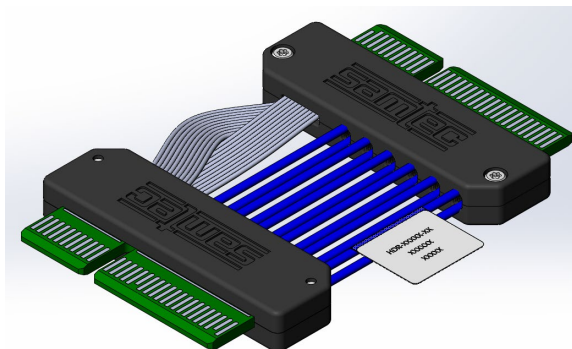




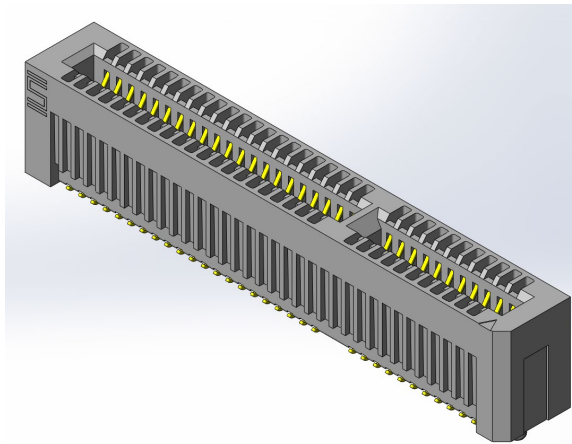
High Speed Characterization Report

PCIEC-G4-064-XXXX-C1



Mated with:

PCIE-G4-04-01-X-DV



Description:

**PCI Express® 4.0 Cable Assembly,
Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card**

Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Table of Contents

Cable Assembly Overview	1
Frequency Domain Data Summary	2
Bandwidth Figures – Differential Insertion Loss	2
Time Domain Data Summary	4
Characterization Details	6
Differential and Single-Ended Data	6
Cable assembly Signal to Ground Ratio	6
Cable Assembly Pin Map	7
Frequency Domain Data	8
Time Domain Data	8
Appendix A – Frequency Domain Responses	9
Differential Application – Insertion Loss	9
Differential Application – Return Loss	10
Differential Application – NEXT Configurations	12
Differential Application – FEXT Configurations	15
Differential Application – Differential to Common Mode Conversion	18
Appendix B – Time Domain Responses	20
Differential Application – Input Pulse	20
Differential Application – Cable Assembly Impedance	20
Differential Application – Cable assembly Impedance	22
Differential Application – Propagation Delay	25
Appendix C – Product and Test System Descriptions	28
Product Description	28
Test System Description	28
PCB-PCIEG4-110033-SIG Test Fixtures	28
Appendix D – Test and Measurement Setup	30
N5225B Measurement Setup	30
Test Instruments	30
Test Cables & Adapters	30
Appendix E - Frequency and Time Domain Measurements	31
Frequency (S-Parameter) Domain Procedures	31
Time Domain Procedures	31
Propagation Delay (TDT)	31
Impedance (TDR)	32
Appendix F – Glossary of Terms	33

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable, End 2: PCIe Edge Card

Cable Assembly Overview

The PCIEC-G4 Cable Assembly is constructed using Samtec 34 AWG, Twinax Cable. The cable is terminated at the first end with an edge card and terminated at the second end with a PCIe edge card or PCIe edge mount socket connector on a printed circuit board. The cable assembly is wired to facilitate a Pin 1 to Pin 1 mapping between the cable terminations. The PCIEC-G4 series cable assemblies are available in 36 (X1), 64 (X4), 98 (X8) and 164 (X16) positions. The data in this report is only applicable to 250 mm, 500mm and 1000 mm length, 100-ohm twinax cable assembly with a PCIe edge card terminated at the second end.

Each PCIEC-G4 cable assembly was tested by mating it to a PCIE-G4 Socket at both ends. One sample of each assembly was tested. The actual part numbers that were tested are shown in Table 1, which also identifies End 1 and End 2 of each assembly. A relative sample picture is shown in Figure 1 and a diagram is shown in Figure 2.

