User's Guide
DS1xxDF111 IBIS-AMI Model

Version 5
March 2024

Table of Contents

1 Document Revision History

Revision	Editor	Comment	Date
1	Liang Liu	Initial creation of User's Guide.	04-June-2013
2	Casey Morrison	Updated default value for TX gain parameter. Added more correlation data to TX section showing correlation for multiple tools.	19-Dec-2013
3	Casey Morrison	Updated TX model parameters section (section 4) to include new model parameter for expanded de-emphasis options.	16-Jan-2014
4	Casey Morrison	Update TX model parameters to include touchstone file for termination.	26-March-2014
5	A0489615	Updated User's Guide for public release.	15-March-2024

2 Overview

This document is a User's Guide for the DS1xxDF111 Retimer. Table 1 below lists pertinent information related to the delivered model.

Table 1: Model information

Item	Value/Comment
Applicable TI device models	• DS110DF111 8.5Gbps to 11.3Gbps low power multi-rate two channel Retimer. • DS125DF111 9.8Gbps to 12.5Gbps low power multi-rate two channel Retimer.
IBIS version	Compliant to IBIS version 5.0. *Note: The concept of a "Retimer" in the context of IBIS-AMI had not been standardized at the time this document was written. However, several EDA vendors have anticipated the standardization of Retimer models and included this feature in their tools (Agilent ADS and SiSoft QCD to name a few).*
Supported platforms	• 32-bit Windows • 64-bit Windows • 64-bit Linux

Release package files	`TI_DS1xxDF111_IBIS_AMI_v1`
	`    |`
	`    +-- Example_Projects`
	`    |      |`
	`    |      +-- TI_DS1xxDF111_ADS_Project_Quick_Guide.pdf`
	`    |      +-- Agilent_ADS_2012.08_DS1xxDF111.7zads`
	`    |`
	`    +-- Model`
	`           |`
	`           +-- TI_DS1xxDF111_IBIS_AMI_User_Guide.pdf`
	`           +-- DS110DF111.ibs`
	`           +-- DS125DF111_TX_AMI_05212013.ami`
	`           +-- DS125DF111_RX_AMI_05272013.dll`
	`           +-- DS125DF111_RX_AMI_05272013.ami`
	`           +-- DS125DF111_TX_AMI_05212013.dll`
	`           +-- DS125DF111_TX_AMI_05212013_x64.so`
	`           +-- DS125DF111_RX_AMI_05272013_x64.so`
	`           +-- DS125DF111_TX_AMI_05272013_x64.dll`
	`           +-- DS125DF111_RX_AMI_05272013_x64.dll`
	`           +-- DS125DF111_TX_AMI_05212013_ibis.txt`
	`           +-- DS125DF111_RX_AMI_05272013_ibis.txt`
	`           +-- Retimer_pkg.s4p`

3 Receiver Model Parameters

The DS1xxDF111 receiver model includes the following model-specific parameters:

1. **EQ_Level:** This parameter is normally auto-adaptive when CTLEAdapt=1. If CTLEAdapt=0, then the value selected for EQ_Level will be applied. This parameter takes 16 values from 0 to 15 in the normal mode and 5 values from 0 to 4 in DWDM mode. Below table gives the mapping of EQ_Level to the device register (Reg_0x03) setting.

Model DWDM_mode setting (Reg_0x13[1])	Model EQ_Level setting	Equivalent device register 0x03 setting	EQ stage 0	EQ stage 1	EQ stage 2	EQ stage 3
0	0	0x00	0	0	0	0
0	1	0x40	1	0	0	0
0	2	0x80	2	0	0	0
0	3	0x50	1	1	0	0
0	4	0xC0	3	0	0	0
0	5	0x90	2	1	0	0
0	6	0x54	1	1	1	0
0	7	0xA0	2	2	0	0
0	8	0xB0	2	3	0	0
0	9	0x95	2	1	1	1
0	10	0x69	1	2	2	1
0	11	0xD5	3	1	1	1
0	12	0x99	2	1	2	1
0	13	0xA5	2	2	1	1
0	14	0xE6	3	2	1	2
0	15	0xF9	3	3	2	1
1	0	0x00	0	N/A	N/A	0
1	1	0x40	1	N/A	N/A	0
1	2	0x80	2	N/A	N/A	0
1	3	0x81	2	N/A	N/A	1
1	4	0xC1	3	N/A	N/A	1

2. **DWDM_mode:** Enables the DWDM mode of operation. It takes two values. The mapping from EQ_Level to register setting changes as shown above depending on the mode of operation.

