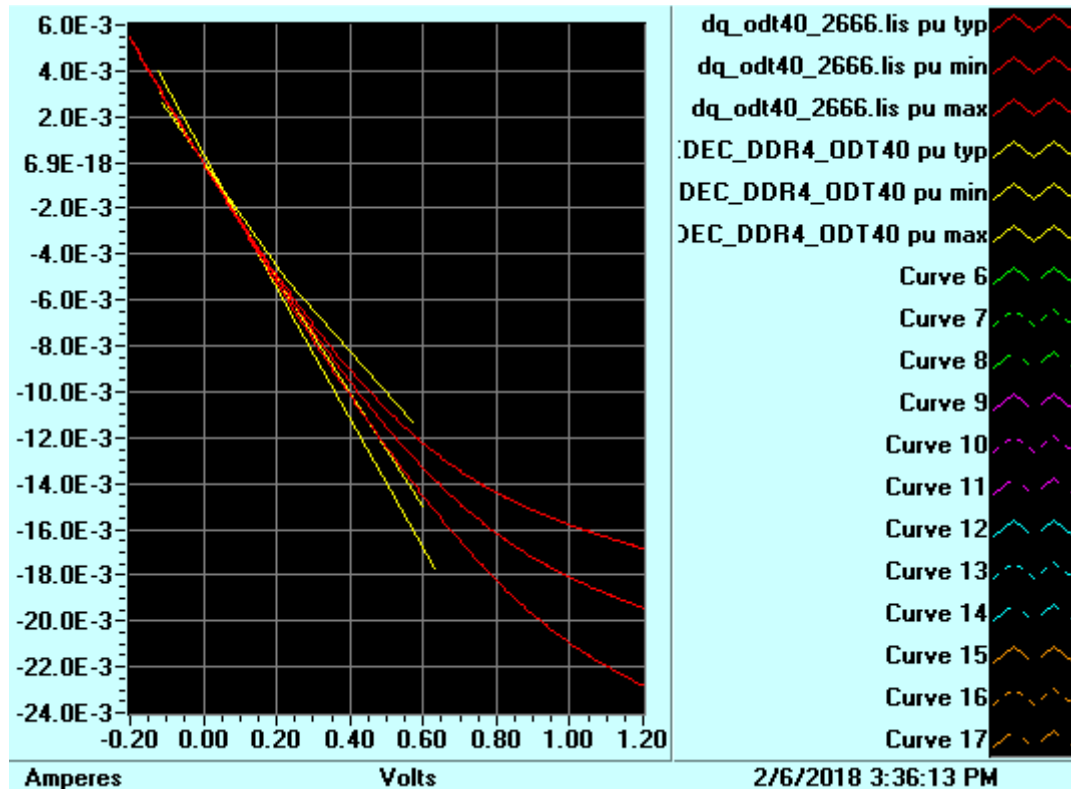
| Model             | Slew Rate (V/ns) | IBIS simulation |      |      | Datasheet |      |
|-------------------|------------------|-----------------|------|------|-----------|------|
|                   |                  | min             | typ  | max  | min       | max  |
| <b>DQ_34_2666</b> | Rising           | 5.52            | 7.11 | 7.98 | 4.00      | 9.00 |
|                   | Falling          | 5.45            | 6.90 | 8.06 | 4.00      | 9.00 |
| <b>DQ_34_3200</b> | Rising           | 6.13            | 7.07 | 7.92 | 4.00      | 9.00 |
|                   | Falling          | 6.00            | 7.07 | 7.85 | 4.00      | 9.00 |

