User's Guide
DS100BR111 DS100BR210 IBIS-AMI Model

Version 4
April 2024

Table of Contents

1 Document Revision History

Revision	Comment	Date
1	Initial creation of User's Guide.	23-Feb-2012
2	Update to include LTI (statistical) mode.	11-March-2014
3	• Update to model-specific parameter default values. • Updated for IBIS version 6.0. • Updated package models.	13-August-2015
4	Updated for public release.	18-April-2024

2 Overview

This document is a User's Guide for the *DS100BR111, DS100BR210* Buffer Repeater. Table 1 below lists pertinent information related to the delivered model.

Table 1: Model information

Item	Value/Comment
TI device models included	*DS100BR111, DS100BR210*
IBIS version	Compliant to IBIS version 6.0.
Supported platforms	• 32-bit Windows • 64-bit Windows • 64-bit Linux

Release package files	TI_DS100BR111_IBIS_AMI_vN
	    |
	    +-- Example_Projects
	    | |
	    | +-- TI_Repeater_DS100BR111_DS100BR210_ADS_Project_Quick_Guide.pdf
	    | +-- Agilent_ADS_2014.01.7zads
	    |
	    +-- Model
	          |
	          +-- TI_DS100BR111_DS100BR210_IBIS_AMI_User_Guide.pdf
	          +-- DS100BR111.ibs
	          +-- DS100KRxxx_Tx_03_2014.ami
	          +-- DS100KRxxx_Rx_03_2014.ami
	          +-- DS100KRxxx_Tx_03_2014.dll
	          +-- DS100KRxxx_Rx_03_2014.dll
	          +-- DS100KRxxx_Tx_03_2014_x64.dll
	          +-- DS100KRxxx_Rx_03_2014_x64.dll
	          +-- DS100KRxxx_Tx_03_2014_x64.s0
	          +-- DS100KRxxx_Rx_03_2014_x64.so
	          +-- repeater_pkg.s4p

3 Receiver Model Parameters

The *DS100BR111, DS100BR210* receiver model includes the following model-specific parameters:

1. **EQ_Level**: This parameter sets the Repeater's input equalization setting. Refer to Table 2 of the device datasheet (copied below for convenience).

Table 2. Equalizer Settings

Model EQ_Level setting	Level	EQA1/EQB1	EQA0/EQB0	EQ — 8 bits [7:0]	dB Boost at 5 Ghz	Suggested Media
0	1	0	0	0000 0000 = 0x00	2.5	FR4 < 5 inch trace
1	2	0	R	0000 0001 = 0x01	6.5	FR4 5 inch trace
2	3	0	Float	0000 0010 = 0x02	9	FR4 10 inch trace
3	4	0	1	0000 0011 = 0x03	11.5	FR4 15 inch trace
4	5	R	0	0000 0111 = 0x07	14	FR4 20 inch trace
5	6	R	R	0001 0101 = 0x15	15	FR4 25 inch trace
6	7	R	Float	0000 1011 = 0x0B	17	FR4 25 inch trace
7	8	R	1	0000 1111 = 0x0F	19	7m 30AWG Cable
8	9	Float	0	0101 0101 = 0x55	20	FR4 30 inch trace
9	10	Float	R	0001 1111 = 0x1F	23	8m 30 AWG Cable FR4 35 inch trace
10	11	Float	Float	0010 1111 = 0x2F	25	10m 30 AWG Cable
11	12	Float	1	0011 1111 = 0x3F	27	10m - 12m, Cable
12	13	1	0	1010 1010 = 0xAA	30	
13	14	1	R	0111 1111 = 0x7F	31	
14	15	1	Float	1011 1111 = 0xBF	33	
15	16	1	1	1111 1111 = 0xFF	34	

2. **Limit**: This parameter puts the device into a limiting or non-limiting mode.