   0 – Normal CTLE mode, default setting
   1 – DWDM CTLE mode

3. **Rx_config:** Parameter to set the output of Rx to either post- or pre-sliced waveform.

   0 – Output set to the slicer output (post-sliced waveform)
   1 – Output set to the DFE summation node (input of the slicer), default setting

4. **DFE tap values (DFEtap1, DFEtap2, DFEtap3, DFEtap4, DFEtap5):**

   These define the DFE tap gains. The following table gives the ranges for each tap coefficient. Actual tap gain equals DFEtap*LSB, where LSB=8mV. For example DFEtap1=10 sets the tap 1 gain to 80mV.

DFEtap	Max value	Min value
DFEtap1	32	-32
DFEtap2	16	-16
DFEtap3	16	-16
DFEtap4	16	-16
DFEtap5	16	-16

5. **DFEAdapt:** Enables or disables DFE adaptation. Takes two values:

   0 – Disables DFE adaptation and user given DFEtap coefficients are used for DFE.
   1 – Enables DFE adaptation. DFE adaptation starts after CTLE adaptation is complete and in this mode the user given DFEtap parameters are ignored and model uses the DFE setting which maximizes the HEO and VEO. Default setting.

6. **CTLEAdapt:** Enables or disables CTLE adaptation. Takes two values

   0 – Disables the CTLE adaptation and user given EQ_Level (above parameter) is used for CTLE block.

1 – Enables the CTLE adaptation. The user given EQ_Level value is ignored and the optimum CTLE value which maximizes the HEO and VEO is used. Default setting

7. **EOM_window:** Parameter used to control the number of bits used for EYE measurement. Default is set to 2000 bits.

4 Transmitter Model Parameters

The DS1xxDF111 transmitter model includes the following model-specific parameters:

1. **DE** and **DE_range:** These two paramters combined are used to set the output de-emphasis level. DE takes on eight values from 0-7. DE_range takes on two values from 0-1. Overall, there are 15 valid combinations, as shown in the table below which matches Table 16 in the datasheet.

DE setting	DE_range setting	De-emphasis value
0	0	0 dB
1	1	-0.9 dB
1	0	-1.5 dB
2	1	-2.0 dB
3	1	-2.8 dB
4	1	-3.3 dB
2	0	-3.5 dB
5	1	-3.9 dB
6	1	-4.5 dB
3	0	-5.0 dB
7	1	-5.6 dB
4	0	-6.0 dB
5	0	-7.5 dB
6	0	-9.0 dB
7	0	-12.0 dB

PIN SETTING	REGISTER 0X15 BIT [2], drv_dem[2]	REGISTER 0X15 BIT [1], drv_dem[1]	REGISTER 0X15 BIT [0], drv_dem[0]	REGISTER 0X15 BIT [6], drv_dem_range	DE-EMPHASIS SETTTING (dB)
0	0	0	0	0	0.0
	0	0	1	1	-0.9
R	0	0	1	0	-1.5
	0	1	0	1	-2.0
	0	1	1	1	-2.8
	1	0	0	1	-3.3
F	0	1	0	0	-3.5
	1	0	1	1	-3.9
	1	1	0	1	-4.5
	0	1	1	0	-5.0
	1	1	1	1	-5.6
1	1	0	0	0	-6.0
	1	0	1	0	-7.5
	1	1	0	0	-9.0
	1	1	1	0	-12.0

2. **VOD:** To set the output peak-to-peak differential amplitude. Takes 8 values from 0-7.

Model VOD setting	Output VOD (mVppd)
0	600
1	700
2	800
3	900
4	1000
5	1100
6	1200
7	1300

3. **Tstonefile**: Touchstone s-parameter file used by the simulator to represent the TX analog front-end, including termination. A dependency table has been implemented in the .ami file to map the VOD setting to the appropriate

touchstone file. If the file needs to be selected manually, the mapping is as follows:

Model VOD setting	**Corresponding touchstone file**
0	tx_term0.s4p
1	tx_term1.s4p
2	tx_term2.s4p
3	tx_term3.s4p
4	tx_term4.s4p
5	tx_term5.s4p
6	tx_term6.s4p
7	tx_term7.s4p

4. **gain:** Adjustment factor for the model. This parameter should always be set to 0.78, which is the default value.

5 Model Usage Tips

The following are general tips for using the DS1xxDF111 IBIS-AMI model.