## 5. Compare ODT data with datasheet.

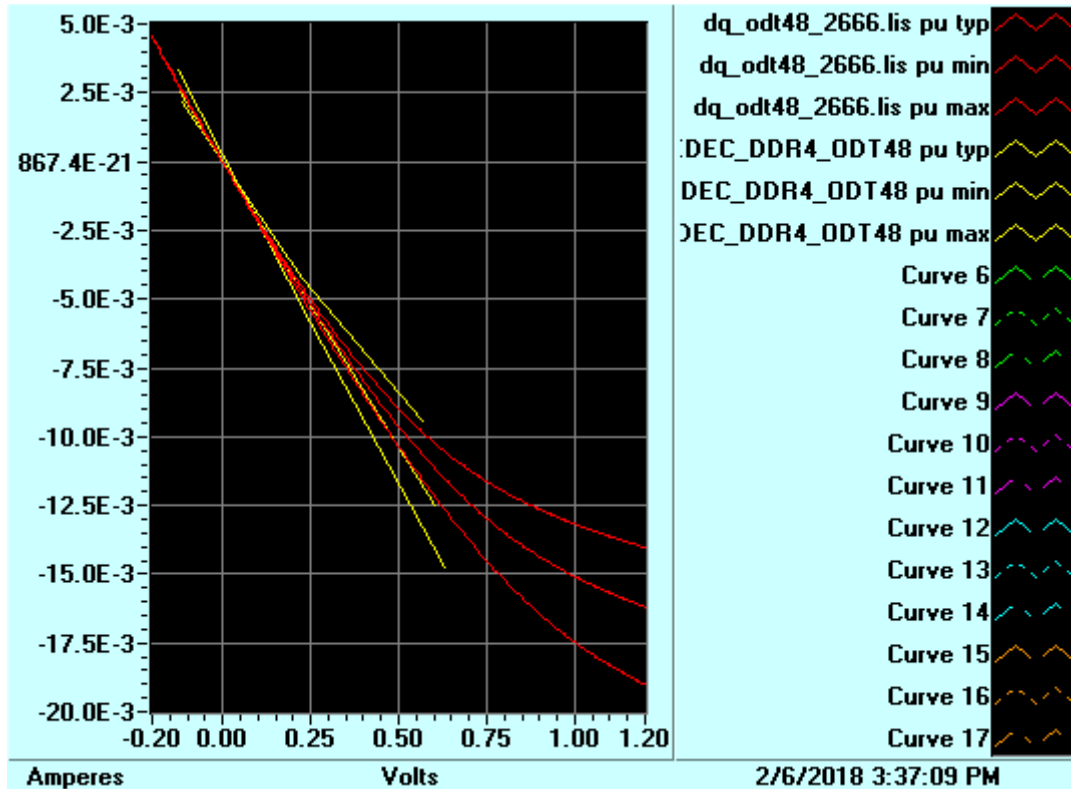
### a. ODT34



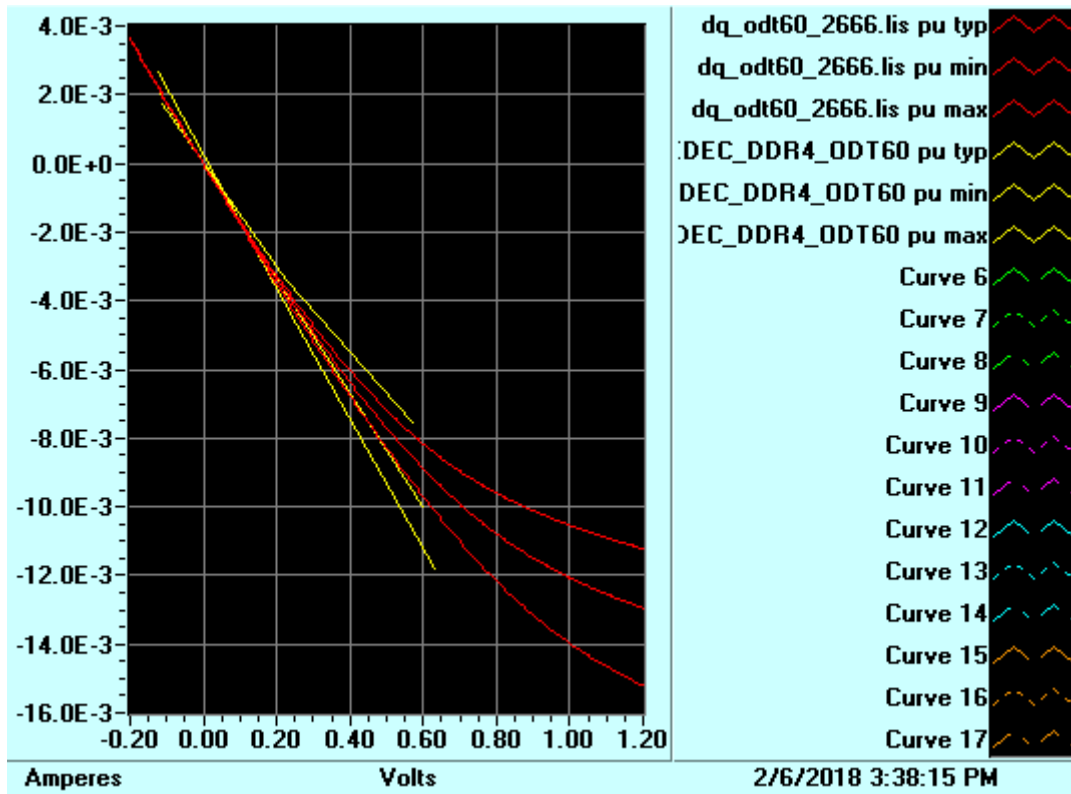
### b. ODT40



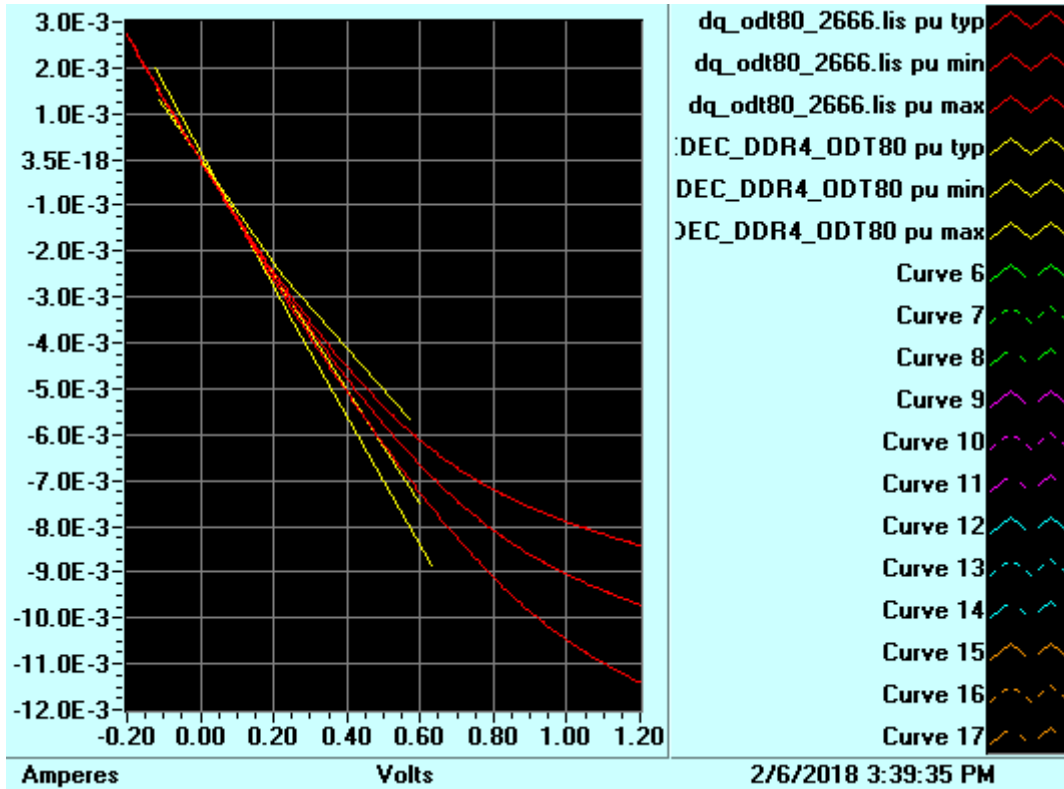
## c. ODT48



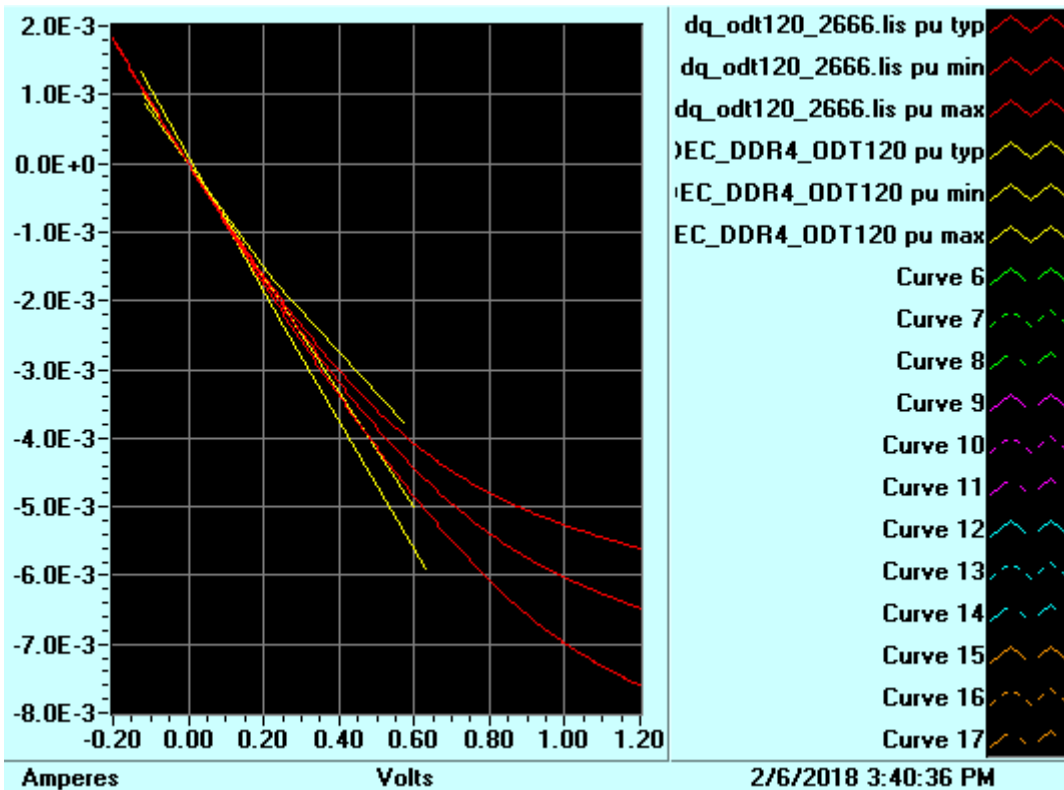
## d. ODT60



## e. ODT80

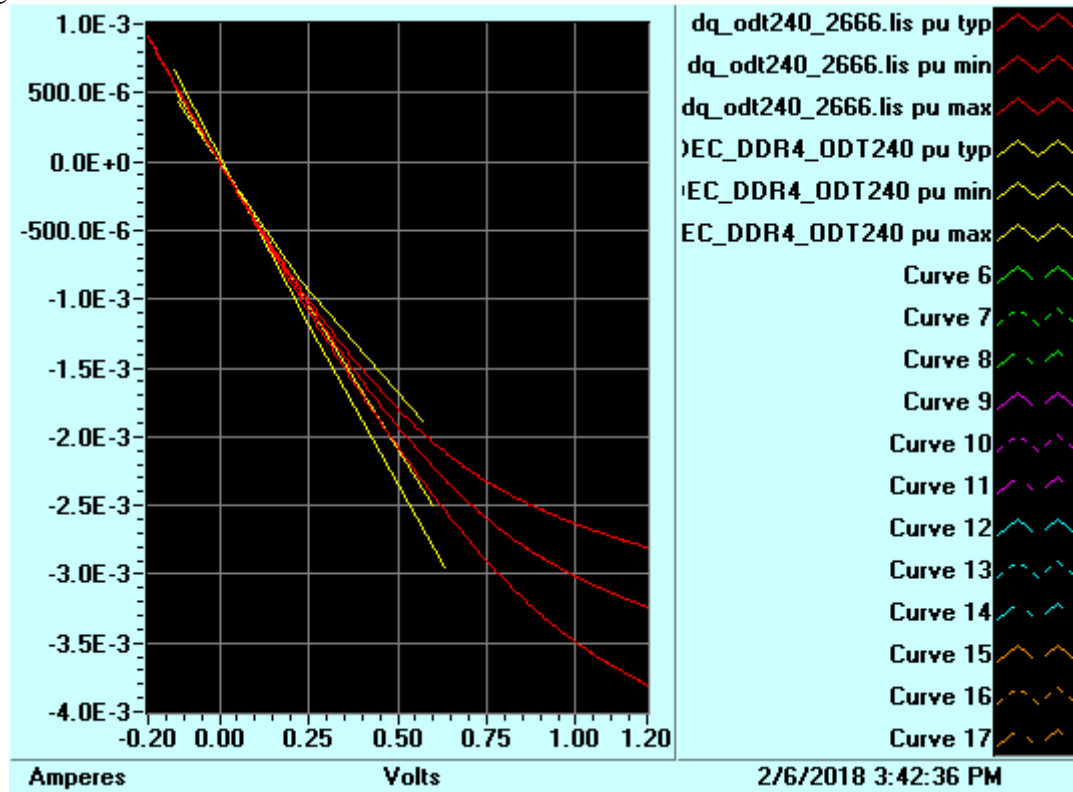


## f. ODT120





g. **ODT240**

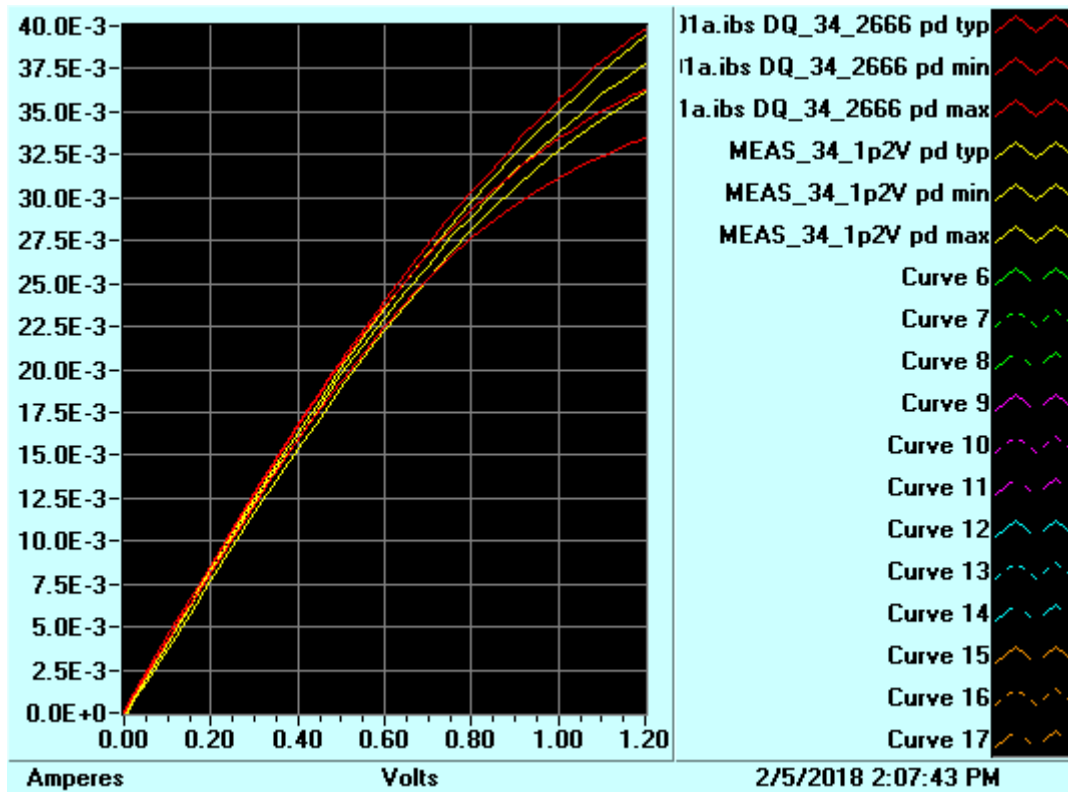


## IBIS Model Correlation: measurements

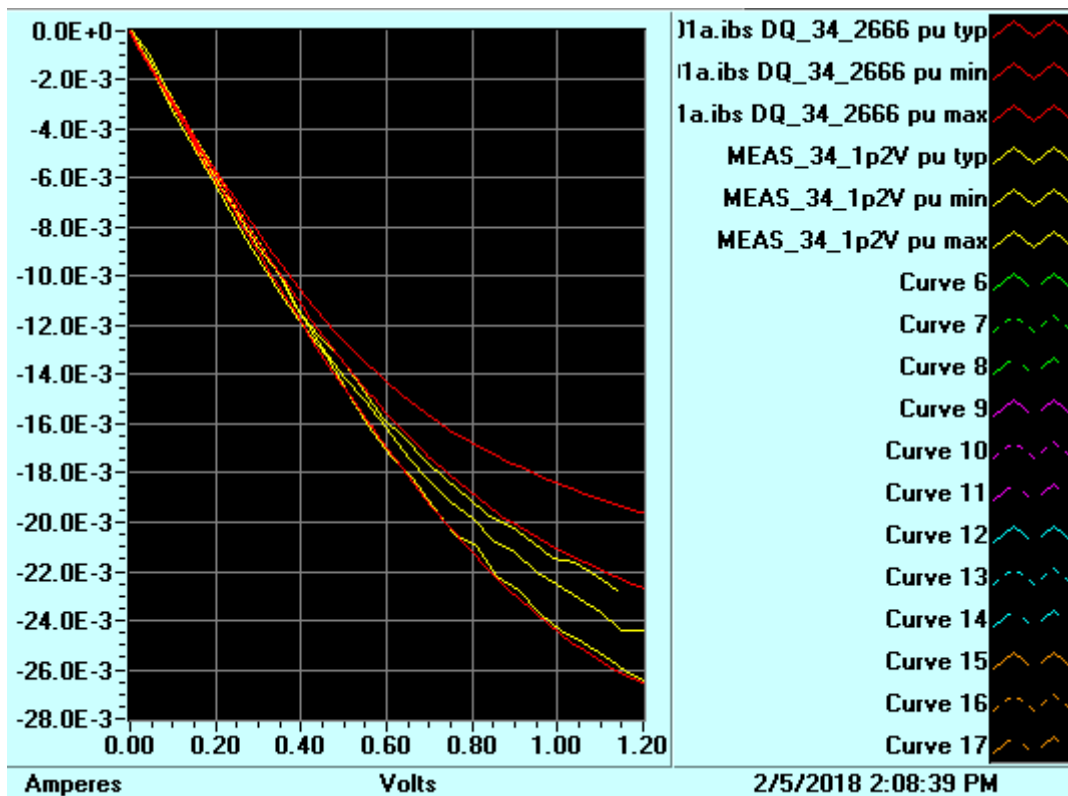
1. ☒ For Output or I/O models compare measured IOH/IOL data with IBIS pullup/pulldown data. If the measurement conditions are different from the IBIS conditions, run Spice simulations using the same measurement conditions such as VCC, temperature, and process. Include measurement conditions in the image labels.

a. Model name: **DQ\_34\_2666**

i. Pullup comparison. Measurement conditions: **0C/1.26V and 95C/1.14V**

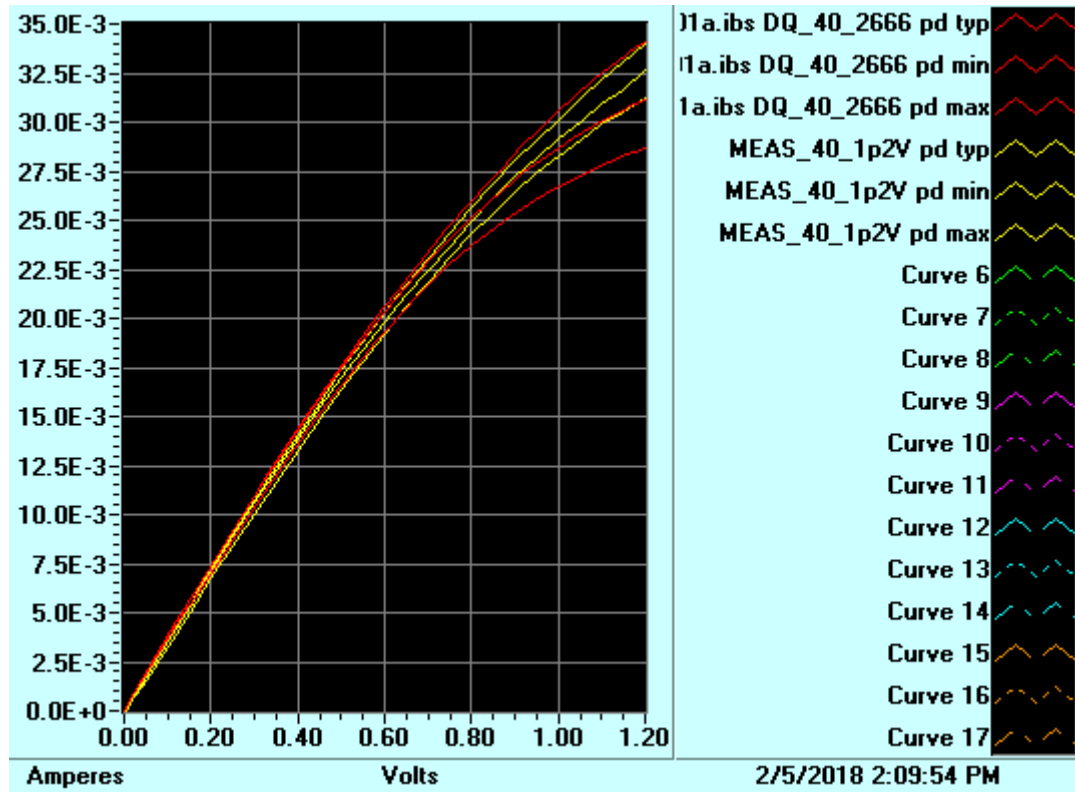


ii. Pulldown comparison. Measurement conditions: **0C/1.26V and 95C/1.14V**

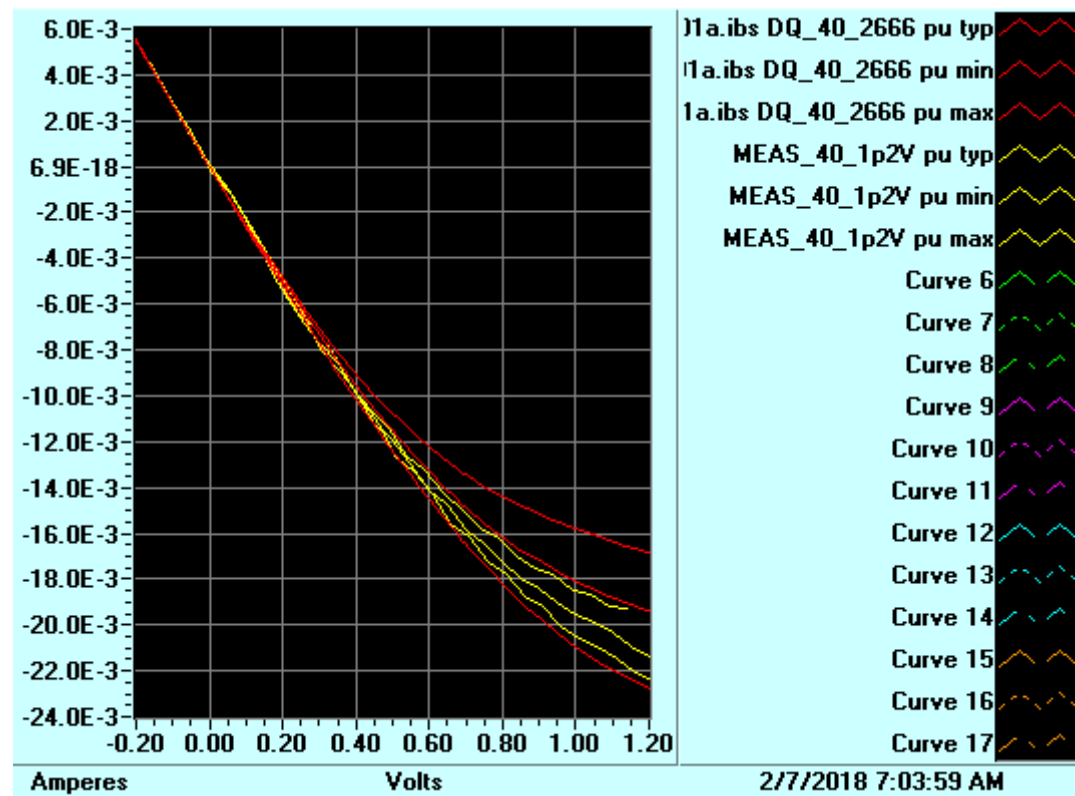


b. Model name: **DQ\_40\_2666**

i. Pullup comparison. Measurement conditions: **0C/1.26V and 95C/1.14V**

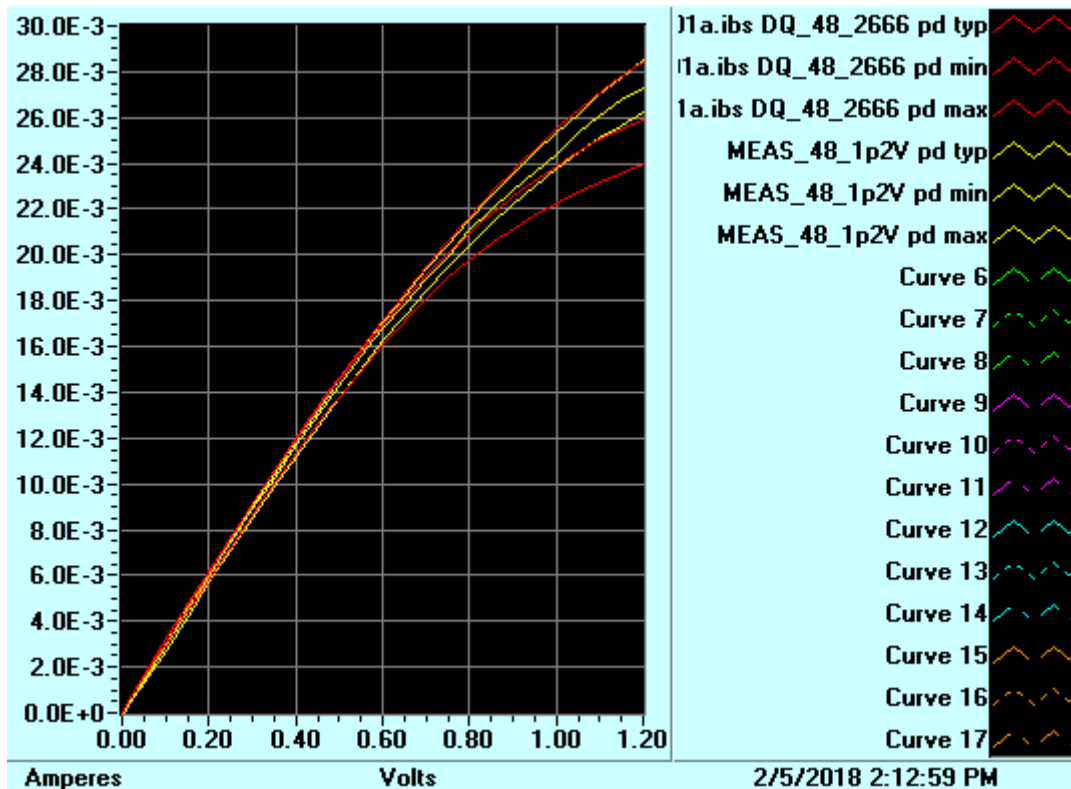


ii. Pulldown comparison. Measurement conditions: **0C/1.26V and 95C/1.14V**

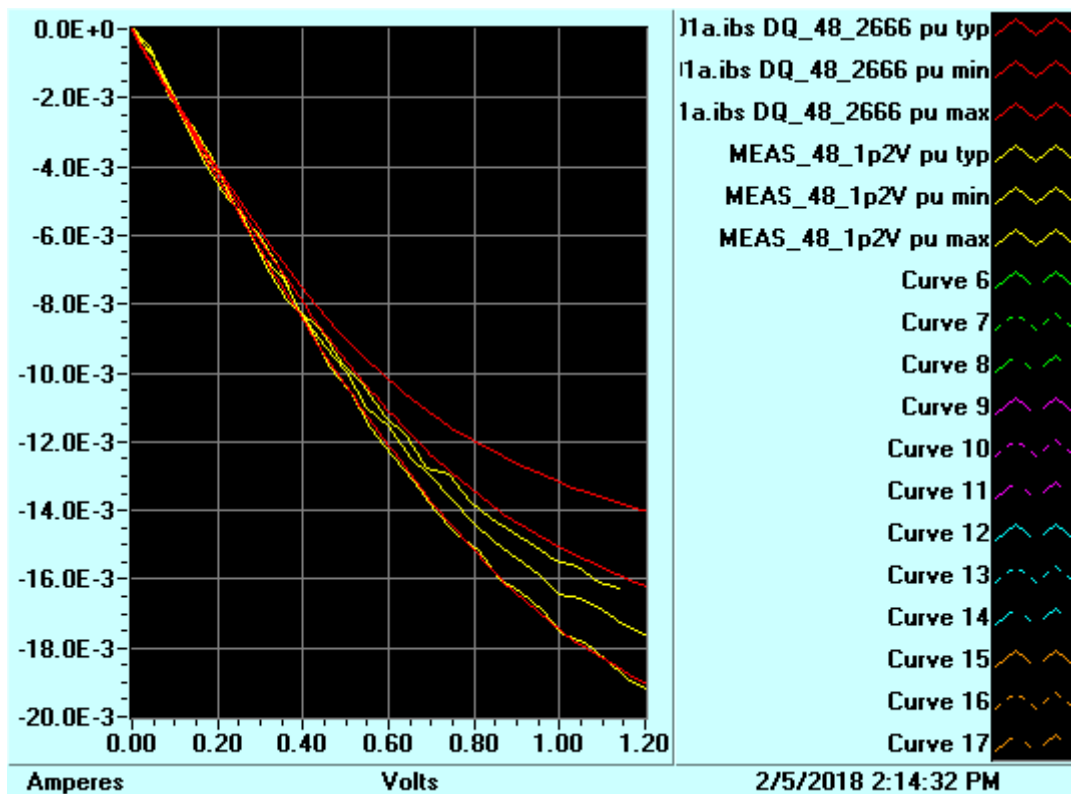


c. Model name: **DQ\_48\_2666**

i. Pullup comparison. Measurement conditions: **0C/1.26V and 95C/1.14V**



ii. Pulldown comparison. Measurement conditions: **0C/1.26V and 95C/1.14V**



2. ☒ Compare C\_comp with measured C\_comp. Provide C\_comp comparison table for all models and for all package combinations (i.e x4, x8 and x16).