Model Limit setting	Description
0	In this mode the model operates in non-limiting mode. The peakto-peak output voltage depends on the peak-to-peak input voltage. *This mode is required for applications which require link training (i.e. 8Gbps PCIe-Gen3 and 10.3125Gbps 10GBASEKR).*
1	In this mode the model operates in limiting mode. An additional gain of 40dB is included and thus the output peak-to-peak voltage will only depend on the limiting amplitude and not the input peak-to-peak voltage. *This mode should be used for applications which do not require link training.*

3. **LTI_mode**: This parameter determines whether the model's AMI_Init() function returns a modified impulse response (for LTI simulations) or an unmodified impulse

response (for non-LTI simulations). Regardless, the model has GetWave_Exists=True and therefore all behavior (LTI and non-LTI) will be represented in time domain simulations.

Note: Not all EDA tools support pure statistical simulations for Redrivers/Retimers. Nevertheless, LTI mode can still be used.

Model LTI_mode	Description
0	Non-linear-time-invariant (non-LTI) mode. The AMI_Init() function does not modify the impulse response. *Not recommended.*
1 (default)	Linear time-invariant (LTI) mode. The AMI_Init() function does modify the impulse response based on the LTI approximation of the RX model's equalization. *Recommended.*

4. **Tstonefile**: On-die termination s-parameter file. This should not be modified by the user.

5. **Rx_R:** Monitor for port termination impedance. Debug only.

6. **Supporting_Files:** List of supporting files used by the model. This should not be modified by the user.

4 Transmitter Model Parameters

The *DS100BR111, DS100BR210* transmitter model includes the following model-specific parameters:

1. **VOD_Level**: This parameter sets the driver output voltage setting. There are eight VOD settings as shown in the table below. Note that in non-limiting mode (Limit=0), the output peak-to-peak amplitude will depend on the input peak-to-peak amplitude, so the output amplitude may not match the values shown in this table. In limiting model (Limit=1) the output peak-to-peak amplitude is directly controllable with the VOD_Level setting.

Model VOD_Level setting	De-emphasis value
0	700 mVp-p
1	800 mVp-p
2	900 mVp-p
3	1000 mVp-p
4	1100 mVp-p
5	1200 mVp-p
6	1300 mVp-p

2. **DE_Level**: This parameter sets the driver de-emphasis level setting. There are eight de-emphasis settings as shown in the table below.

Model DE_Level setting	De-emphasis value
0	0 dB
1	-1.5 dB
2	-3.5 dB
3	-5.0 dB
4	-6.0 dB
5	-8.0 dB
6	-9.0 dB
7	-12.0 dB

3. **LTI_mode**: This parameter determines whether the model's AMI_Init() function returns a modified impulse response (for LTI simulations) or an unmodified impulse response (for non-LTI simulations). Regardless, the model has GetWave_Exists=True and therefore all behavior (LTI and non-LTI) will be represented in time domain simulations.

   Note: Not all EDA tools support pure statistical simulations for Redrivers/Retimers. Nevertheless, LTI mode can still be used.

Model LTI_mode	Description
0	Non-linear-time-invariant (non-LTI) mode. The AMI_Init() function does not modify the impulse response. *Not recommended.*
1 (default)	Linear time-invariant (LTI) mode. The AMI_Init() function does modify the impulse response based on the LTI approximation of the TX model's equalization. *Recommended.*

4. **Gain_debugonly**: This parameter should not be changed by the user. It is included for debug purposes only.

5. **Tstonefile**: On-die termination s-parameter file. This should not be modified by the user.

6. **Tx_R:** Monitor for on-die supply series resistance. Debug only.

7. **Supporting_Files:** List of supporting files used by the model. This should not be modified by the user.