Length	Part Number	End 1	End 2
250 mm	PCIEC-G4-064-0250-C1	Edge-Card	Edge-Card
500 mm	PCIEC-G4-064-0500-C1	Edge-Card	Edge-Card
1000 mm	PCIEC-G4-064-1000-C1	Edge-Card	Edge-Card

Table 1: Sample Description



Figure 1: Test Sample

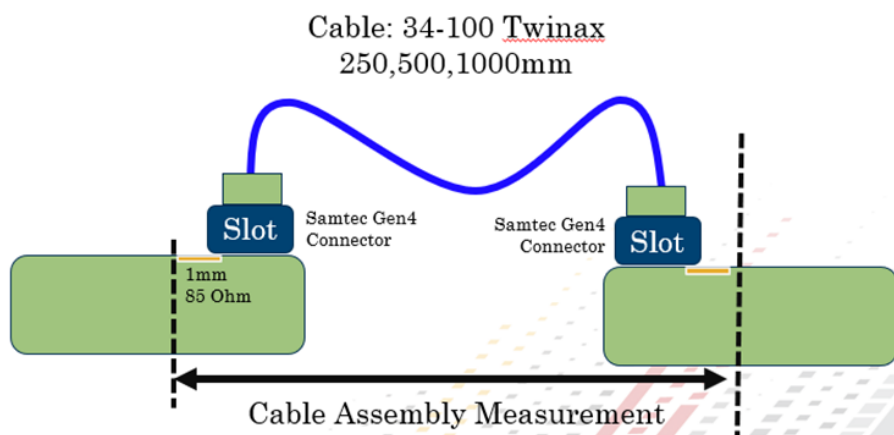
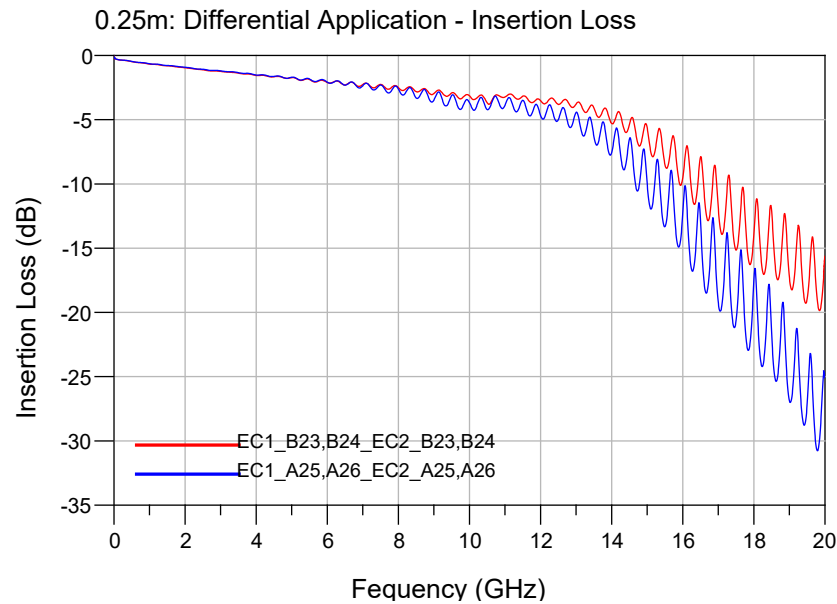
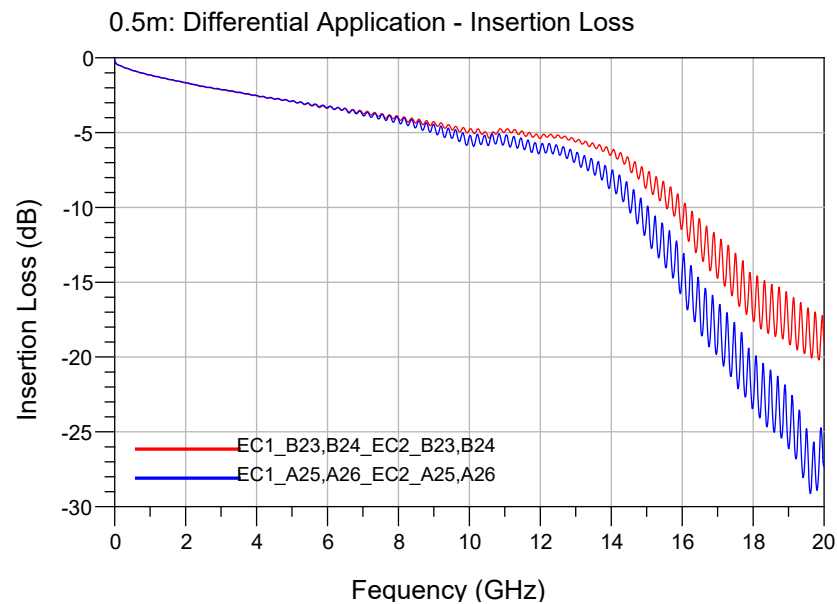