1. ***How to set the samples per UI in the simulator***: Samples per UI should be chosen such that the sample time (UI divided by samples per UI) should be less than 10E-12 for accurate results. Typical recommended values for different bit rates are as follows:

Bit rate	Recommended samples per UI setting
≥ 1 Gbps	≥ 128 samples per UI
≥ 4 Gbps	≥ 64 samples per UI
≥ 8 Gbps	≥ 32 samples per UI

   Maximum allowable for this model is 256. This parameter can be changed in the EDA tool channel simulation settings (QCD, ADS, etc.).

2. **Ignore_Bits and number of bits to simulate:** As the model has inbuilt CTLE and DFE adaptation, only the data after CTLE and DFE adaptation completes should be used for EYE diagram. The number of bits taken for the adaptation depends on EOM_window. The default is set to 300,000 bits. In order to give the CTLE and DFE sufficient data and time to adapt, it is recommended that at least 400,000 bits are simulated,

3. **Log file**: Each simulation will produce Adapt.txt file, which records the adaption steps and the final values to which the CTLE settles. Note that if this file is already present, any subsequent simulations will append to this file.

4. **Analysis mode:** This model only supports bit-by-bit mode simulation. Statistical mode is not supported.

6 Model Verification

To verify the functionality and accuracy of the model, comparisons were made between IBIS-AMI model simulations and Cadence transistor-level simulations at different data rates and for different channel media.

6.1 Receiver test #1

Signal source: 10 Gbps, 0.8 V peak-to-peak differential, 0 dB de-emphasis, PRBS31
Channel: 20inch, 4mil FR4 stripline channel
DS1xxDF111 EQ_Level: 5 (Normal CTLE Mode)
Measurement point: Receiver output

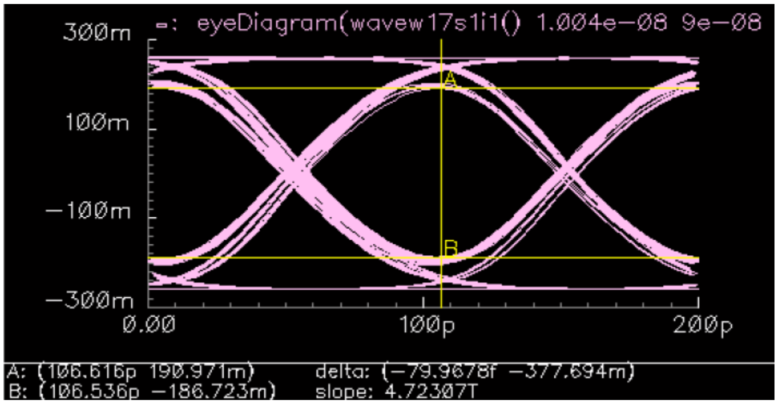

Figure 1: Cadence simulation

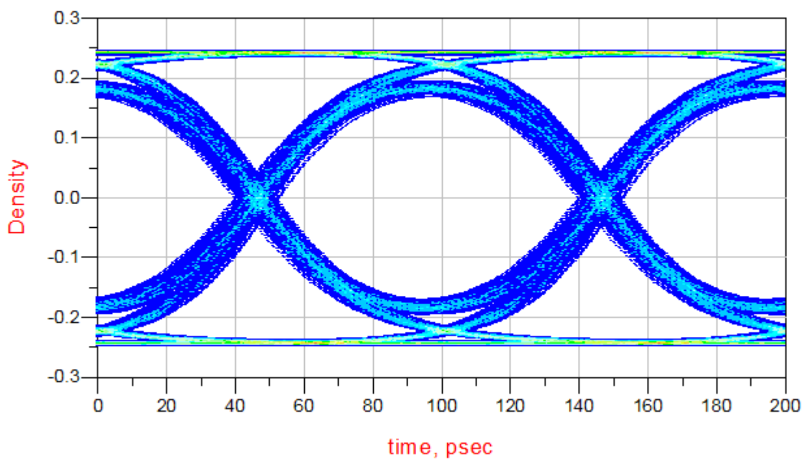

Figure 2: IBIS-AMI simulation

6.2 Receiver test #2

Signal source: 10 Gbps, 0.8 V peak-to-peak differential, 0 dB de-emphasis, PRBS31
Channel: 10inch, 4mil FR4 stripline channel
DS1xxDF111 EQ_Level: 3 (DWDM Mode)
Measurement point: Receiver output