5 Model Usage Tips

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

2. ***Note on [Repeater Pin]***. The [Repeater Pin] key word in the IBIS file is used to define the Rx input pin and Tx output pin pairs which form repeaters. At the time this document was written, this was not yet part of the official IBIS standard and hence the IBIS parser throws an 'Invalid Keyword' error upon encountering the [Repeater Pin] keyword. Please ignore this error as the model runs fine in most EDA tools (SiSoft QCD and Agilent ADS to name a few). In fact, the [Repeater Pin] definition is necessary to simulate 'Repeater' models in SiSoft QCD. If the model needs to be run in other tools which do not support this keyword (like Mentor Graphics Hyperlynx), the [Repeater Pin] definition can be deleted without any change in the functionality of the model.

3. ***Note on IBIS Version 6.0***. Not all tools support IBIS Version 6.0 features such as AMI_Version and Repeater_Type reserved parameters. Check with your tool vendor. If the tool does not support IBIS version 6.0, it is safe to remove the AMI_Version and Repeater_Type parameters in the .ami files and change the [IBIS Ver] from 6.0 to 5.1.

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. In addition, comparisons between different IBISAMI simulators were made.

6.1 Receiver test #1

Signal source: 8.0 Gbps, 1 V peak-to-peak differential, 0 dB de-emphasis
Channel: 10 meter, 30 AWG copper cable
DS100BRxxx EQ_Level: 10
DS100BRxxx Limit: 0
Measurement point: Receiver output

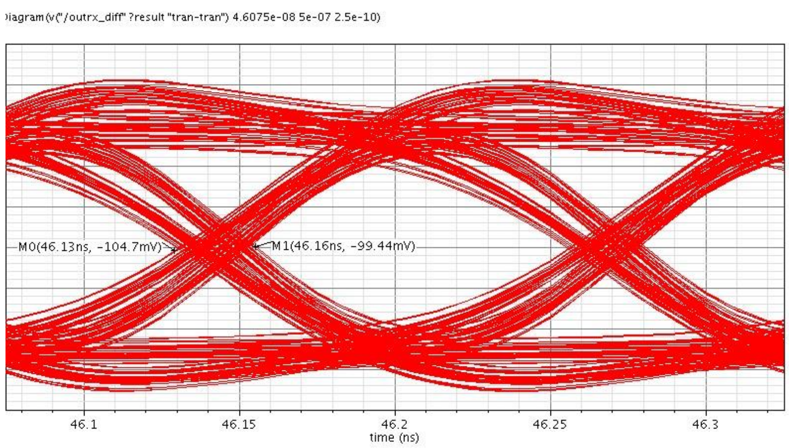
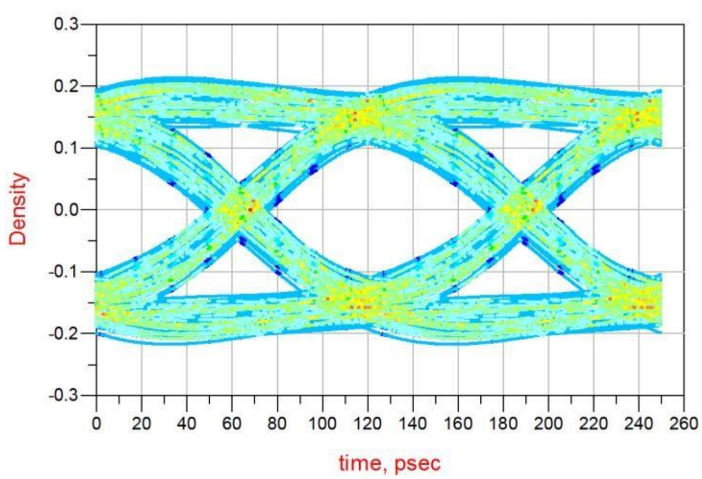


Figure 1: Cadence simulation (Jitter = 30 ps p-p)



measurement	Summary
Level1	0.150
Level0	-0.149
LevelMean	1.710E-4
Amplitude	0.299
Height	0.174
Width	9.625E-11
RiseTime	5.949E-11
FallTime	6.067E-11
JitterPP	2.875E-11
JitterRMS	7.109E-12
WidthAtBER	9.813E-11
HeightAtBER	0.214