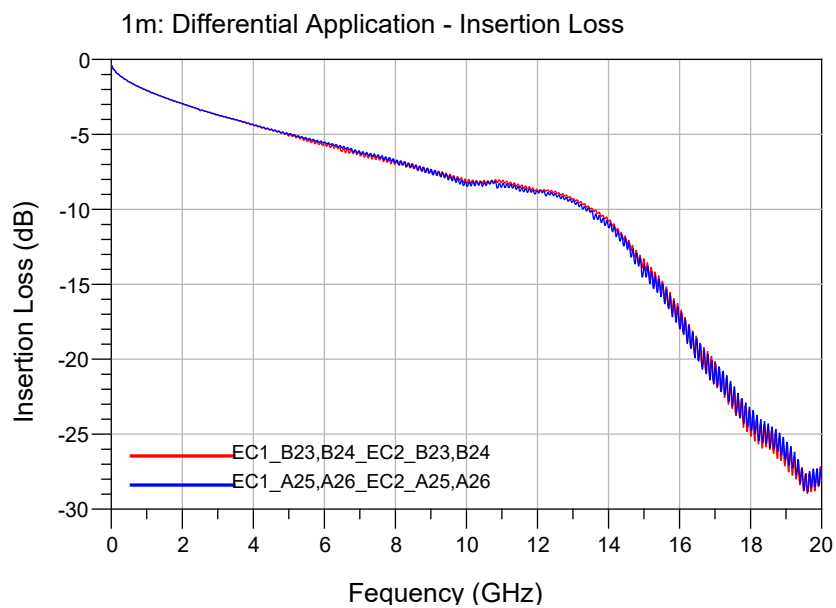
Figure 2: Diagram of the DUT

Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Frequency Domain Data Summary