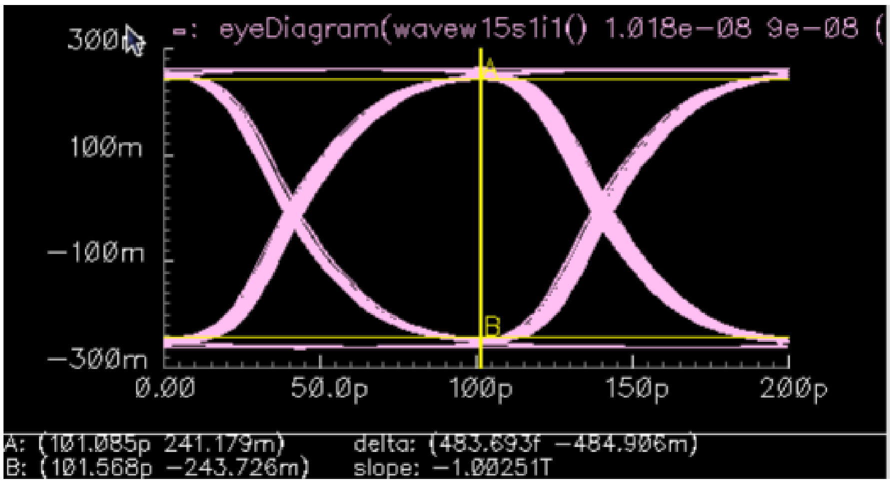

Figure 3: Cadence simulation

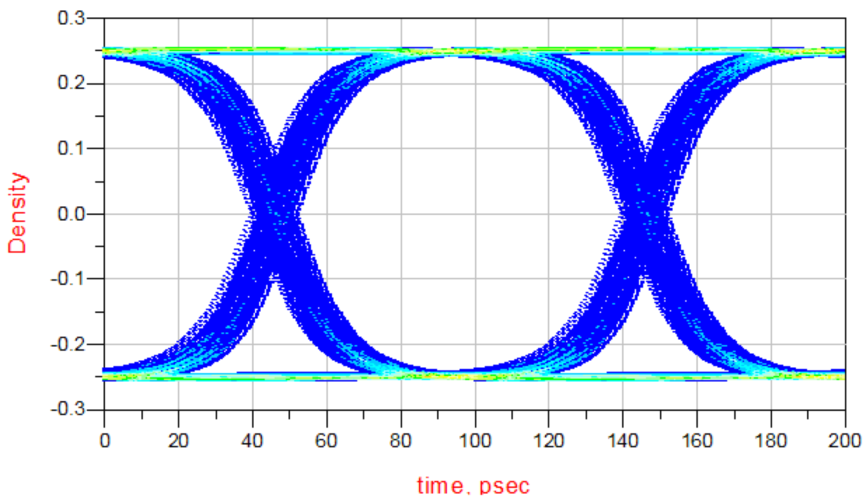

Figure 4: IBIS-AMI simulation

6.3 Receiver test #3

Signal source: 12.5 Gbps, 0.8 V peak-to-peak differential, 0 dB de-emphasis, PRBS9
Channel: 20inch, 4mil FR4 stripline channel
DS1xxDF111 EQ_Level: 6 (Normal CTLE Mode)
Measurement point: Receiver output