Figure 2: IBIS-AMI simulation (Jitter = 29 ps p-p)

6.2 Receiver test #2

Signal source: 8.0 Gbps, 1 V peak-to-peak differential, 0 dB de-emphasis
Channel: 10 inches, 4 mil stripline
DS100BRxxx EQ_Level: 6*
DS100BRxxx Limit: 0
Measurement point: Receiver output
**This test case is to deliberately show over-equalization, hence the misshapen eye.*

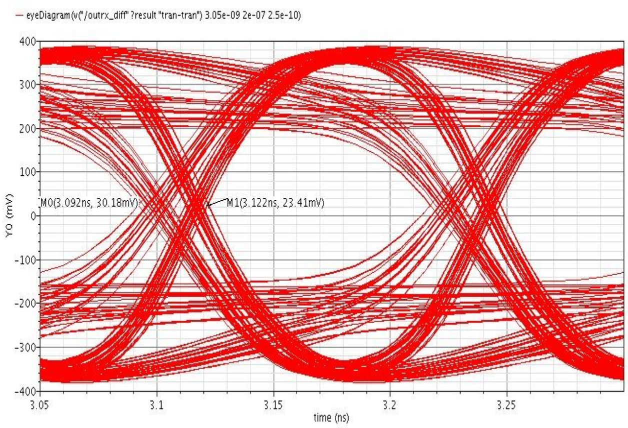
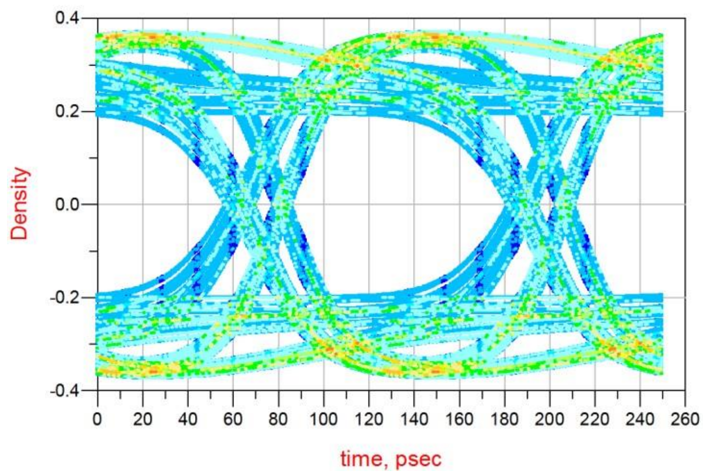


Figure 3: Cadence simulation (Jitter = 30 ps p-p)



measurement	Summary
Level1	0.300
Level0	-0.301
LevelMean	-3.958E-4
Amplitude	0.600
Height	0.347
Width	9.625E-11
RiseTime	4.745E-11
FallTime	5.028E-11
JitterPP	2.875E-11
JitterRMS	9.840E-12
WidthAtBER	9.500E-11
HeightAtBER	0.390

Figure 4: IBIS-AMI simulation (Jitter = 29 ps p-p)

6.3 Receiver test #3

Signal source: 10.3125 Gbps, 1 V peak-to-peak differential, 0 dB de-emphasis
Channel: 20 inches, 4 mil stripline
DS100BRxxx EQ_Level: 6
DS100BRxxx Limit: 0
Measurement point: Receiver output