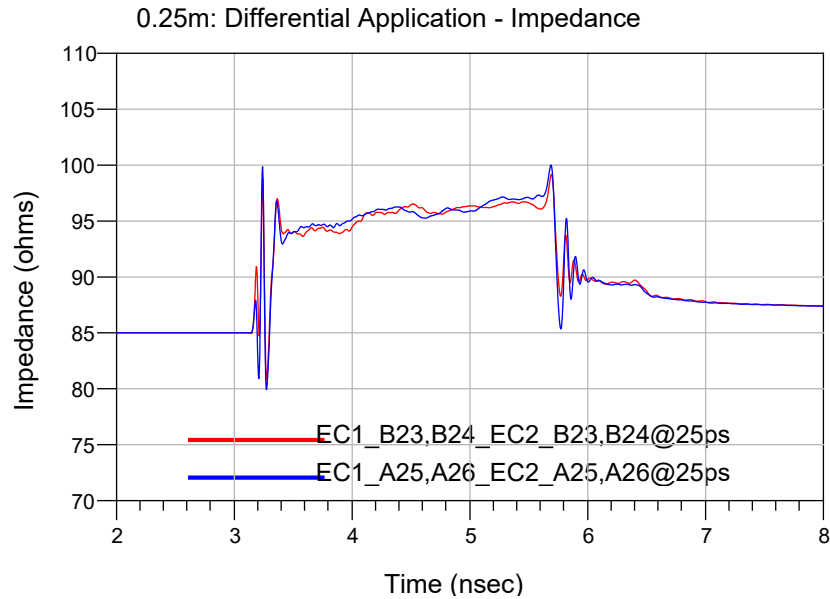
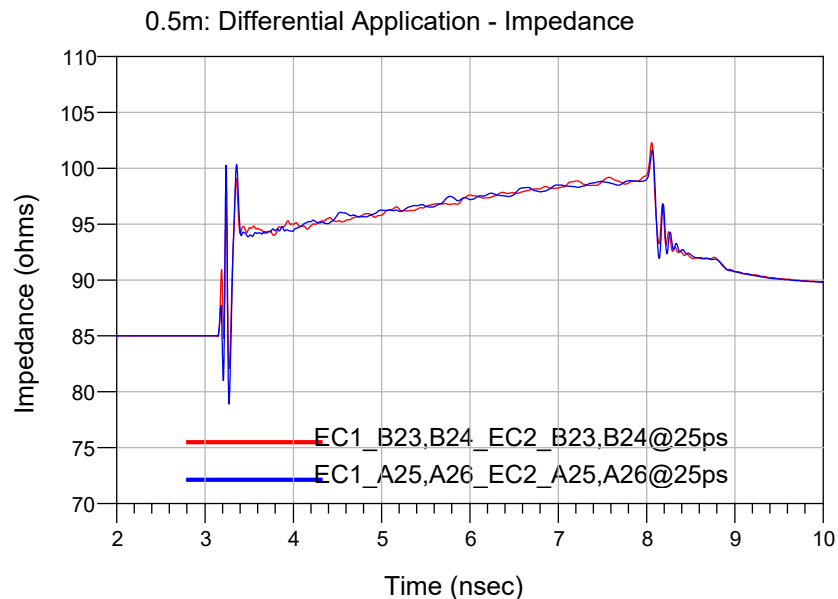
Bandwidth Figures – Differential Insertion Loss

**Figure 3****Figure 4**

Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card**Figure5**

Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Time Domain Data Summary

**Figure 6****Figure 7**

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

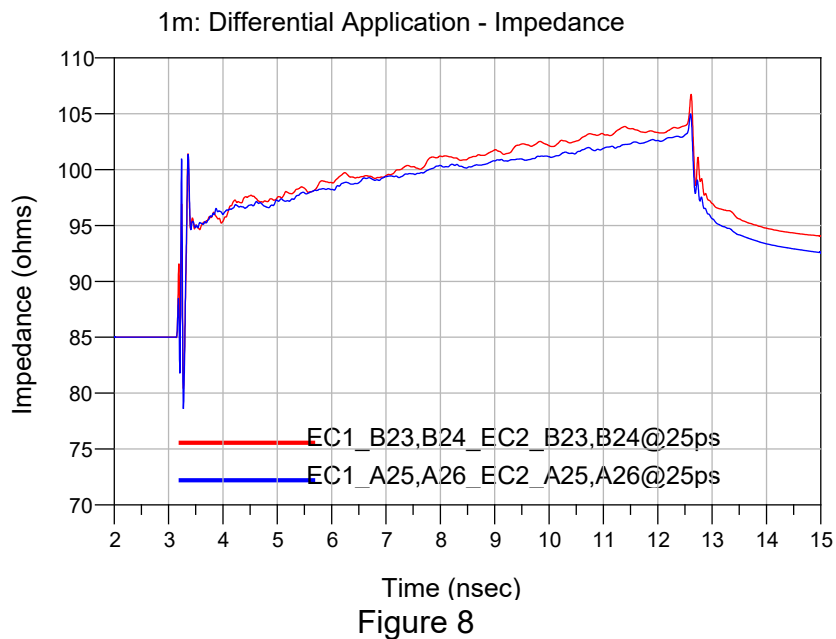


Table 2 - Propagation Delay (Cable Assembly)				
Driver	Receiver	0.25 m	0.5 m	1 m
EC1_B23,B24	EC2_B23,B24	1.353 ns	2.547 ns	4.842 ns
EC1_A25,A26	EC2_A25,A26	1.354 ns	2.549 ns	4.839 ns

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Characterization Details

This report presents data that characterizes the signal integrity response of a cable assembly in a controlled printed circuit board (PCB) environment. All efforts are made to reveal typical best-case responses inherent to the system under test (SUT).