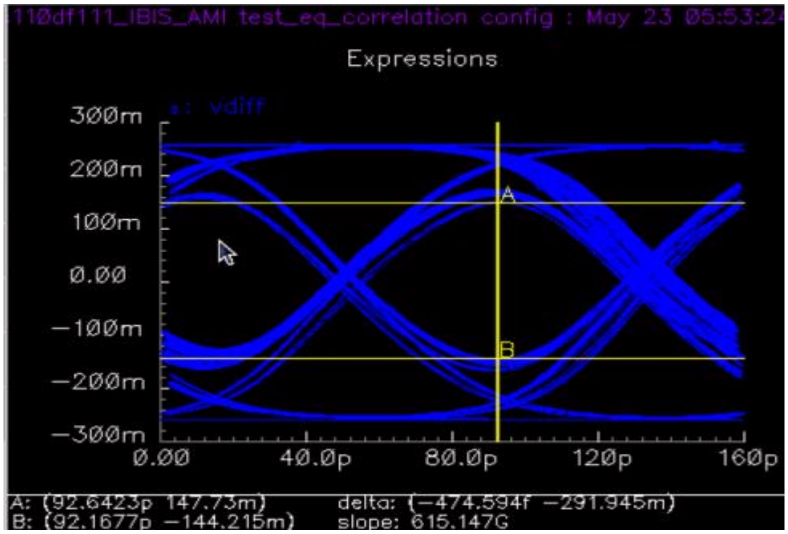

Figure 5: Cadence simulation

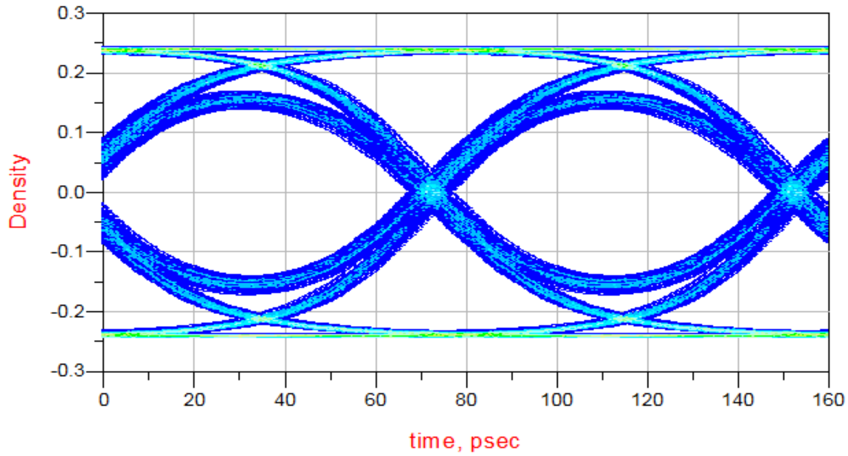

Figure 6: IBIS-AMI simulation

6.4 Receiver test #4

Signal source: 12.5 Gbps, 0.8 V peak-to-peak differential, 0 dB de-emphasis, PRBS31
Channel: 30inch, 4mil FR4 stripline channel
DS1xxDF111 EQ_Level: 6 (Normal CTLE Mode)
Measurement point: Receiver output

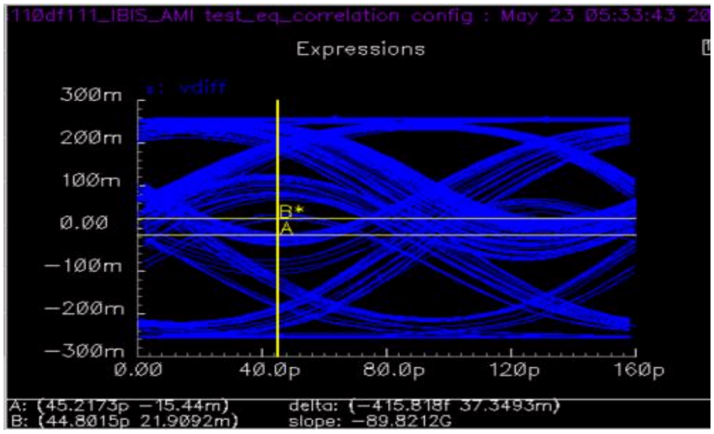

Figure 7: Cadence simulation

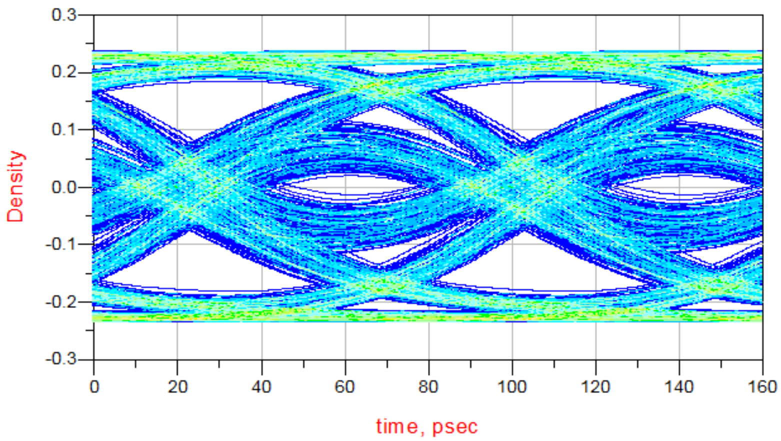

Figure 8: IBIS-AMI simulation

6.5 Transmitter test #1

Signal source: 10.3125Gbps
Channel: 5 inches, 4 mil FR4 stripline
DS1xxDF111 DE_Level: 4
DS1xxDF111 VOD_Level: 0
Measurement point: Far-end channel output