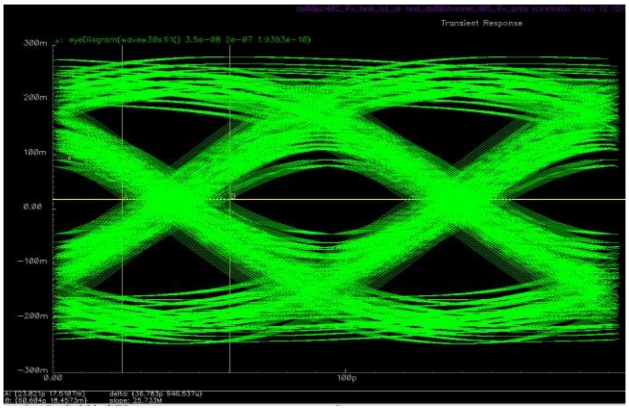
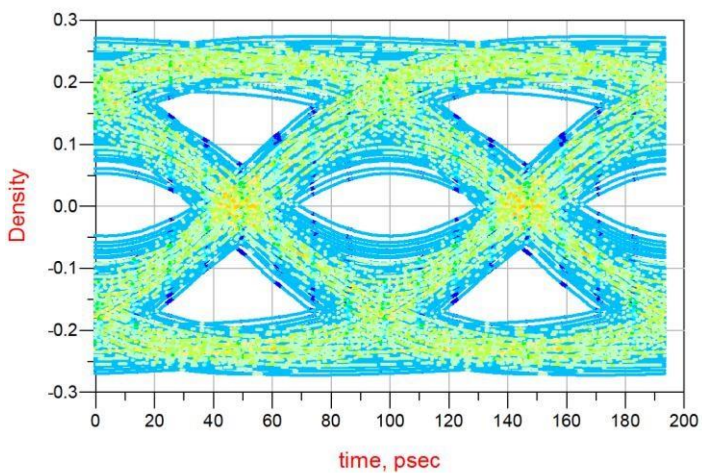


Figure 5: Cadence simulation (Jitter = 37 ps p-p)



measurement	Summary
Level1	0.173
Level0	-0.173
LevelMean	6.445E-5
Amplitude	0.345
Height	0.082
Width	6.061E-11
RiseTime	6.491E-11
FallTime	6.304E-11
JitterPP	3.636E-11
JitterRMS	7.848E-12
WidthAtBER	6.158E-11
HeightAtBER	0.099

Figure 6: IBIS-AMI simulation (Jitter = 36 ps p-p)

6.4 Transmitter test #1

Signal source: 8.0 Gbps, 0.6 V peak-to-peak differential, 0 dB de-emphasis
Channel: 15 inches, 4 mil stripline
DS100BRxxx DE_Level: 4
DS100BRxxx VOD_Level: 6

Measurement point: Far-end channel output

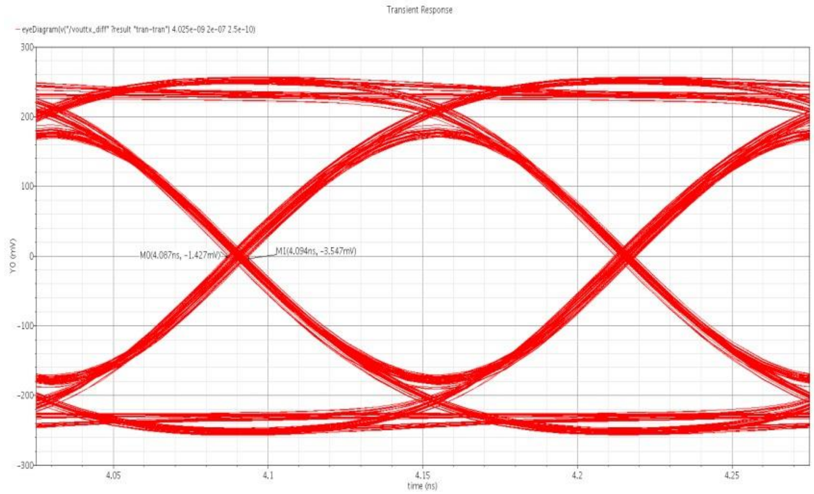
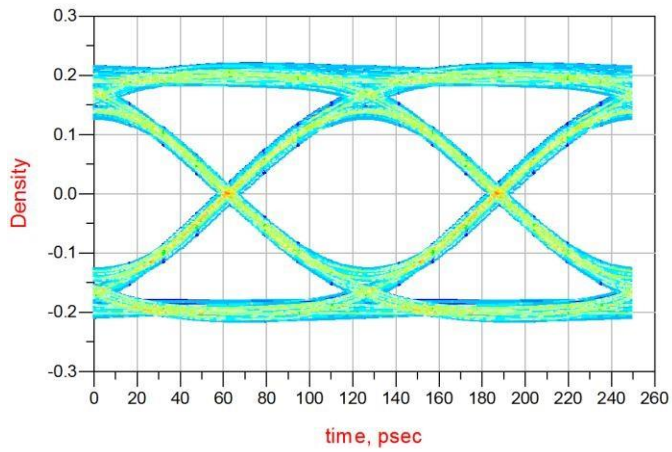