Component name: **MT40A1G8WE, MT40A2G4WE (78-Ball, x4/x8)**

|              |           | IBIS (pF) |      |      | Measured (pF) |      |      |
|--------------|-----------|-----------|------|------|---------------|------|------|
|              |           | min       | typ  | max  | min           | typ  | max  |
| <b>DQ</b>    | C_comp    | 0.87      | 0.92 | 0.97 | NA            | NA   | NA   |
|              | C package | 0.40      | 0.45 | 0.50 | NA            | NA   | NA   |
|              | C_total   | 1.27      | 1.37 | 1.47 | 1.29          | 1.36 | 1.43 |
| <b>INPUT</b> | C_comp    | 0.42      | 0.47 | 0.52 | NA            | NA   | NA   |
|              | C package | 0.35      | 0.40 | 0.43 | NA            | NA   | NA   |
|              | C_total   | 0.77      | 0.87 | 0.95 | 0.81          | 0.86 | 0.94 |
| <b>ALERT</b> | C_comp    | 0.76      | 0.81 | 0.86 | NA            | NA   | NA   |
|              | C package | 0.80      | 0.80 | 0.80 | NA            | NA   | NA   |
|              | C_total   | 1.56      | 1.61 | 1.66 | 1.55          | 1.58 | 1.61 |
| <b>CLK</b>   | C_comp    | 0.41      | 0.46 | 0.51 | NA            | NA   | NA   |
|              | C package | 0.43      | 0.45 | 0.47 | NA            | NA   | NA   |
|              | C_total   | 0.84      | 0.91 | 0.98 | 0.87          | 0.89 | 0.93 |
| <b>CTRL</b>  | C_comp    | 0.38      | 0.43 | 0.48 | NA            | NA   | NA   |
|              | C package | 0.42      | 0.43 | 0.43 | NA            | NA   | NA   |
|              | C_total   | 0.80      | 0.86 | 0.91 | 0.81          | 0.83 | 0.86 |

Component name: **MT40A512M16JY (96-Ball, x16)**

|              |           | IBIS (pF) |      |      | Measured (pF) |      |      |
|--------------|-----------|-----------|------|------|---------------|------|------|
|              |           | min       | typ  | max  | min           | typ  | max  |
| <b>DQ</b>    | C_comp    | 0.87      | 0.92 | 0.97 | NA            | NA   | NA   |
|              | C package | 0.35      | 0.41 | 0.51 | NA            | NA   | NA   |
|              | C_total   | 1.22      | 1.33 | 1.48 | 1.25          | 1.34 | 1.50 |
| <b>INPUT</b> | C_comp    | 0.42      | 0.47 | 0.52 | NA            | NA   | NA   |
|              | C package | 0.35      | 0.41 | 0.45 | NA            | NA   | NA   |
|              | C_total   | 0.77      | 0.88 | 0.97 | 0.82          | 0.90 | 0.98 |
| <b>ALERT</b> | C_comp    | 0.76      | 0.81 | 0.86 | NA            | NA   | NA   |
|              | C package | 0.68      | 0.68 | 0.68 | NA            | NA   | NA   |
|              | C_total   | 1.44      | 1.49 | 1.54 | 1.48          | 1.51 | 1.53 |
| <b>CLK</b>   | C_comp    | 0.41      | 0.46 | 0.51 | NA            | NA   | NA   |
|              | C package | 0.38      | 0.41 | 0.44 | NA            | NA   | NA   |
|              | C_total   | 0.79      | 0.87 | 0.95 | 0.83          | 0.89 | 0.95 |
| <b>CTRL</b>  | C_comp    | 0.38      | 0.43 | 0.48 | NA            | NA   | NA   |
|              | C package | 0.32      | 0.34 | 0.35 | NA            | NA   | NA   |
|              | C_total   | 0.70      | 0.77 | 0.83 | 0.76          | 0.79 | 0.82 |

3. ☐ If measured clamp current data is available, provide an IBIS versus measurement comparison for all models. Include measurement conditions in the image labels.

**Not Available**

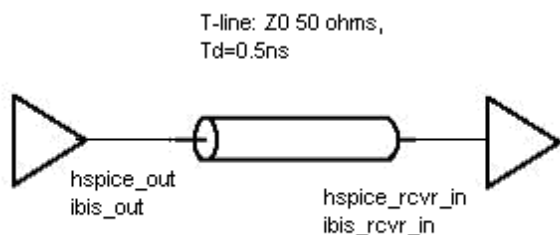
4. ☒ If slew rate data (rise/fall slew) is available from measurements, complete Spice simulations to generate slew rate data and provide a comparison table.

| Model      | Slew Rate (V/ns) | IBIS |      |      | Measurement |      |
|------------|------------------|------|------|------|-------------|------|
|            |                  | min  | typ  | max  | min         | max  |
| DQ_34@2666 | Rising           | 5.52 | 7.11 | 7.98 | 5.66        | 7.75 |
|            | Falling          | 5.45 | 6.90 | 8.06 | 5.76        | 7.64 |

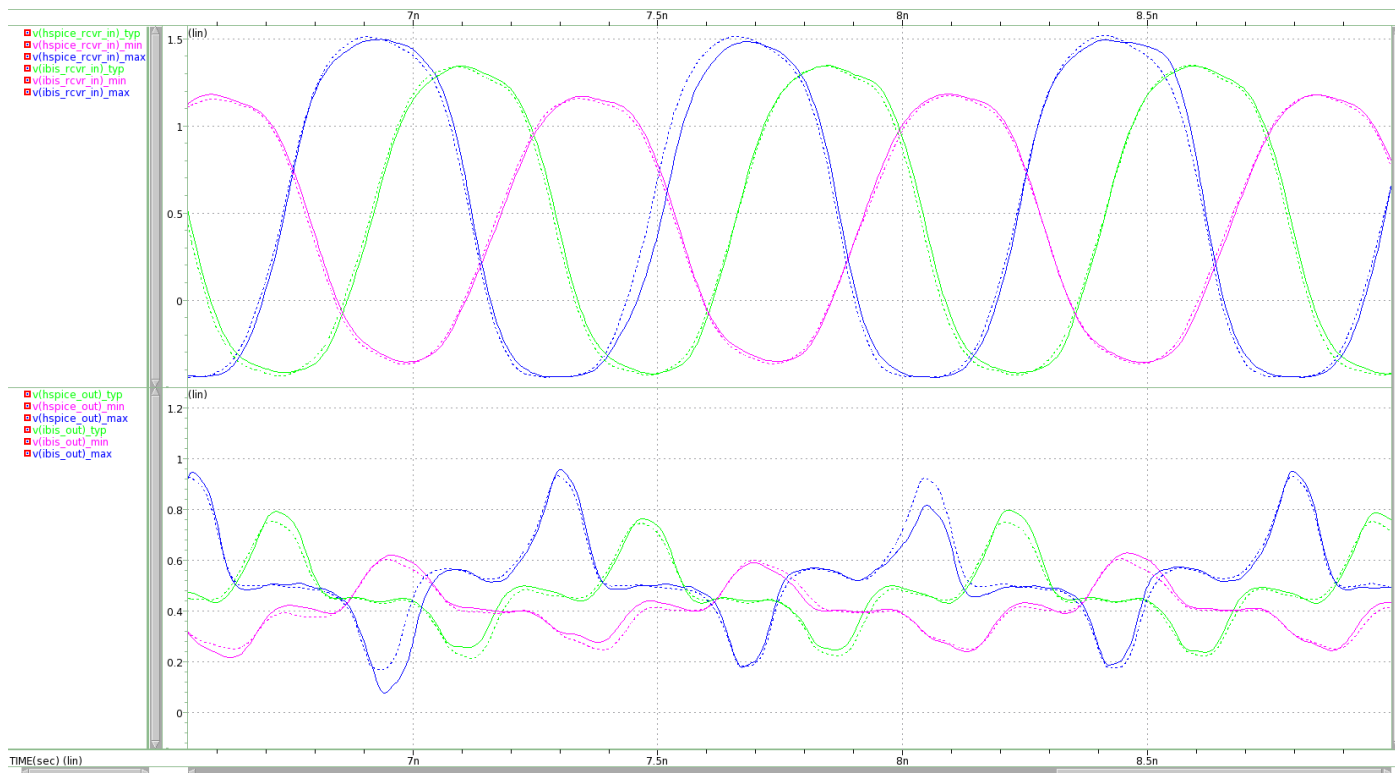
## IBIS Model Correlation: IBIS vs Spice (IBIS 4.2)

1. ☒ For all Output or I/O models, run Spice transient simulations using encrypted netlists and the IBIS model (b-element).
  - a. ☒ Use the setup and node naming conventions shown below for the IBIS and Spice files. Update the setup diagram if it is different. Indicate the version of Spice simulator used for simulations: **HSPICE 2016.06**
  - b. ☒ Run simulations for all corners cases and at fastest speed grades, testing ODT models as loads when applicable

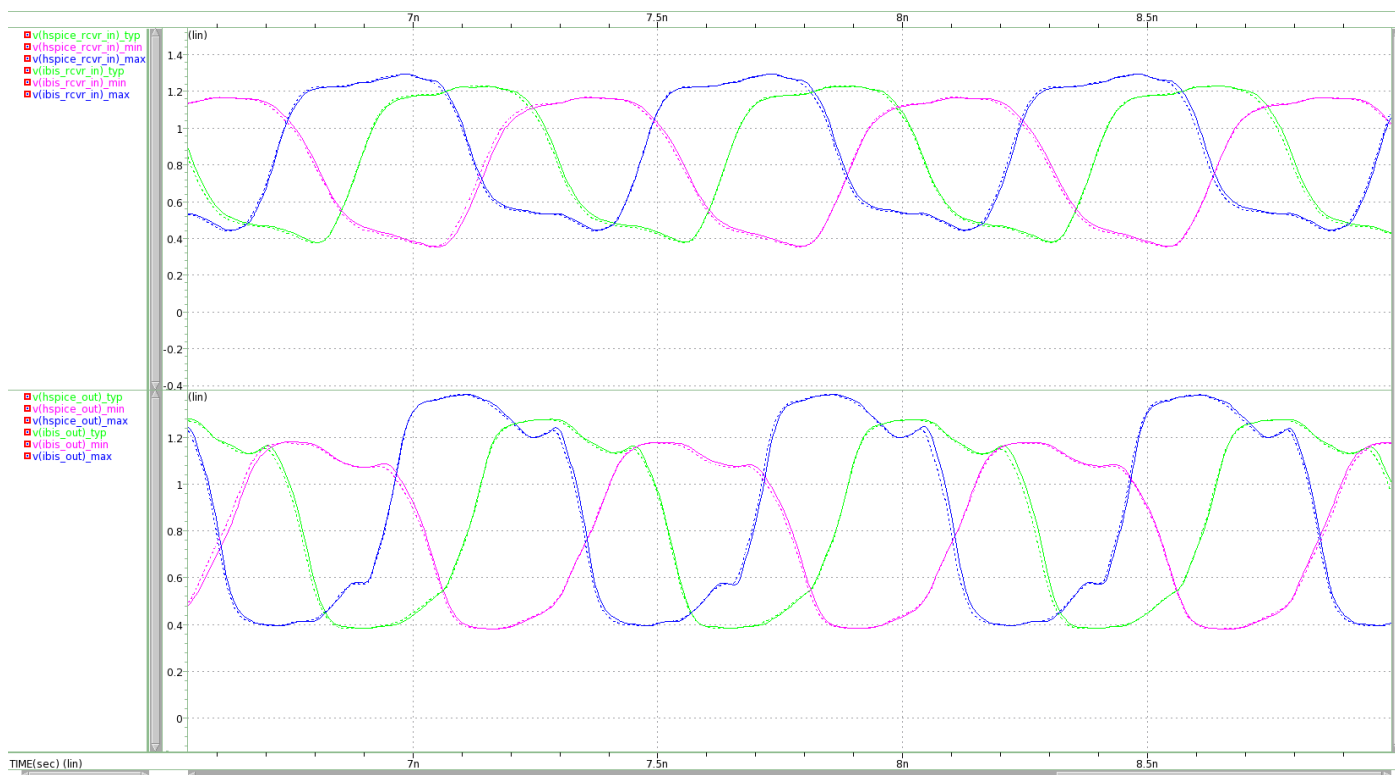
SETUP:



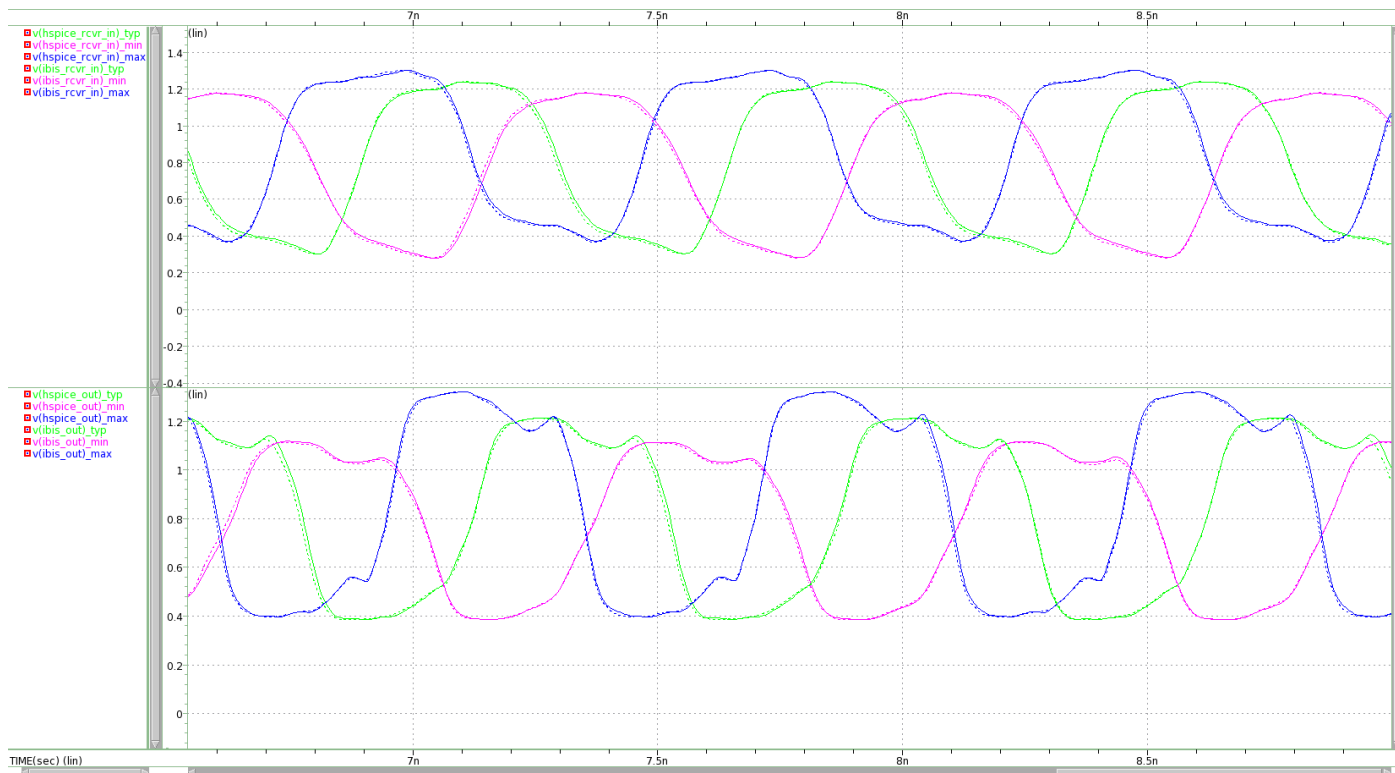
## i. DQ\_34\_2666 driving DQ\_34\_2666



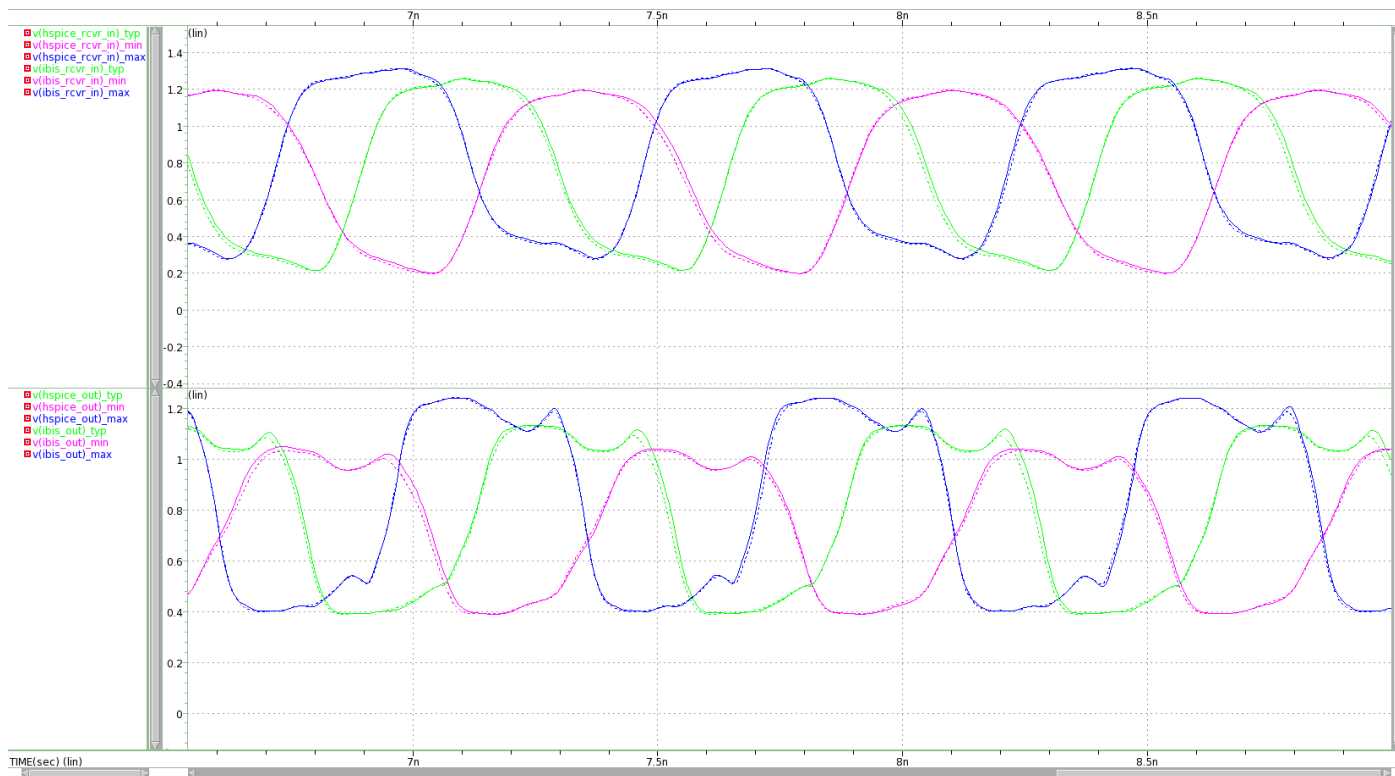
## ii. DQ\_34\_2666 driving DQ\_IN\_ODT34\_2666



## iii. DQ\_34\_2666 driving DQ\_IN\_ODT40\_2666

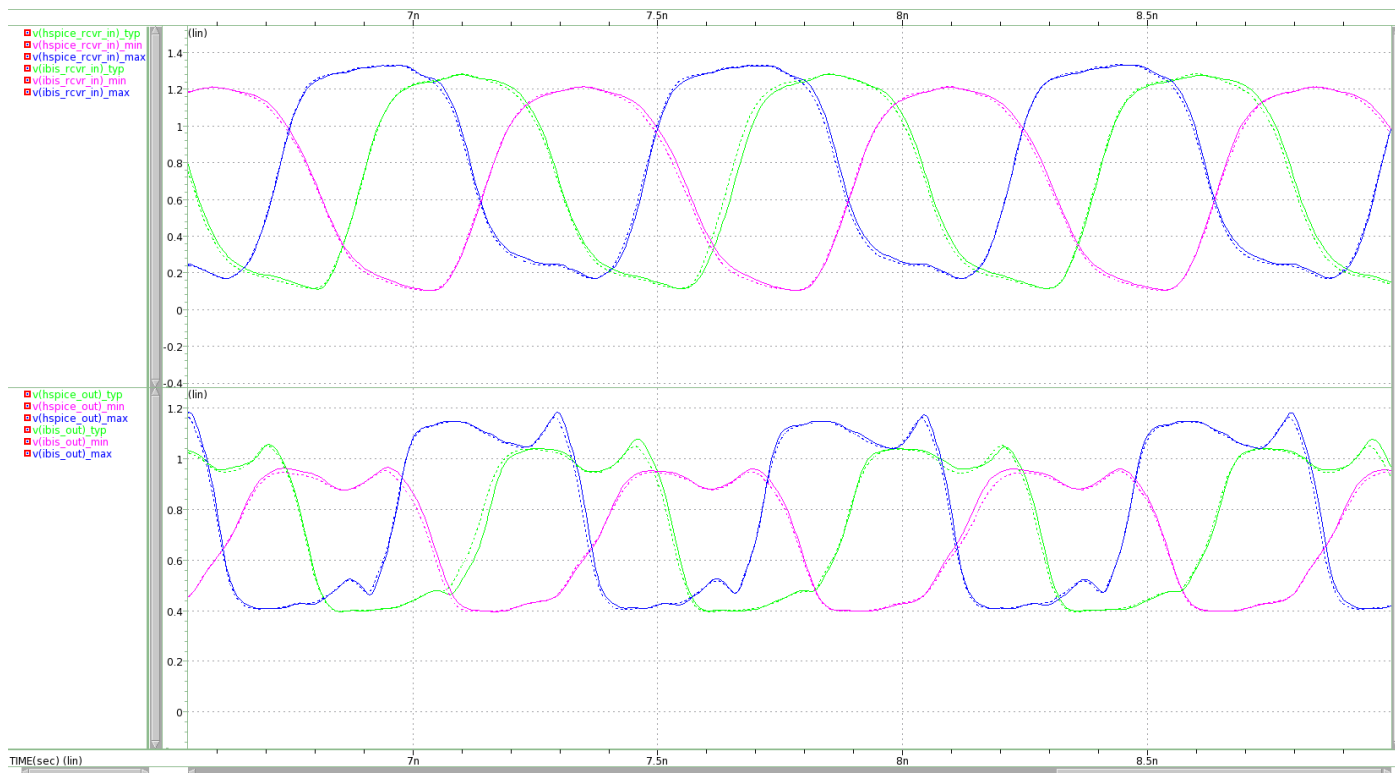


## iv. DQ\_34\_2666 driving DQ\_IN\_ODT48\_2666

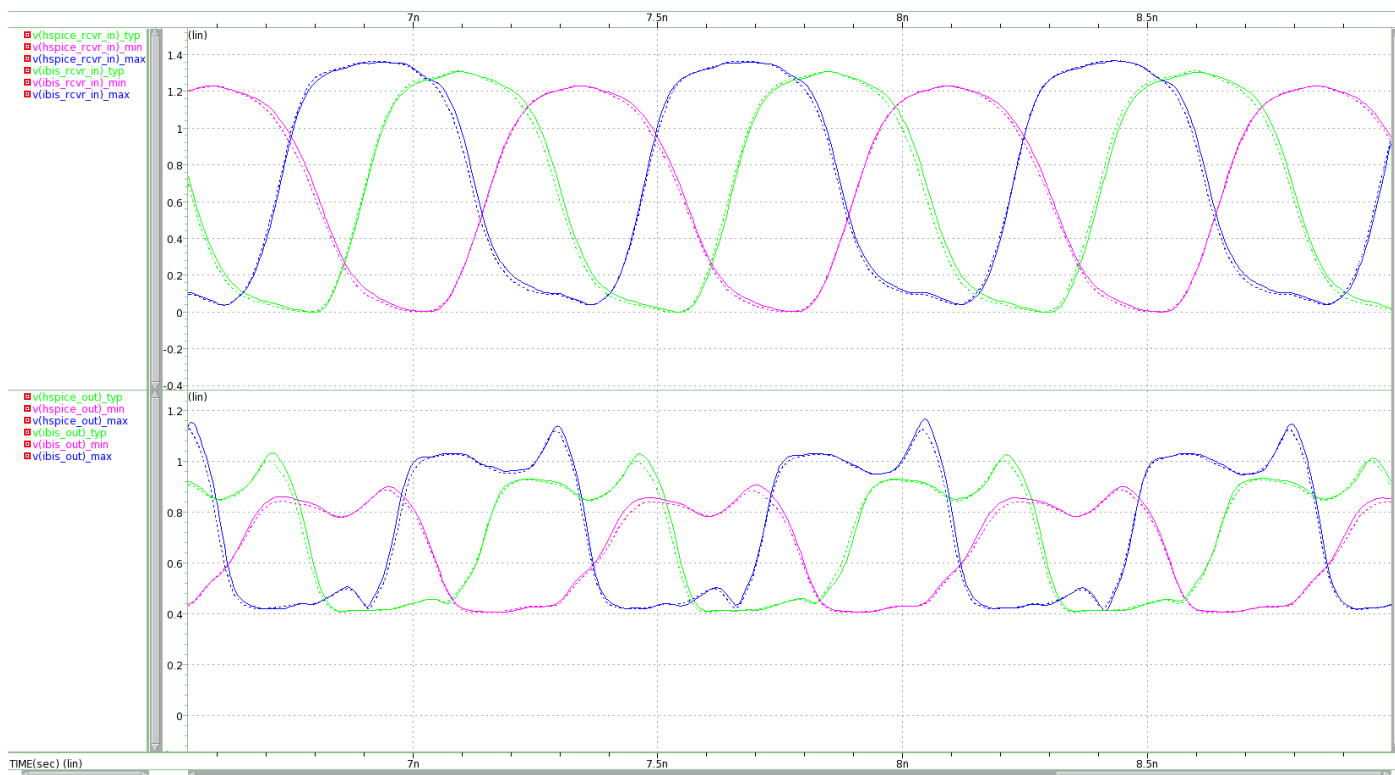




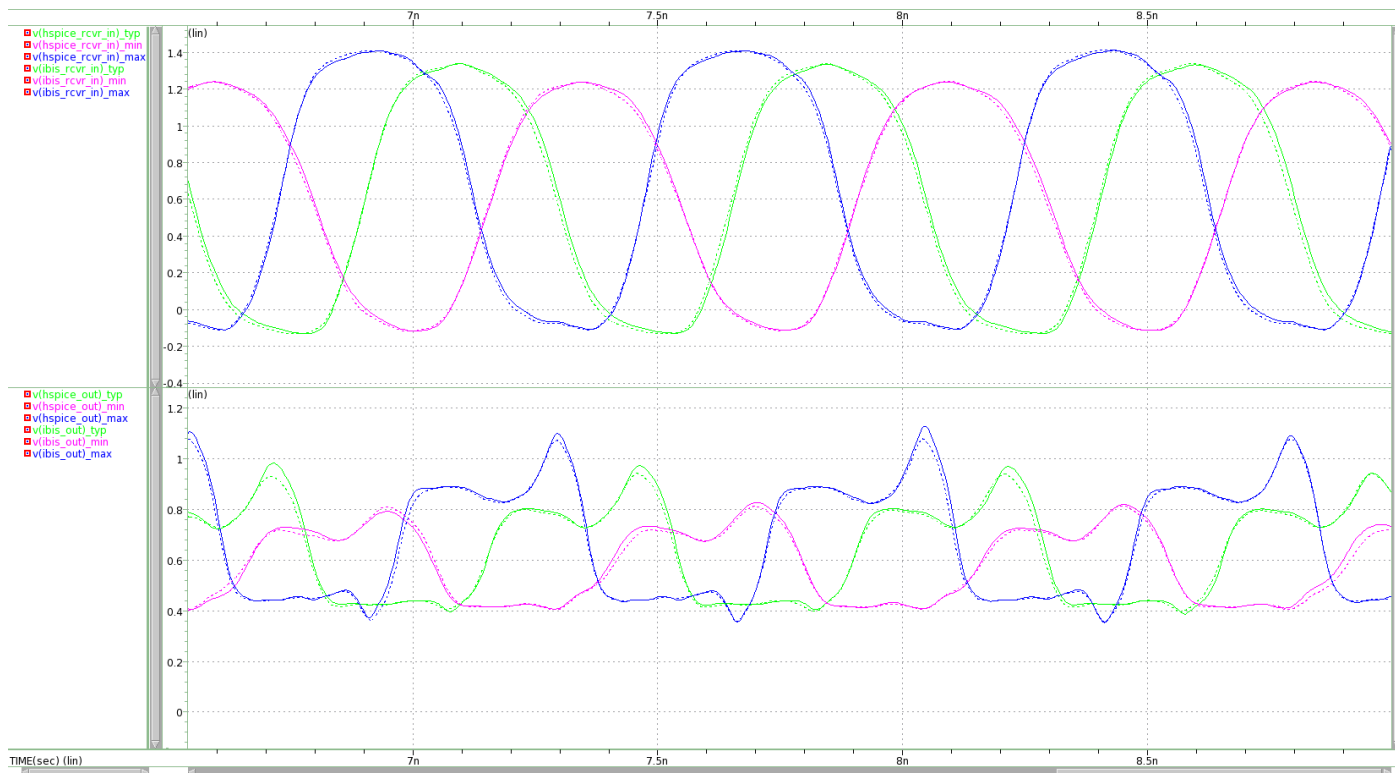
## v. DQ\_34\_2666 driving DQ\_IN\_ODT60\_2666



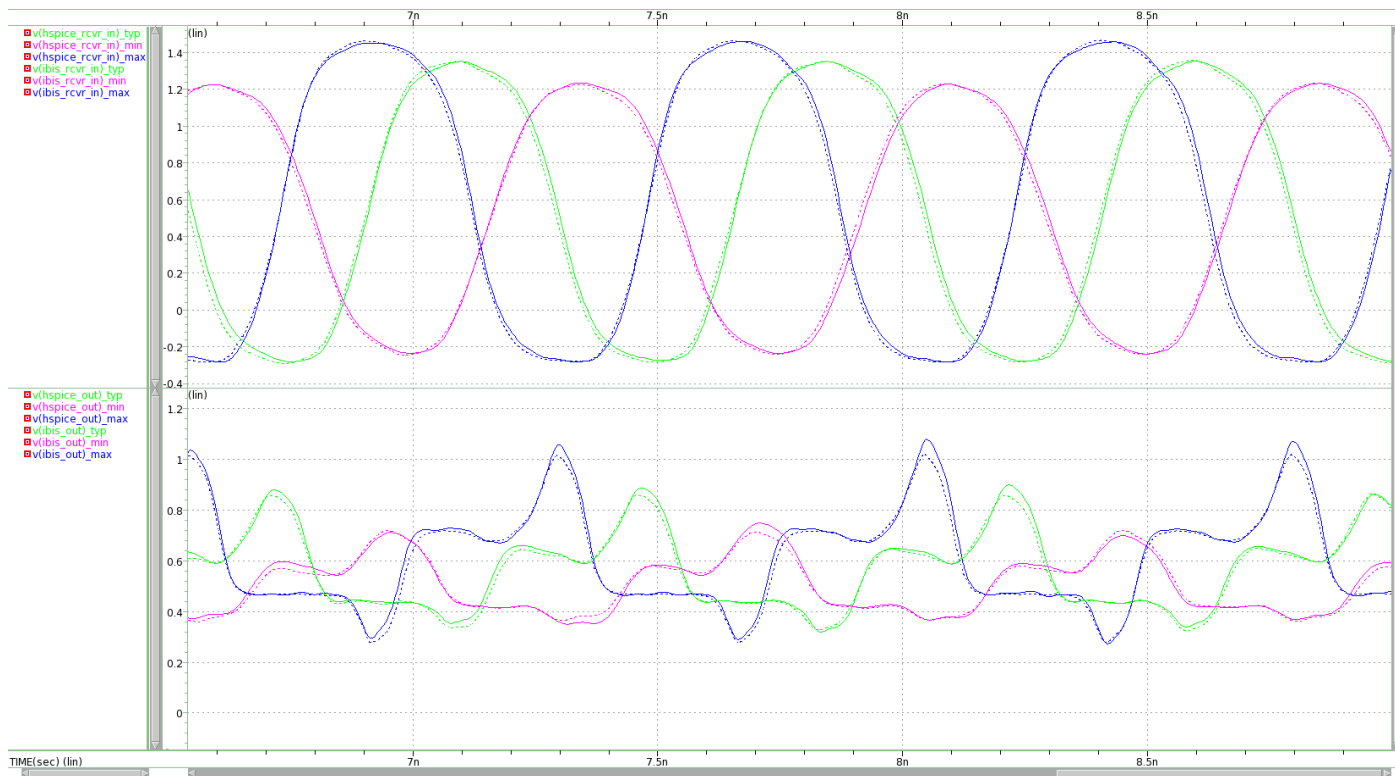
## vi. DQ\_34\_2666 driving DQ\_IN\_ODT80\_2666