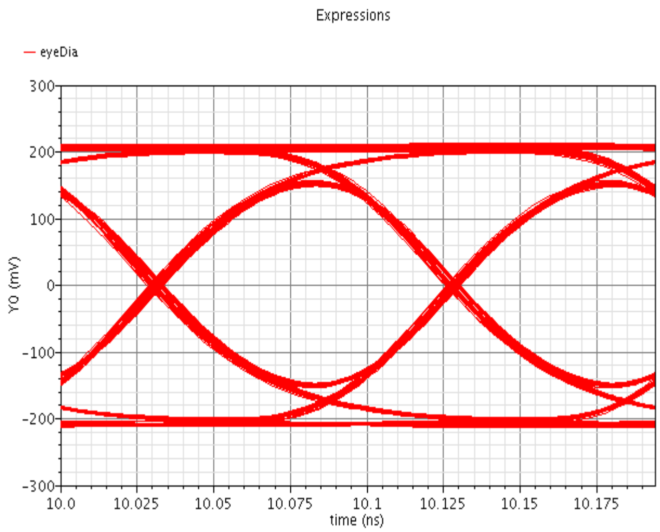

Figure 9: Cadence simulation

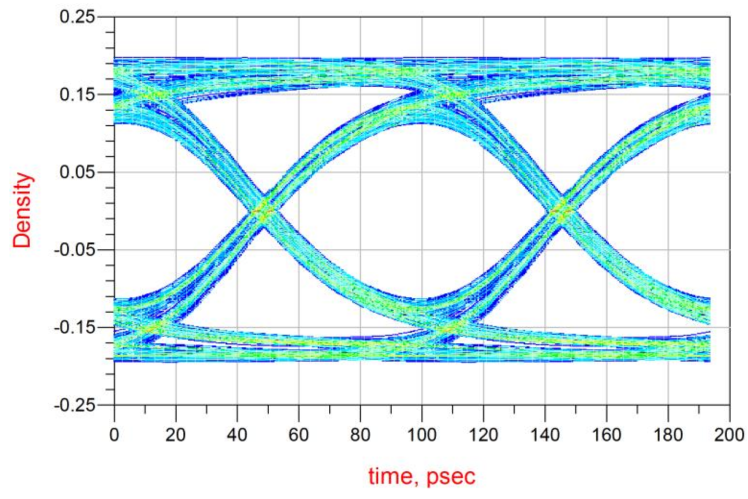

Figure 10: IBIS-AMI simulation

6.6 Transmitter test #2

Signal source: 10.3125Gbps
Channel: 10 inches, 4 mil FR4 stripline
DS1xxDF111 DE_Level: 4
DS1xxDF111 VOD_Level: 7
Measurement point: Far-end channel output