Figure 7: Cadence simulation (Jitter = 7 ps p-p)

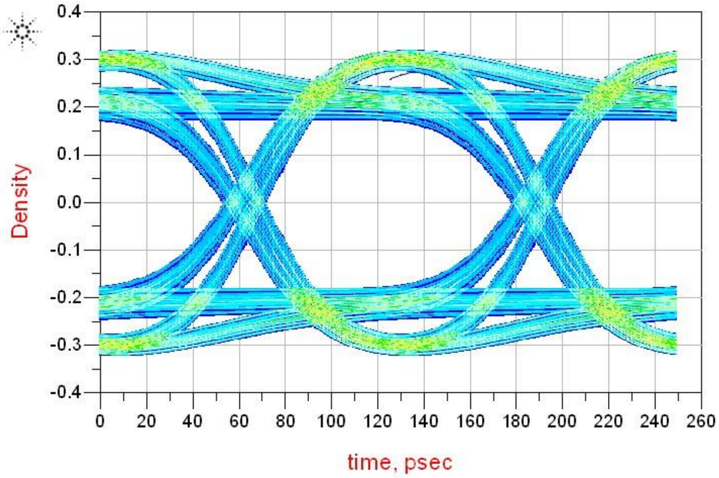


measurement	Summary
Level1	0.166
Level0	-0.166
Amplitude	0.332
Height	0.234
HeightDB	-6.308
Width	1.144E-10
RiseTime	6.359E-11
FallTime	6.356E-11
JitterPP	1.054E-11
JitterRMS	2.108E-12
WidthAtBER	1.144E-10
HeightAtBER	0.250
CrossingLevel	0.000

Figure 8: IBIS-AMI simulation (Jitter = 10 ps p-p)

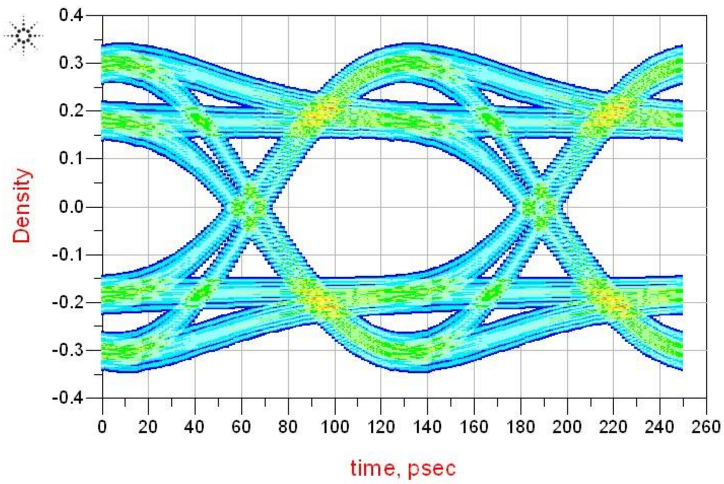
6.5 Statistical versus Time Domain: RX test