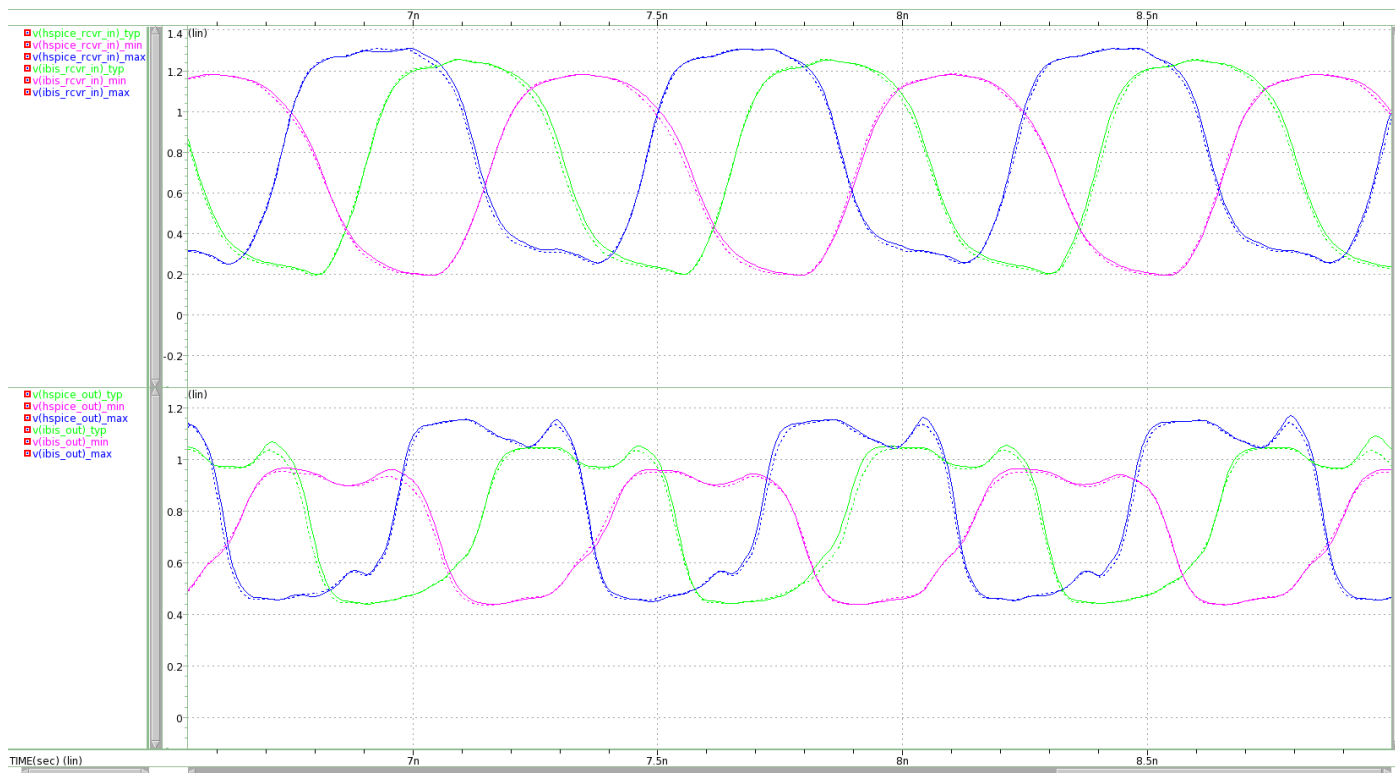
## vii. DQ\_34\_2666 driving DQ\_IN\_ODT120\_2666



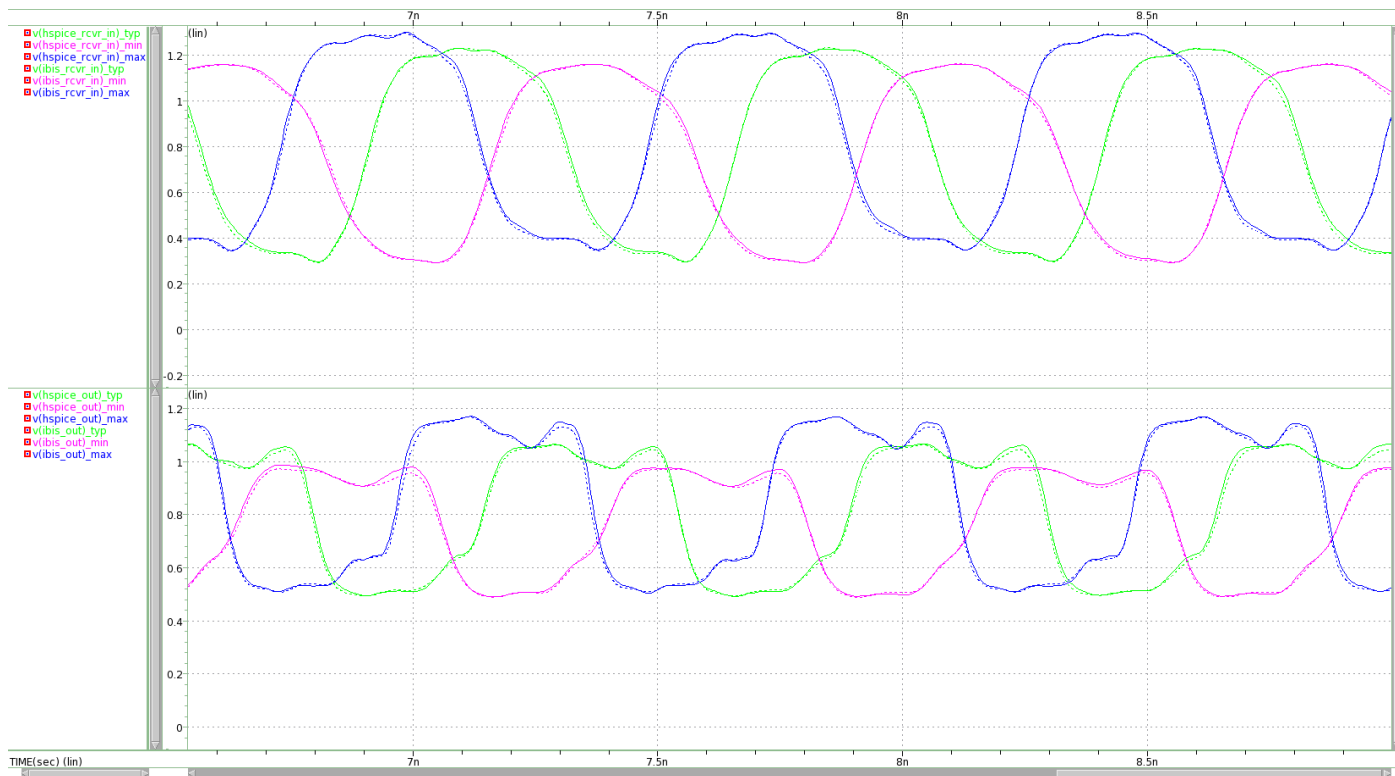
## viii. DQ\_34\_2666 driving DQ\_IN\_ODT240\_2666



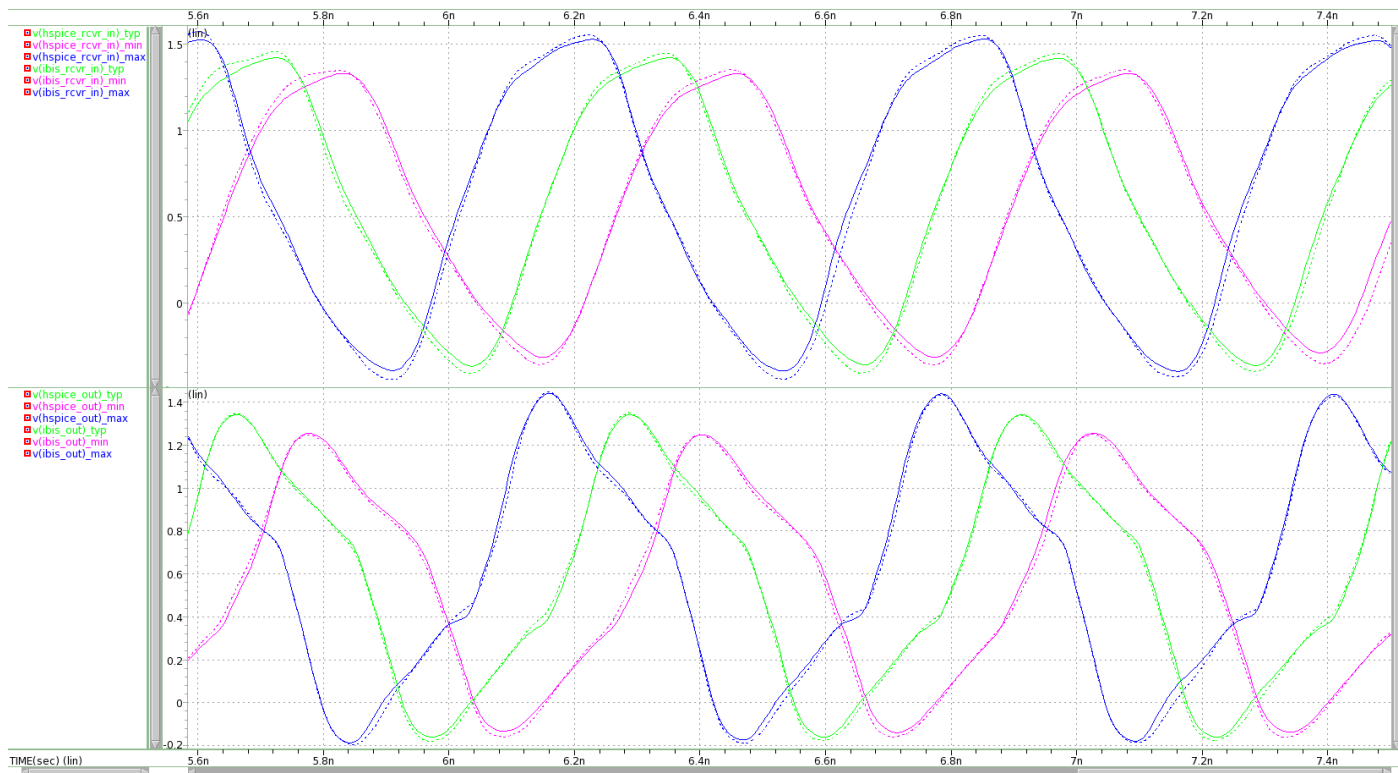
## ix. DQ\_40\_2666 driving DQ\_IN\_ODT60\_2666



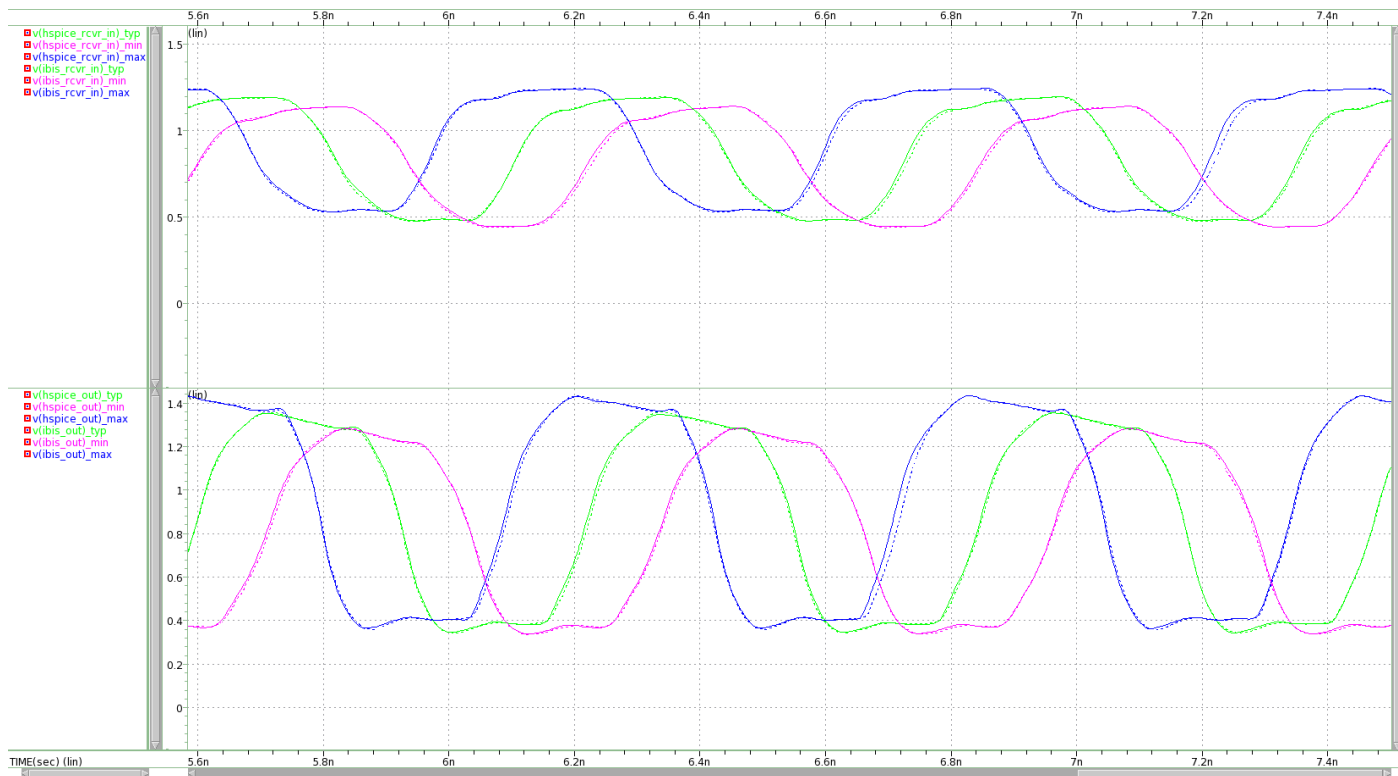
## x. DQ\_48\_2666 driving DQ\_IN\_ODT60\_2666



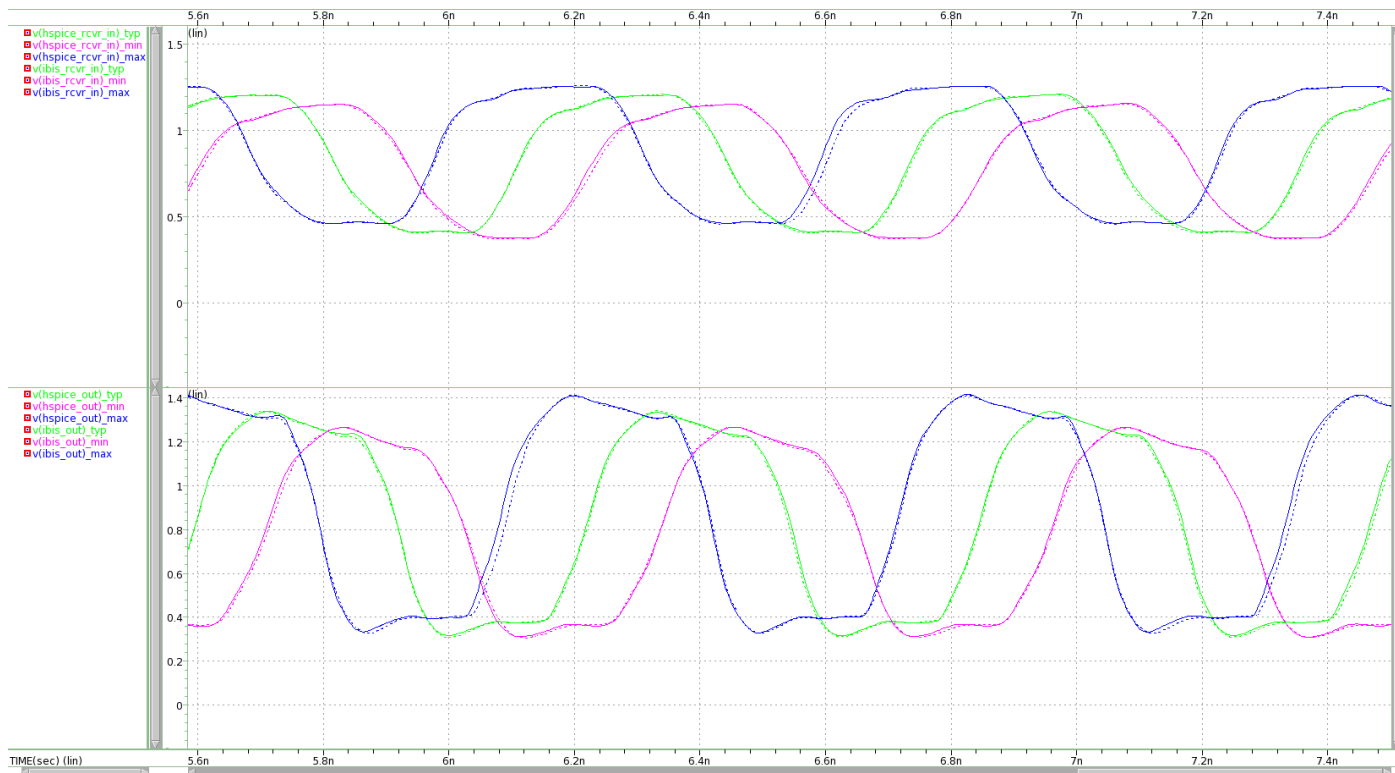
## xi. DQ\_34\_3200 driving DQ\_34\_3200