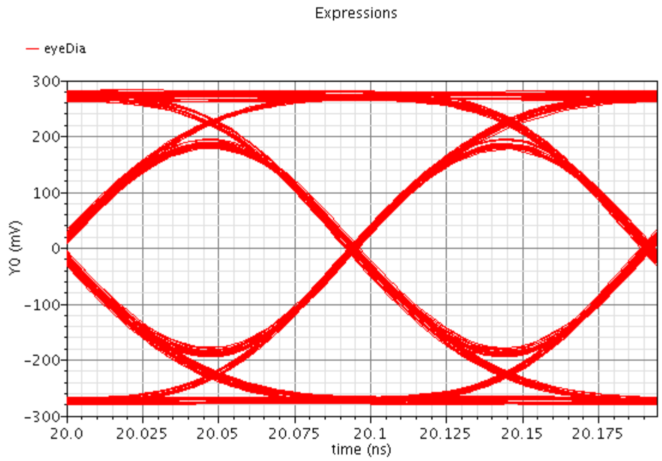

Figure 7: Cadence simulation

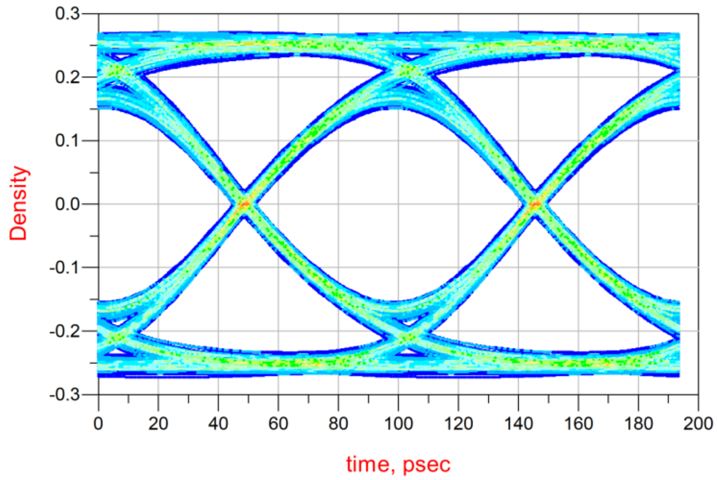

Figure 8: IBIS-AMI simulation

6.7 Transmitter test #3

Signal source: 10.3125Gbps
Channel: 15 inches, 4 mil FR4 stripline
DS1xxDF111 DE_Level: 7
DS1xxDF111 VOD_Level: 4
Measurement point: Far-end channel output

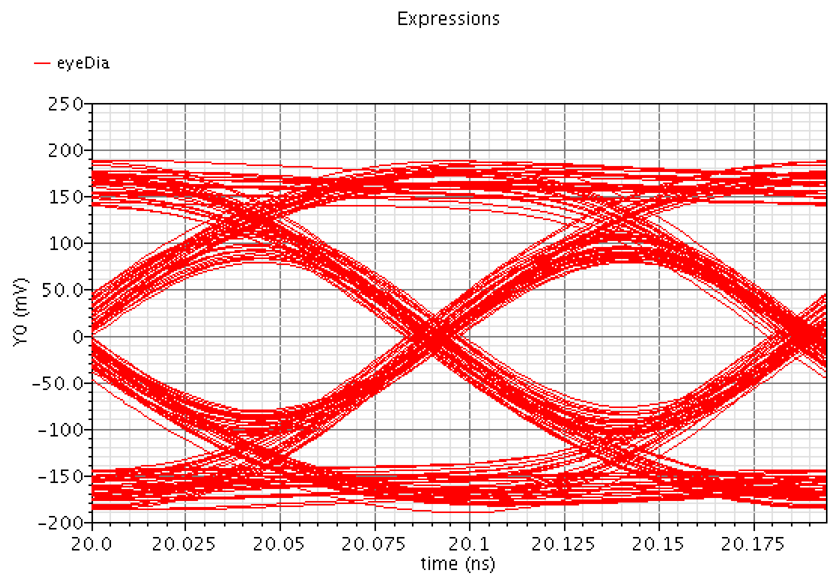

Figure 7: Cadence simulation

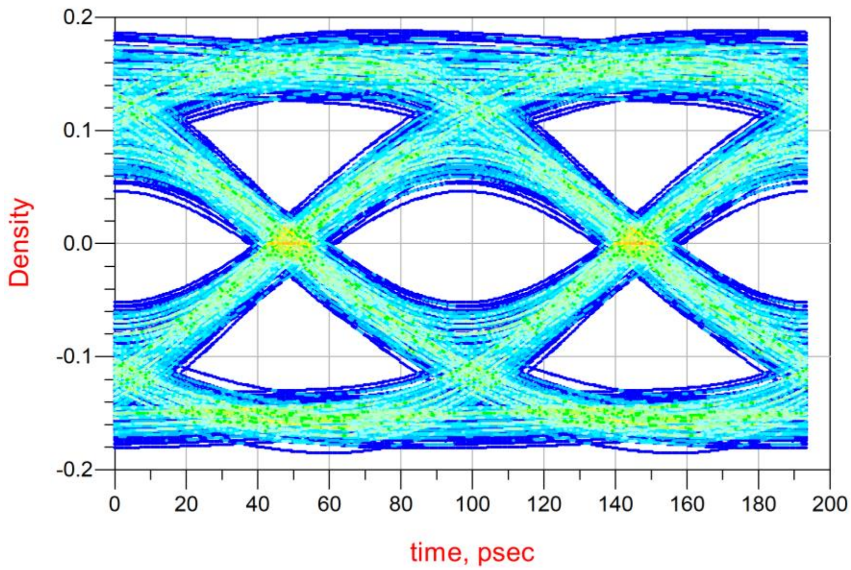

Figure 8: IBIS-AMI simulation

6.8 Transmitter test #4

Signal source: 10.3125Gbps
Channel: Retimer package
DS1xxDF111 DE_Level: 0
DS1xxDF111 VOD_Level: 7
Measurement point: Retimer output