Signal source: 8.0 Gbps, 1 V peak-to-peak differential, 0 dB de-emphasis
Channel: 20 inches, 4 mil stripline
DS100BRxxx EQ_Level: 8
DS100BRxxx Limit: 0
Measurement point: Receiver output



measurement	Summary
Level1	0.253
Level0	-0.253
Height	0.329
Width	1.069E-10

Figure 9: Time domain (bit-by-bit) simulation result



measurement	Summary
Level1	0.237
Level0	-0.240
Height	0.266
Width	1.063E-10

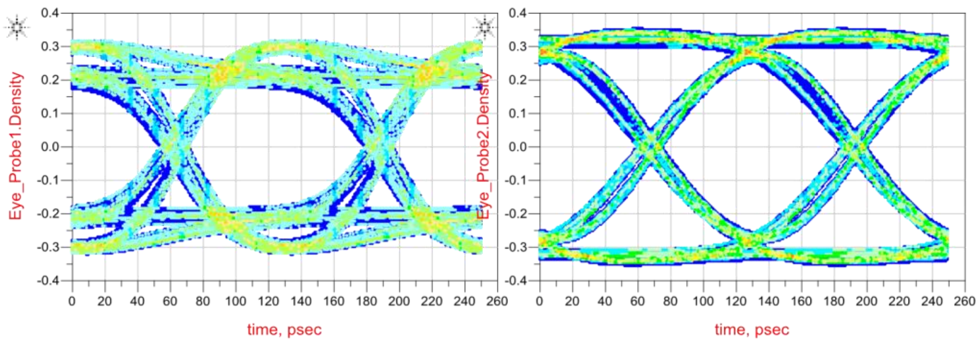
Figure 10: Statistical simulation result

6.6 Statistical versus Time Domain: Full Link test

Note: Some tools do not support pure statistical simulations for Redrivers/Retimers, so the results shown below are for two time domain simulations, one executed with init-only processing (i.e. GetWave_Exists=False), and one executed with GetWave-only processing (i.e. LTI_mode=0).

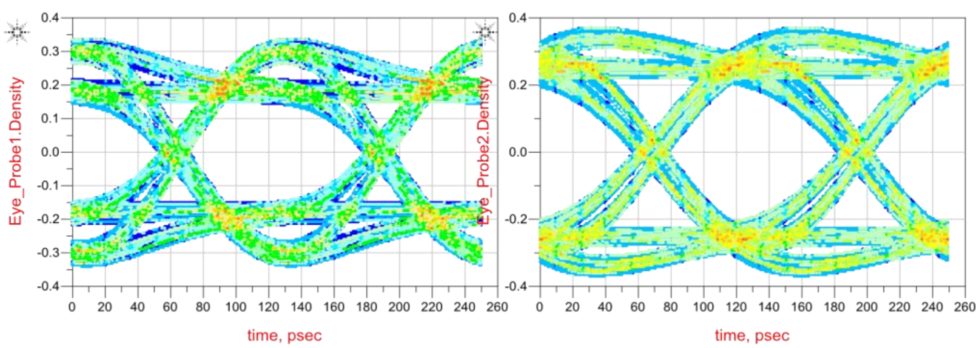
Signal source: 8.0 Gbps, 1 V peak-to-peak differential, 0 dB de-emphasis
Input channel: 20 inches, 4 mil stripline

DS100BRxxx RX EQ_Level: 8
DS100BRxxx RX Limit: 0
Output channel: 10 inches, 4 mil stripline
DS100BRxxx RX DE_Level: 1
Measurement points: Redriver RX and TX outputs



measurement	Eye_Probe1.Summary	Eye_Probe2.Summary
Level1	0.253	0.289
Level0	-0.254	-0.289
Height	0.335	0.446
Width	1.094E-10	1.106E-10

Figure 11: Time domain simulation result; GetWave_Exists=True, LTI_mode=0



measurement	Eye_Probe1.Summary	Eye_Probe2.Summary
Level1	0.238	0.262
Level0	-0.239	-0.263
Height	0.275	0.334
Width	1.088E-10	1.056E-10

Figure 12: Time domain simulation result; GetWave_Exists=False, LTI_mode=1