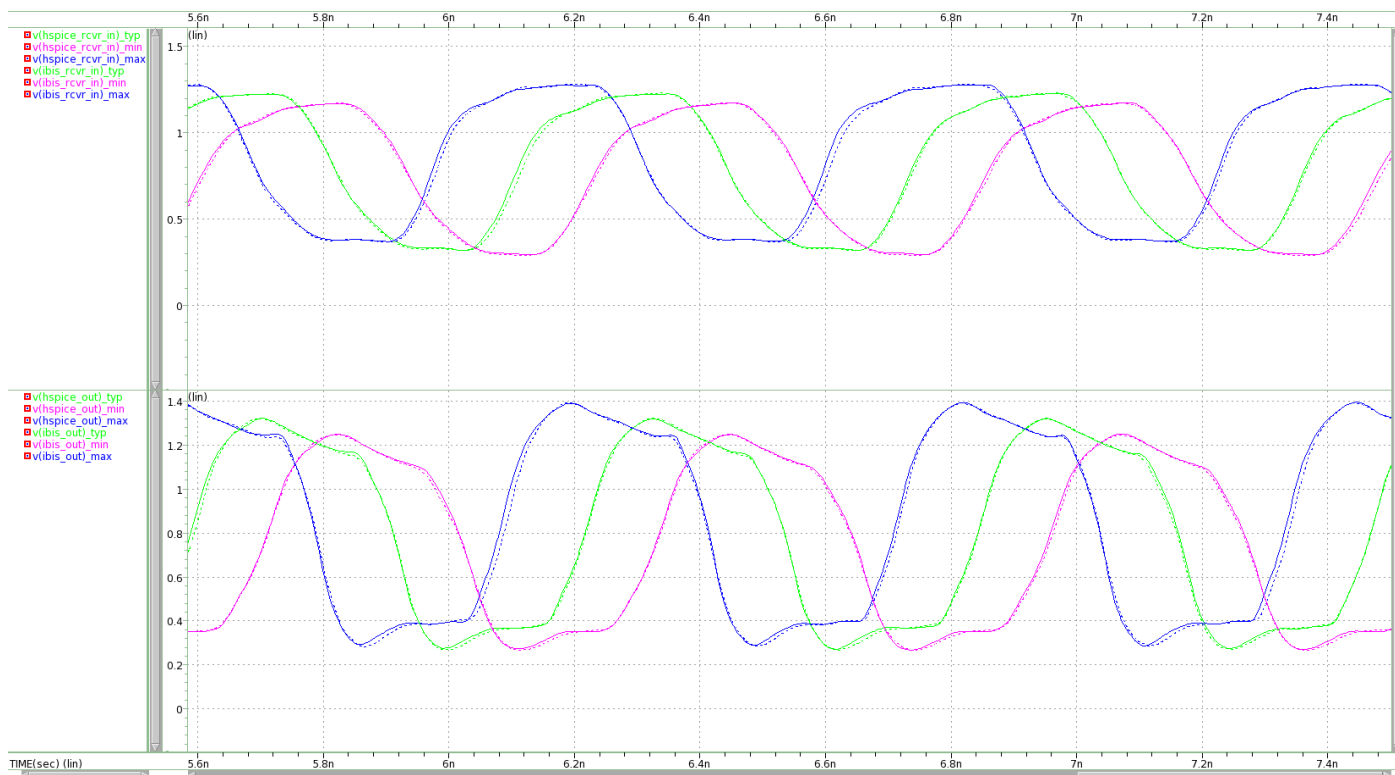
## xii. DQ\_34\_3200 driving DQ\_IN\_ODT34\_3200



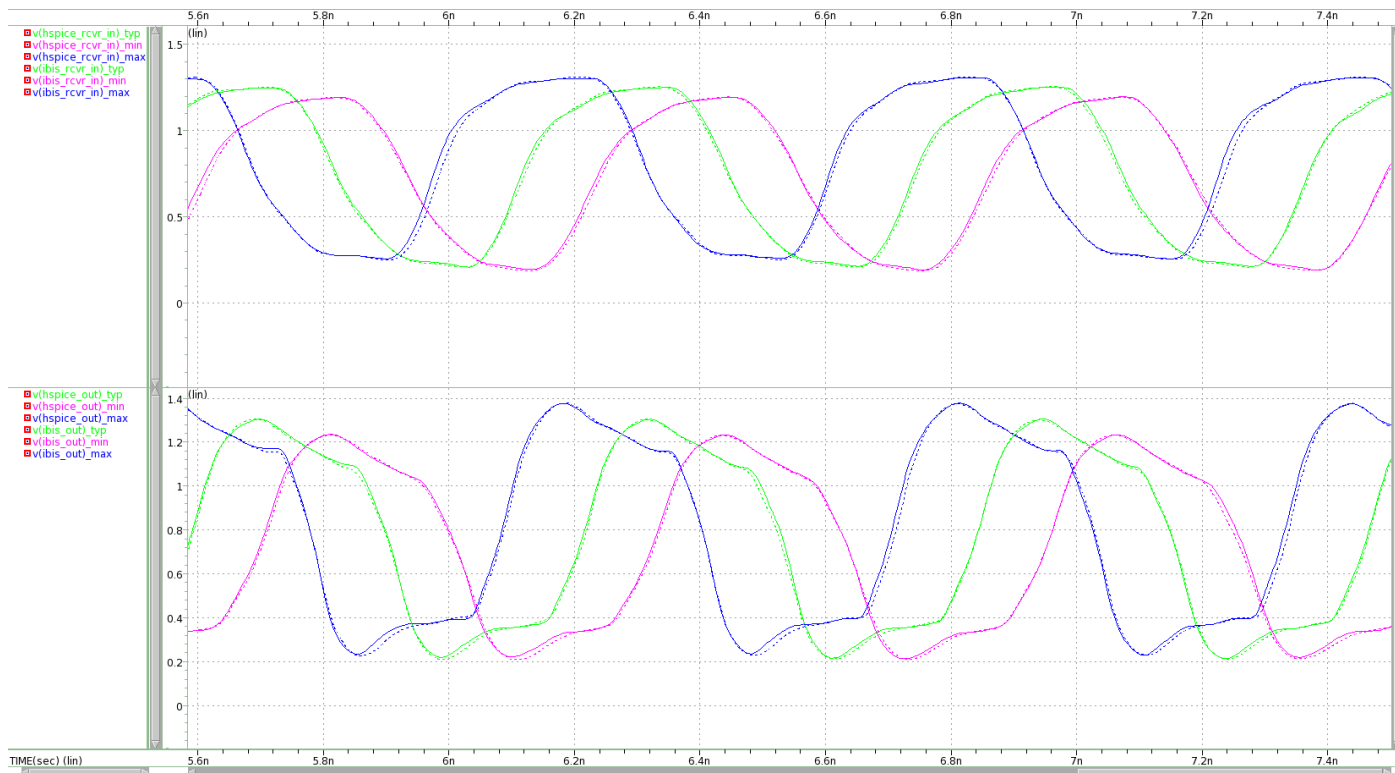
## xiii. DQ\_34\_3200 driving DQ\_IN\_ODT40\_3200



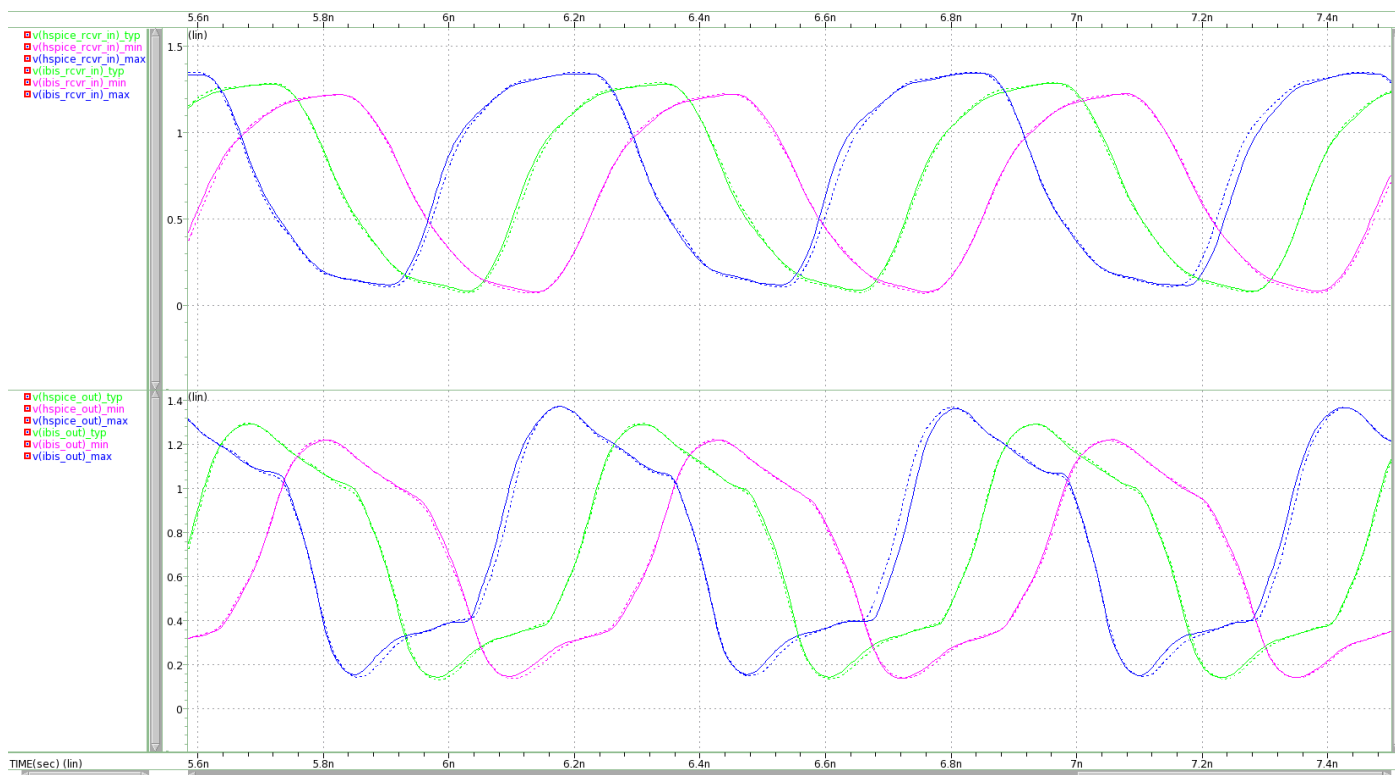
## xiv. DQ\_34\_3200 driving DQ\_IN\_ODT48\_3200



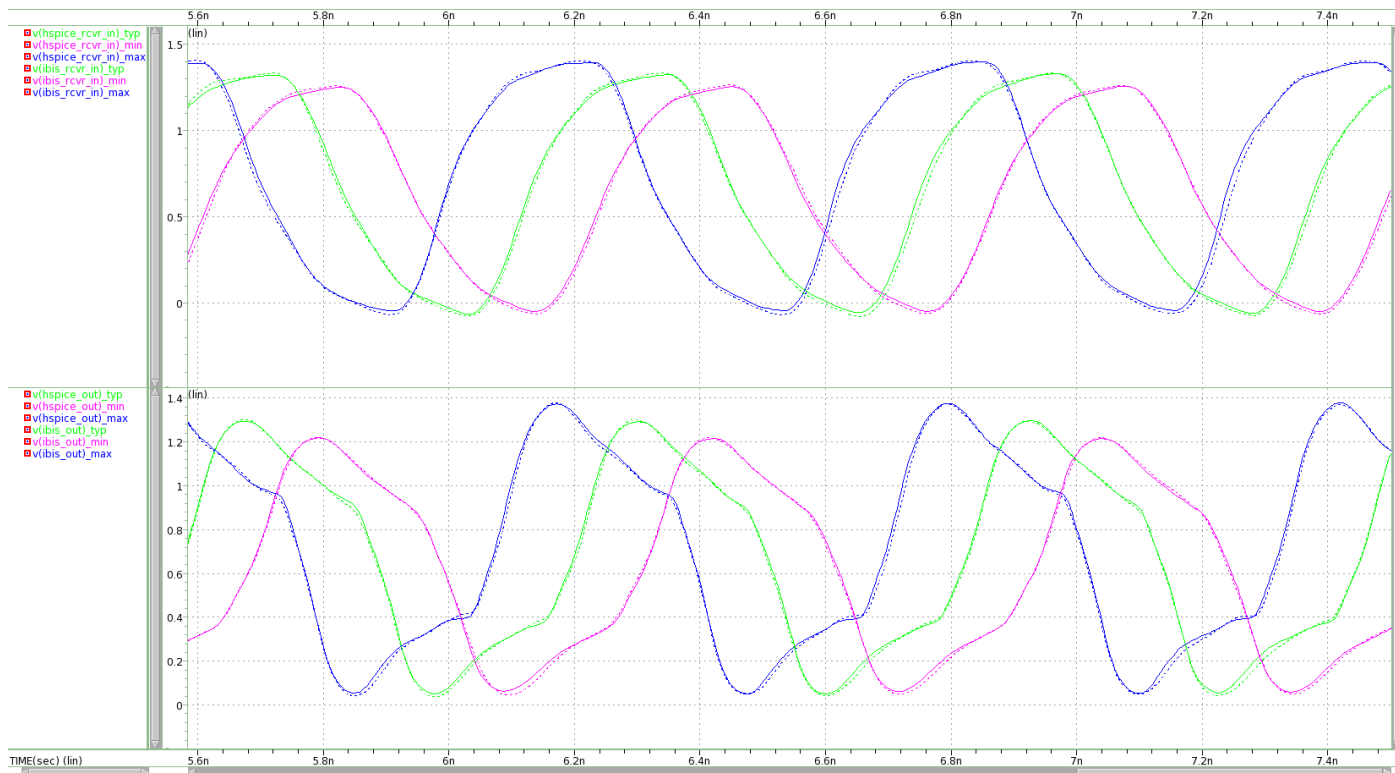
## xv. DQ\_34\_3200 driving DQ\_IN\_ODT60\_3200