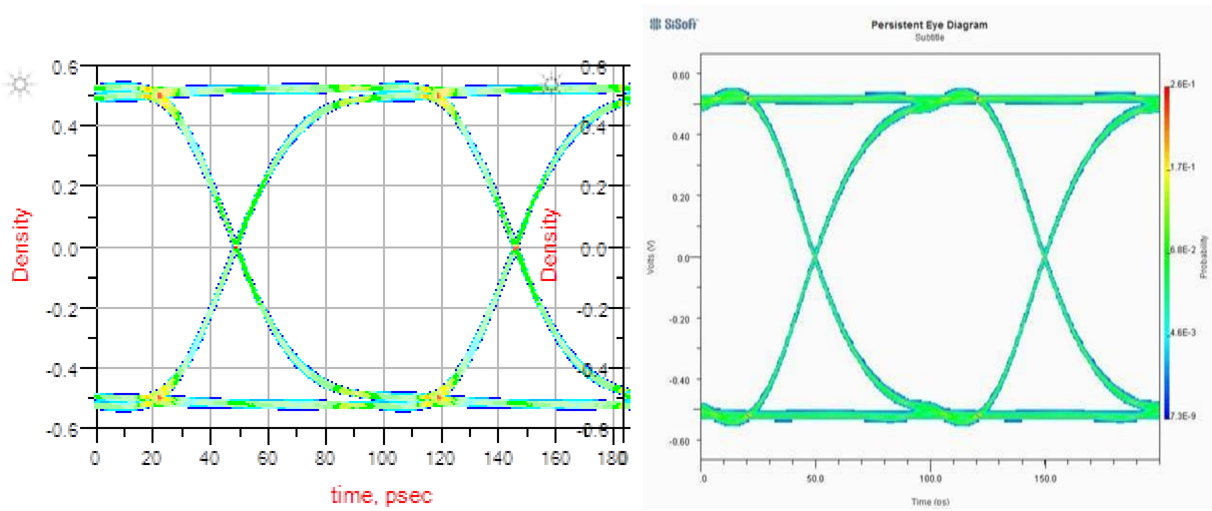

Figure 11: Comparison between Agilent ADS (left) and SiSoft QCD (right)

6.9 Transmitter test #4

Signal source: 10.3125Gbps
Channel: Retimer package
DS1xxDF111 DE_Level: 3
DS1xxDF111 VOD_Level: 7
Measurement point: Retimer output

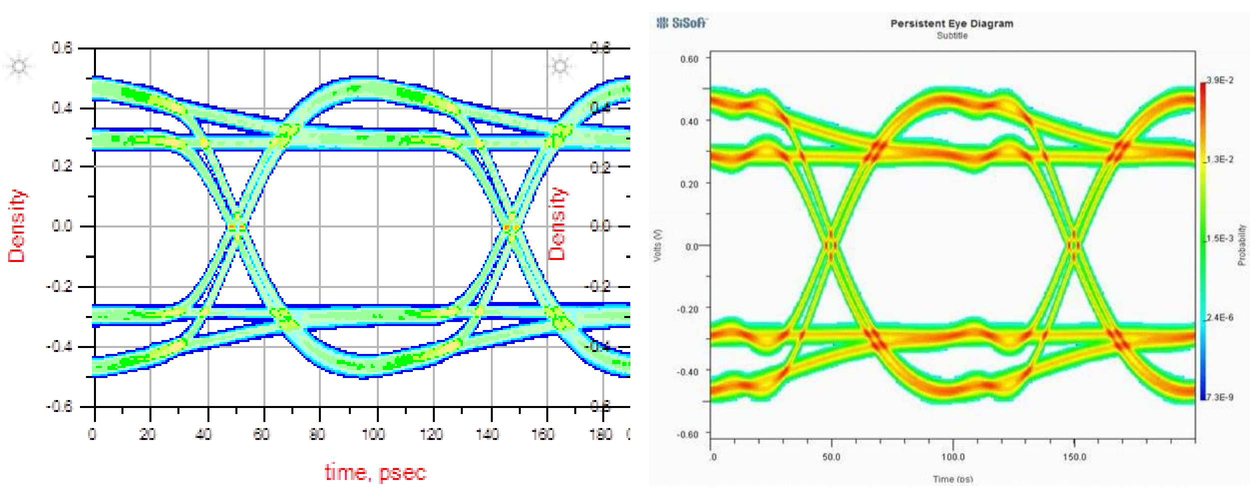

Figure 12: Comparison between Agilent ADS (left) and SiSoft QCD (right)