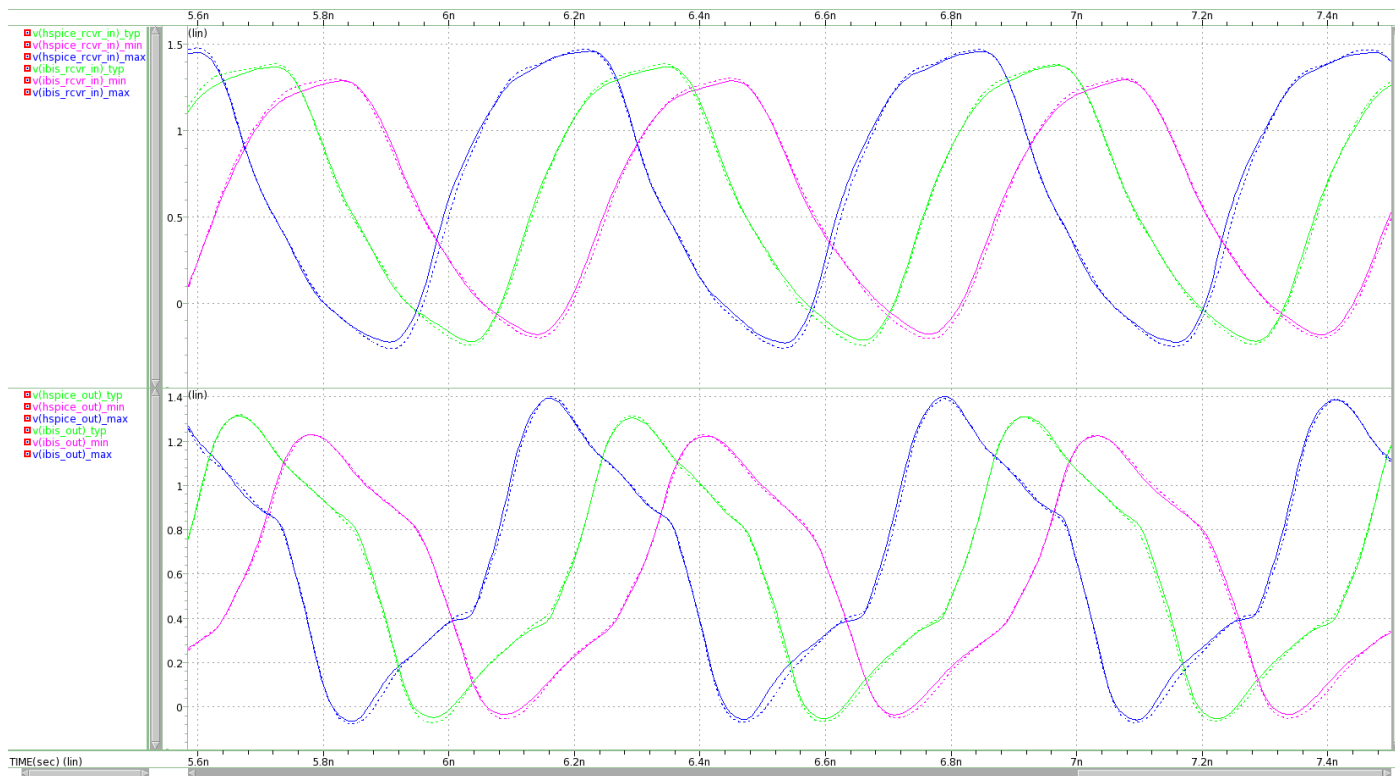
## xvi. DQ\_34\_3200 driving DQ\_IN\_ODT80\_3200



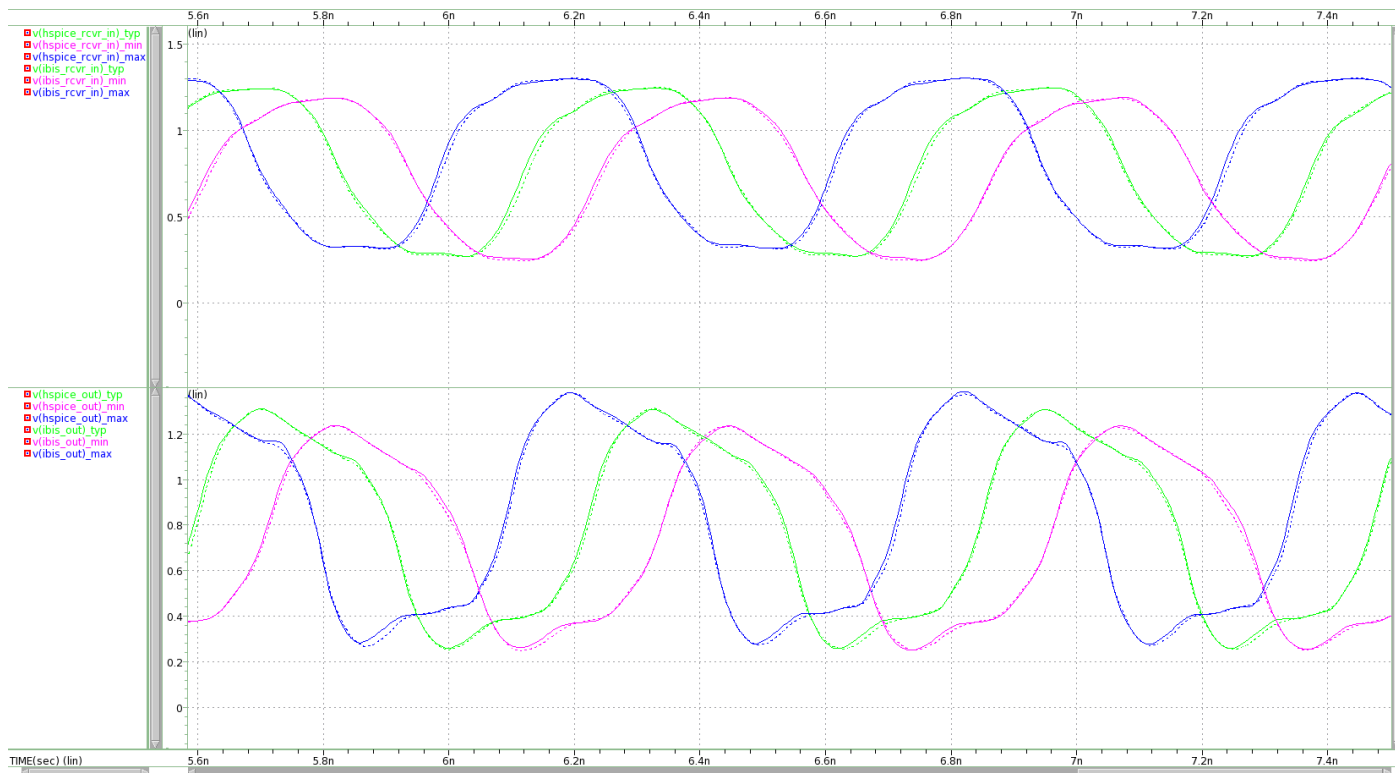
## xvii. DQ\_34\_3200 driving DQ\_IN\_ODT120\_3200



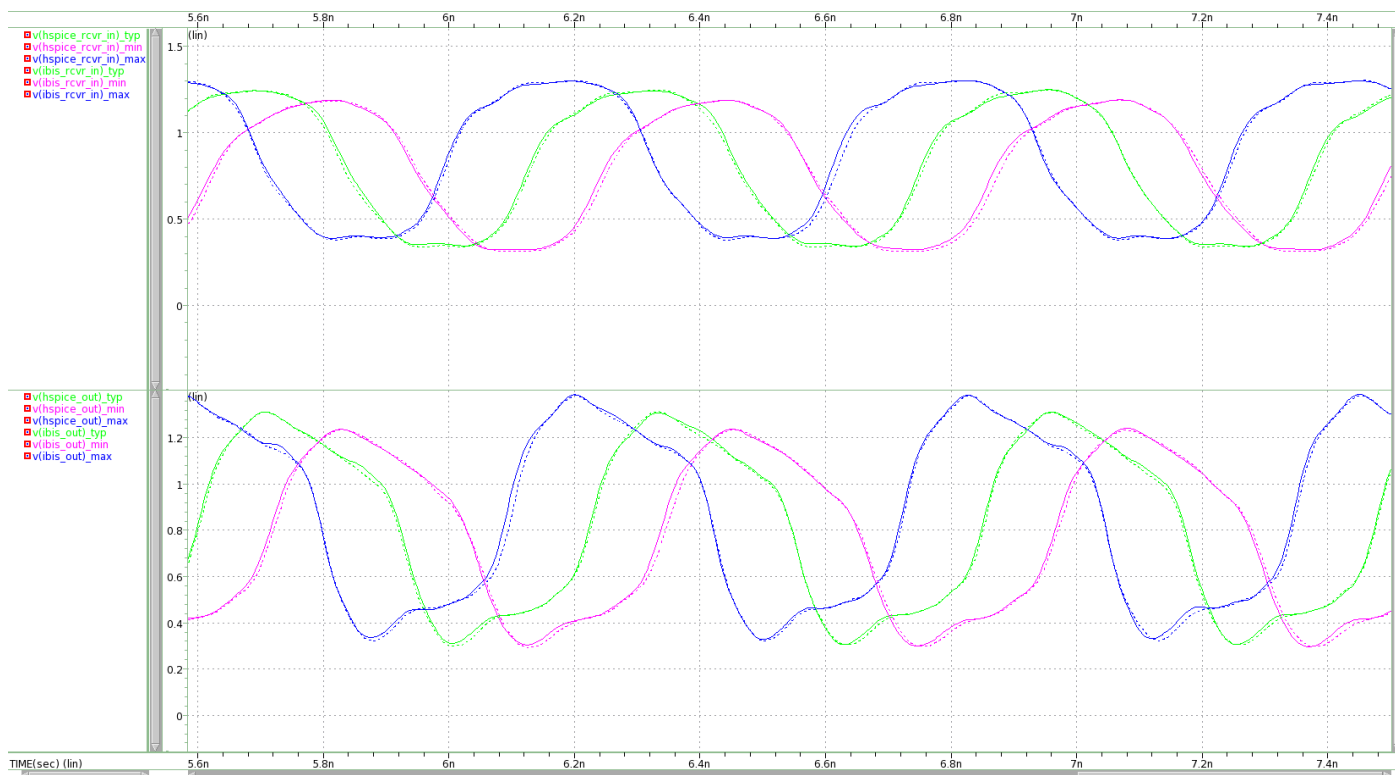
## xviii. DQ\_34\_3200 driving DQ\_IN\_ODT240\_3200



## xix. DQ\_40\_3200 driving DQ\_IN\_ODT60\_3200



## xx. DQ\_48\_3200 driving DQ\_IN\_ODT60\_3200

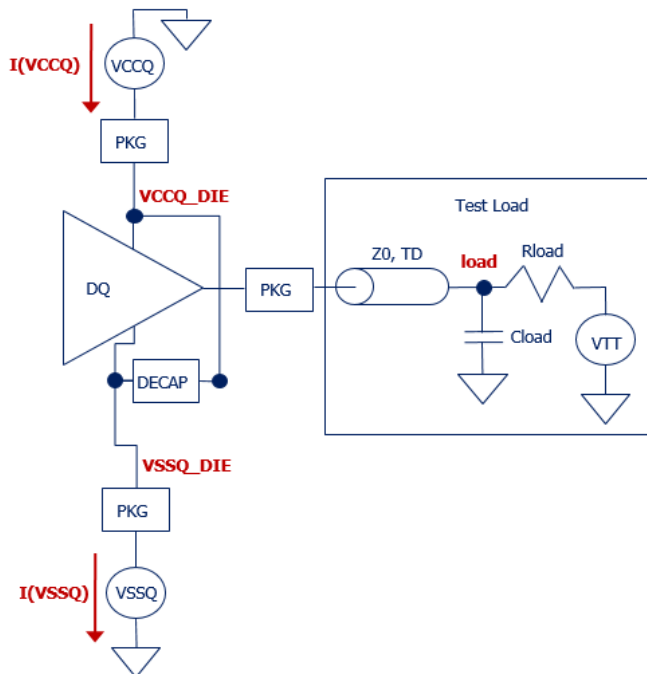




## IBIS Model Correlation: IBIS vs Spice (IBIS 5.0)

1. ☒ For all Output or I/O IBIS Version 5.0 power-aware models, run Spice transient simulations using encrypted netlists and the IBIS model (b-element) with a non-ideal power supply connection.
  - a. ☒ Use the setup and node naming conventions shown in Setup B below for the IBIS and Spice files. Update the setup diagram if it is different. Indicate the version of Spice simulator used for simulations: **HSPICE 2016.06**
  - b. ☒ Run simulations for all corner cases and at fastest speed grades

SETUP B:



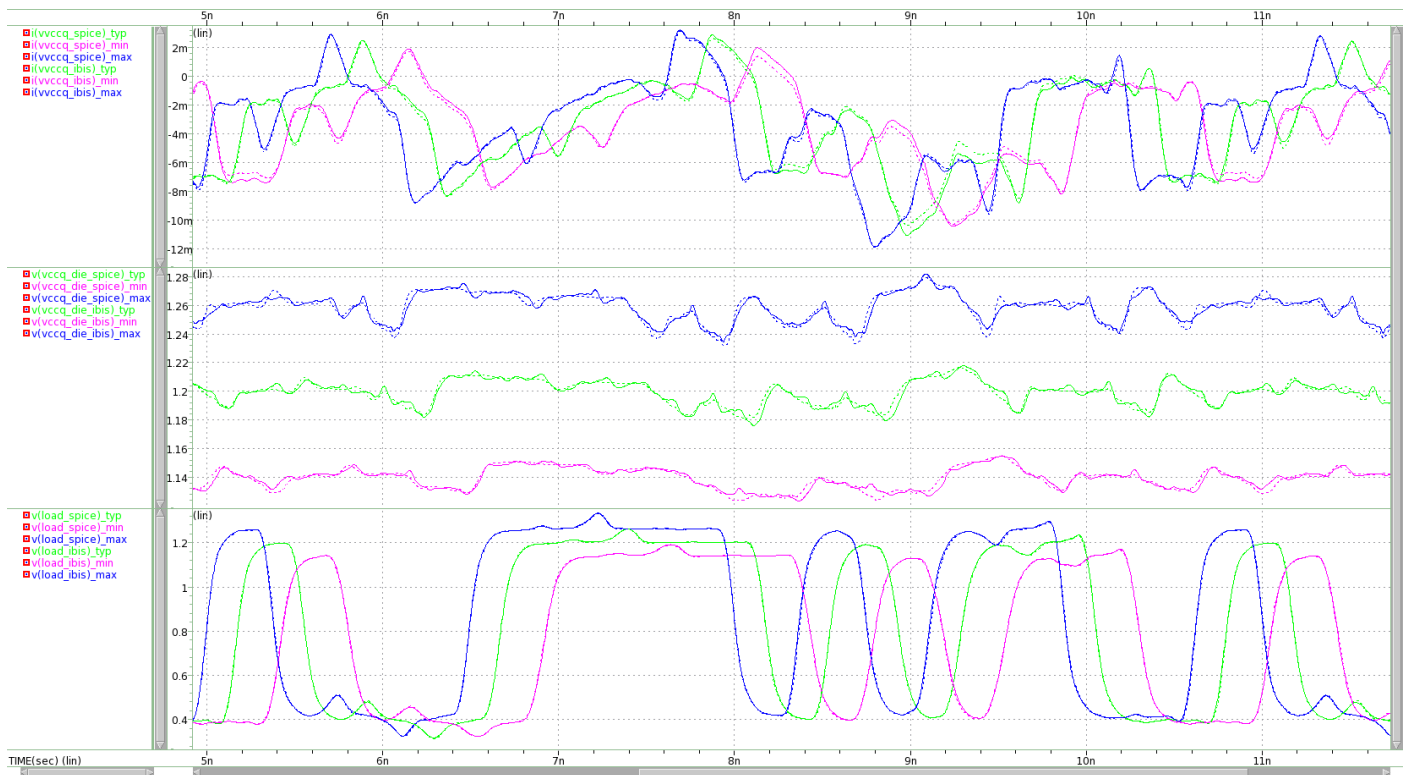
Test Load Values

|       |   |             |
|-------|---|-------------|
| Z0    | = | 50 $\Omega$ |
| Td    | = | 338.5 ps    |
| Cload | = | 2 pF        |
| Rload | = | 50 $\Omega$ |
| VTT   | = | VDDQ        |

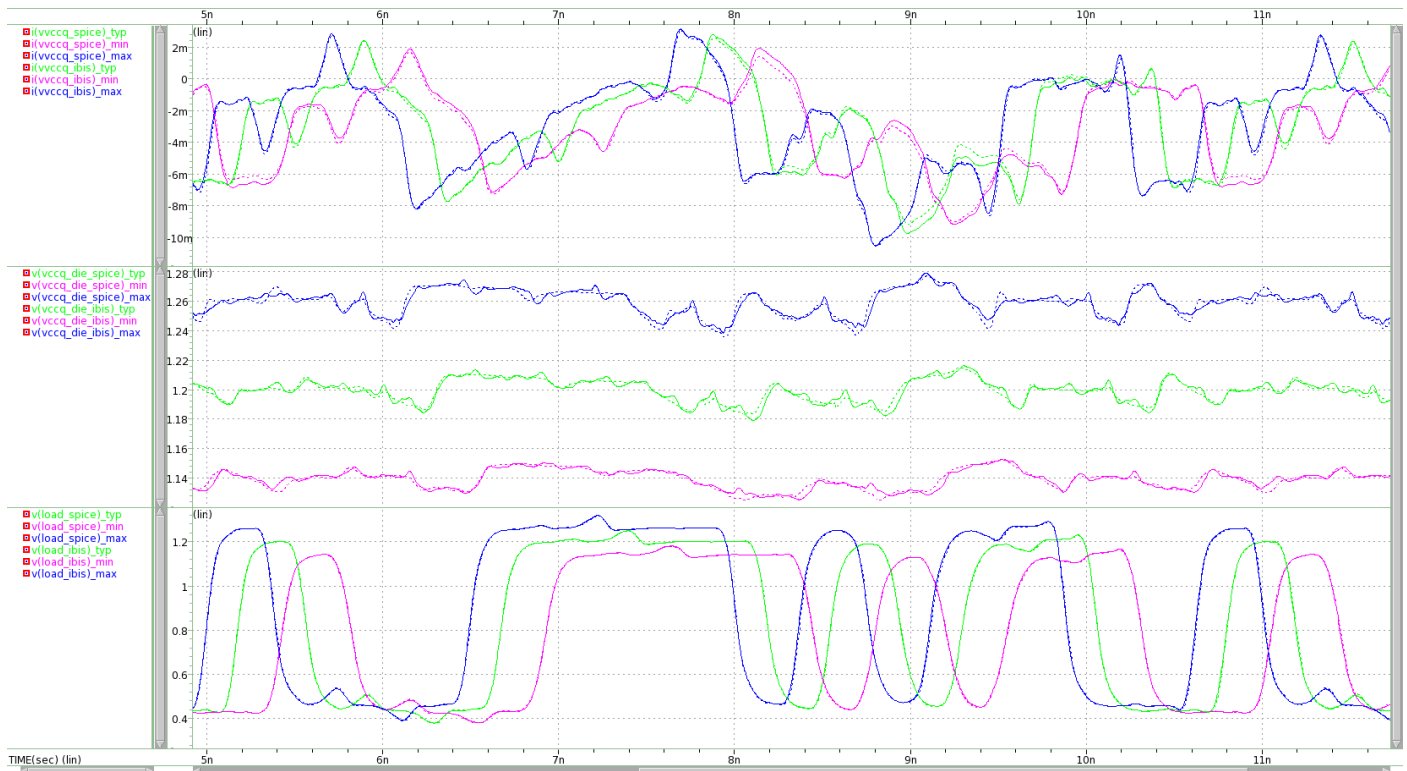
Package Model used for correlation

|                |           |           |       |      |
|----------------|-----------|-----------|-------|------|
| Lpkg           | PAD       | BALL      | 1.25n | 0.25 |
| Lpkg_vccq      | vccq_die  | vccq_ball | 1.25n | 0.25 |
| Lpkg_vssq      | vssq_die  | vssq_ball | 0.10n | 0.05 |
| K1             | Lpkg_vccq | Lpkg_vssq | 0.20  |      |
| K2             | Lpkg      | Lpkg_vccq | 0.20  |      |
| K3             | Lpkg      | Lpkg_vssq | 0.20  |      |
| Cpkg_vccq      | BALL      | vccq_ball | 0.20p |      |
| Cpkg_vssq      | BALL      | vssq_ball | 0.20p |      |
| Cpkg_vccq_vssq | vccq_ball | vssq_ball | 0.40p |      |

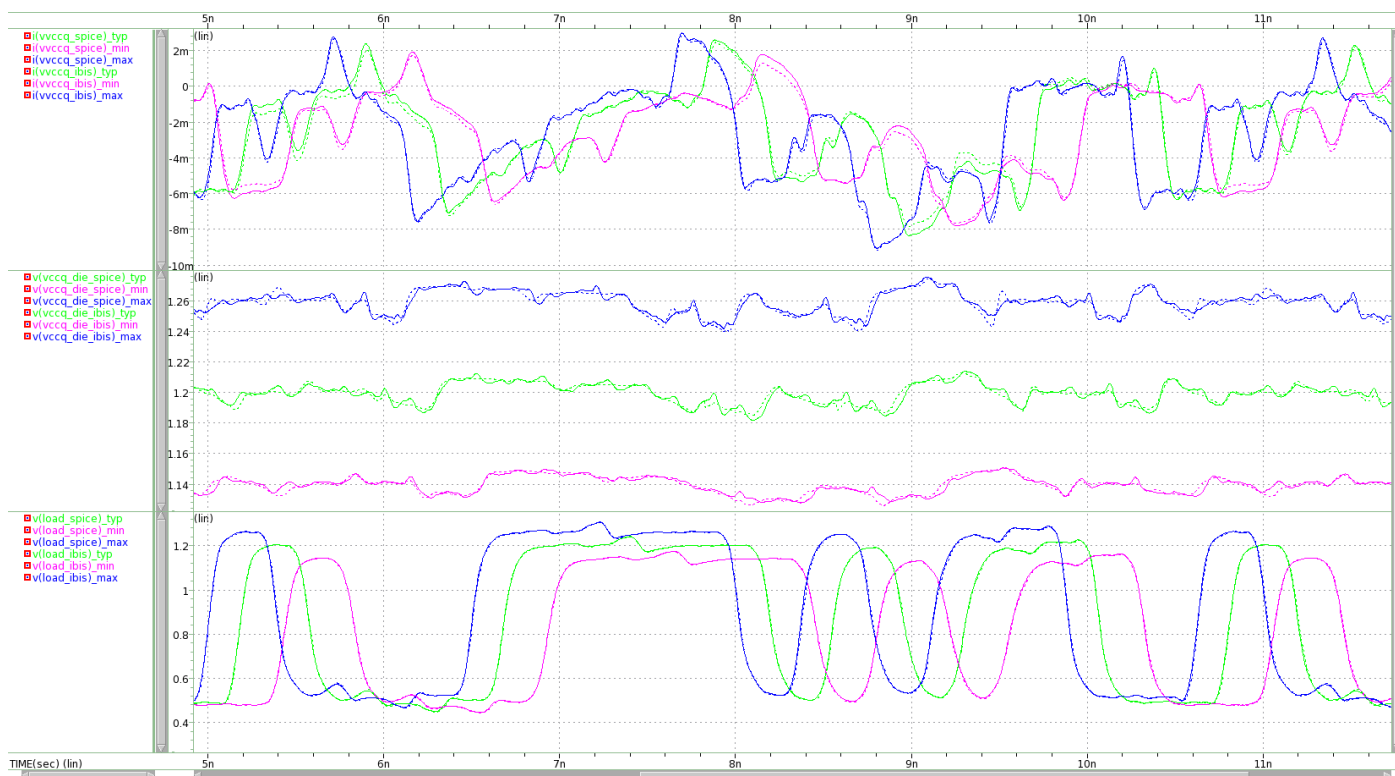
## i. DQ\_34\_2666



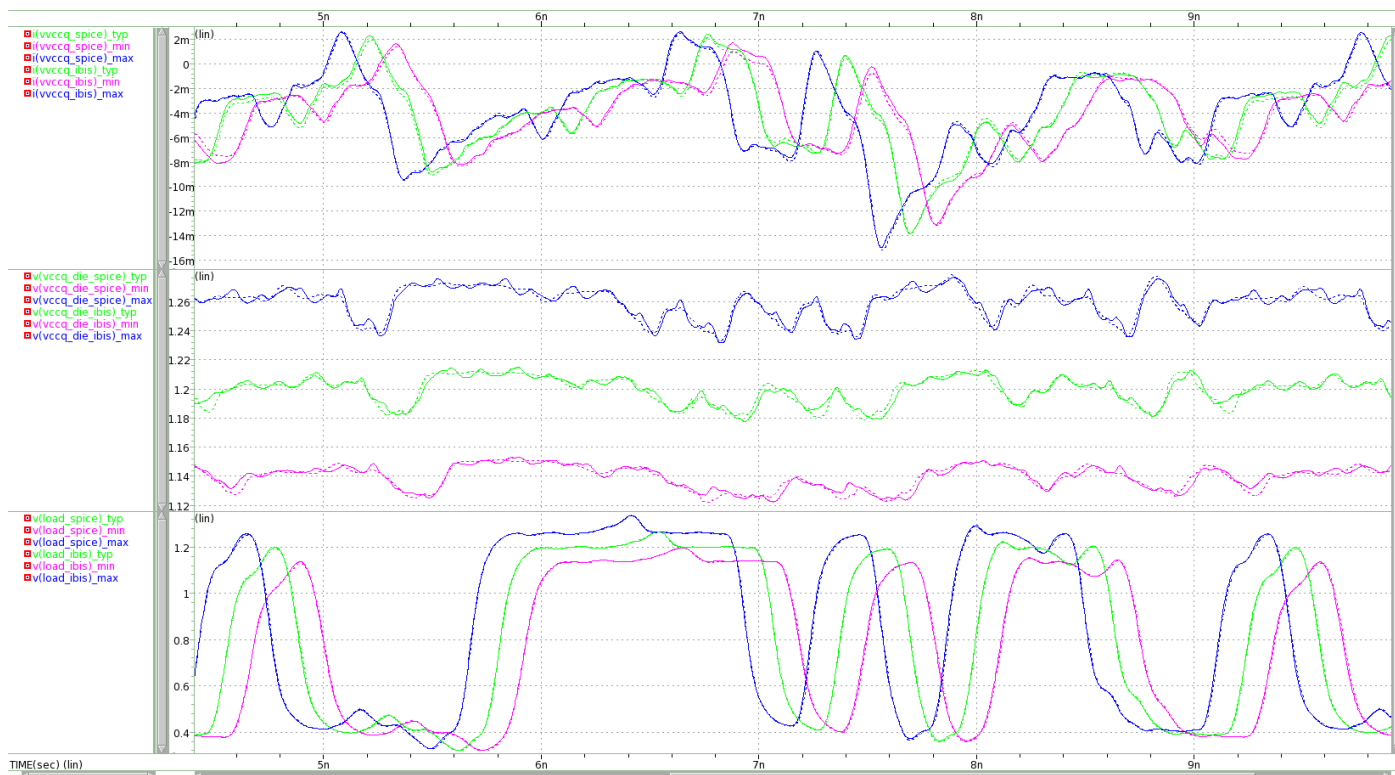
## ii. DQ\_40\_2666



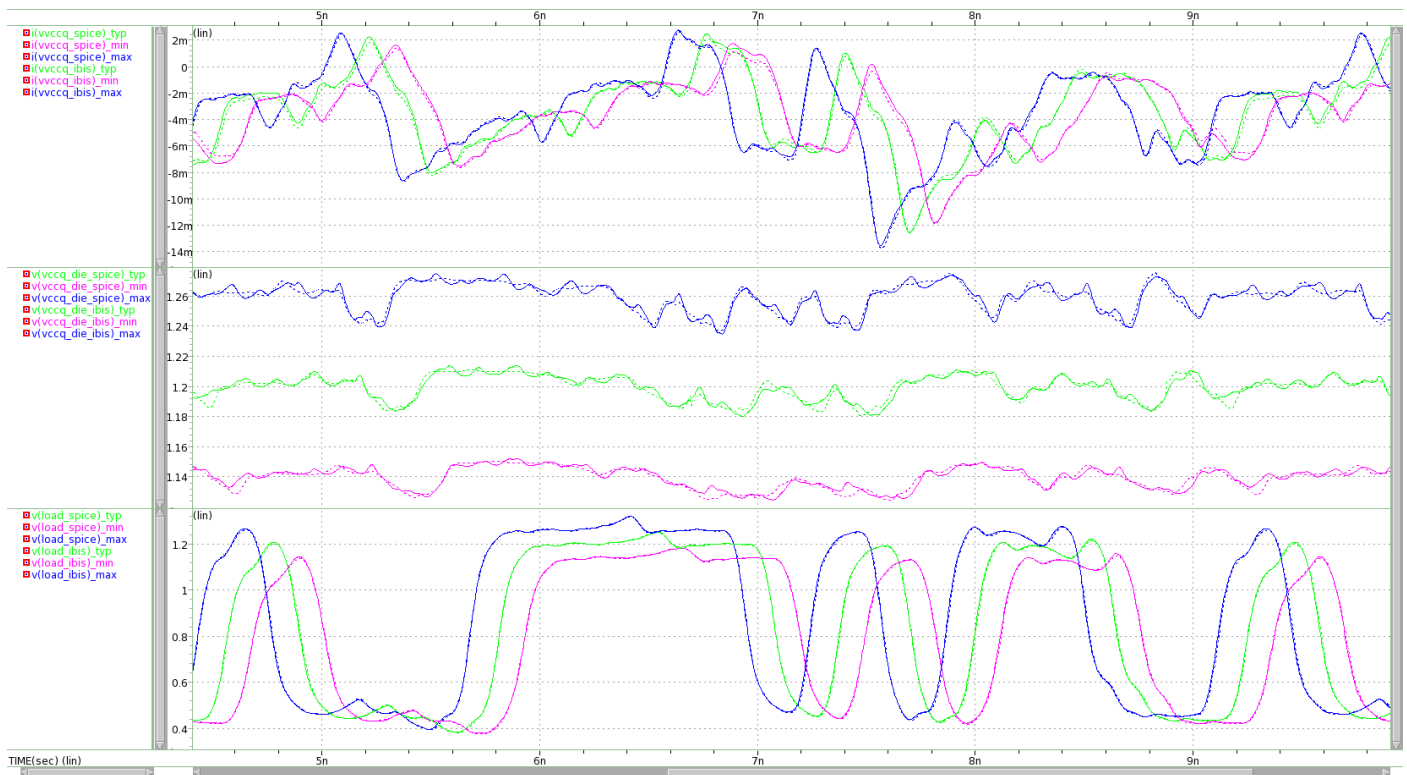
## iii. DQ\_48\_2666



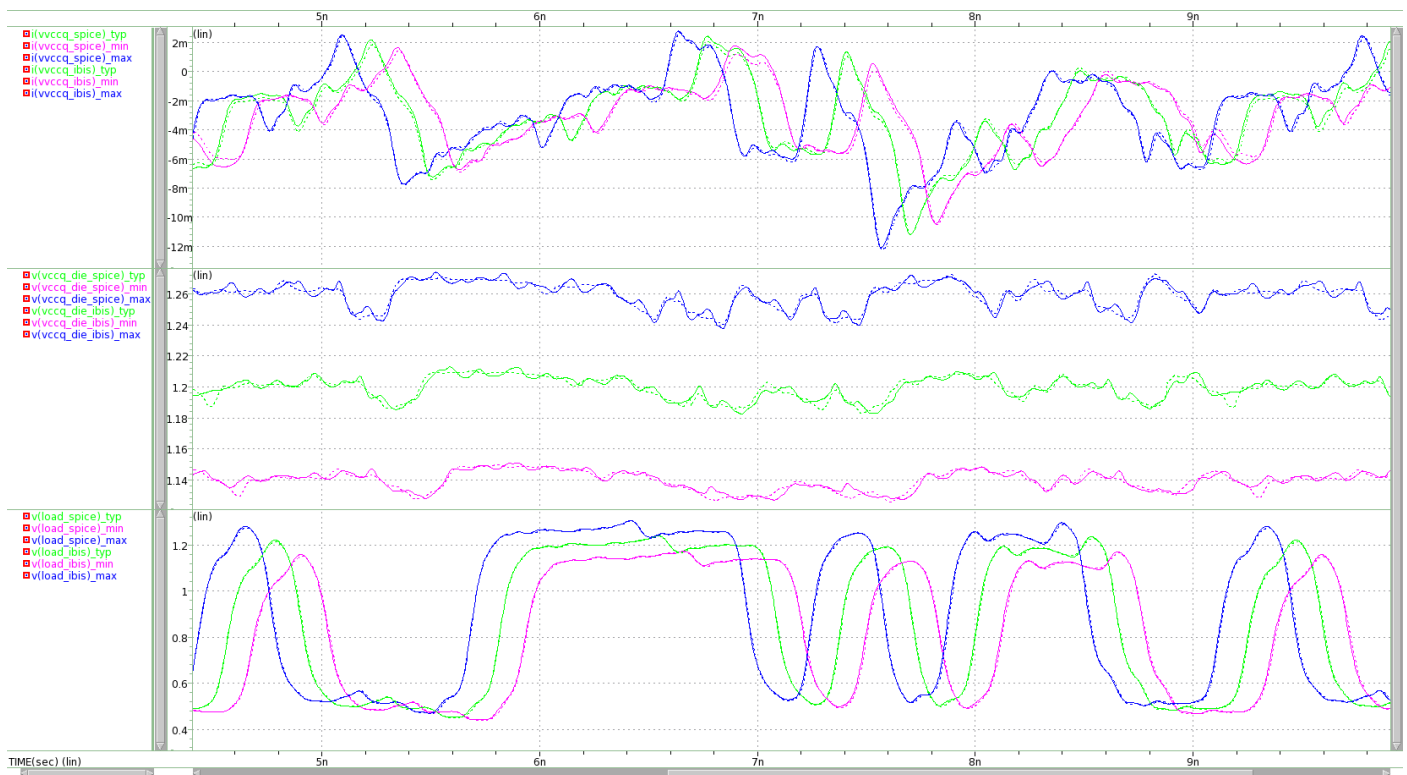
## iv. DQ\_34\_3200



## v. DQ\_40\_3200



## vi. DQ\_48\_3200



## **Comments**

1. **IBIS model may not reflect current speed grade availability.**
2. **C\_comp is compared with the DDR4-2666 specification only.**
3. **Slew rate is based on HSPICE simulation with a 50ohm load to VDDQ. This includes simple package parasitics for pin and power/gnd nets**

## **Document Revision History**

Rev **1.0** - Date **March 27, 2015**

- a. IBIS revision **1.0**
- b. HSPICE revision **1.0**

Rev **2.0** - Date **April 27, 2016**

- a. IBIS revision **2.0**
- b. HSPICE revision **2.0**

Rev **2.1** - Date **February 7, 2018**

- a. IBIS revision **2.1**
- b. HSPICE revision **2.3**