In this report, the SUT includes the mating connectors, cable assembly, and footprint effects on a typical multi-layer PCB. PCB effects (trace loss) are de-embedded from test data. Board related effects, such as pad-to-ground capacitance, are included in the data presented in this report.

Additionally, intermediate test signal connections can mask the cable assembly's true performance. Such connection effects are minimized by using high performance test cables and adapters. Where appropriate, calibration and de-embedding routines are also used to reduce residual effects.

Differential and Single-Ended Data

Most Samtec cable assemblies can be used successfully in both differential and single-ended applications. However, electrical performance will differ depending on the signal drive type. In this report, data is presented for "GGSSGG" differential drive configuration only.

Cable assembly Signal to Ground Ratio

Samtec cable assemblies are most often designed for generic applications and can be implemented using various signal and ground pin assignments. In high-speed systems, provisions must be made in the interconnect for signal return currents. Such paths are often referred to as "ground". In some cable assemblies, a ground plane or blade, or an outer shield, is used as the signal return, while in others, cable assembly pins are used as signal returns. Various combinations of signal pins, ground blades, and shields can also be utilized. Electrical performance can vary significantly depending upon the number and location of ground pins.

In general, the more pins dedicated to ground, the better electrical performance will be. But dedicating pins to ground reduces signal density of a cable assembly. Therefore, care must be taken when choosing signal/ground ratios in cost or density-sensitive applications.

In a real system environment, active signals might be located at the outer edges of the signal contacts of concern, as opposed to the ground signals utilized in laboratory testing. For example, in a single-ended system, a pin-out of "SSSS", or four adjacent single ended signals might be encountered as opposed to the "GSG" and "GSSG" configurations tested in the laboratory. Electrical characteristics in such applications could vary

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable, End 2: PCIe Edge Card

slightly from laboratory results. But in most applications, performance can safely be considered equivalent.

Cable Assembly Pin Map

The PCIEC-G4 cable assembly is pre-defined and following standard PCIe GEN4.0 pinout. For this report, the following configurations are evaluated.

For NEXT

B19	T
B20	A20
B21	A21
B22	A22
B23	A23
B24	A24
B25	A25
B26	A26
B27	A27
B28	A28
B29	T
B30	T
T	A31
T	A32

For FEXT

B19	T
B20	A20
B21	A21
B22	A22
B23	A23
B24	A24
B25	A25
B26	A26
B27	A27
B28	A28
B29	T
B30	T
T	A31
T	A32

T: Terminators

Differential Impedance (denoted by green circles)

- GGSSGG (Ground-ground-positive signal-negative signal-ground-Ground)

Differential Crosstalk (denoted by red circles)

- In Row: from the terminals to the other terminal on the same row
- Across Row: from one row of terminals to the other row of terminals

See Appendix C – Product and Test System Descriptions for details.

Signal Edge Speed (Rise Time)

In pulse signaling applications, the perceived performance of the interconnect can vary significantly depending on the edge rate or the rise time of the exciting signal. For this report, the fastest rise time used was 25 ps. Generally, this should demonstrate the worst-case performance.

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

In many systems, the signal edge rate will be significantly slower at the cable assembly than at the driver launch point. To estimate interconnect performance at other edge rates, data is provided for several rise times between 25ps and 100ps.

For this report, measured rise times were at 20%-80% signal levels.

Frequency Domain Data

Frequency Domain parameters are helpful in evaluating the cable assembly system's signal loss and crosstalk characteristics across a range of sinusoidal frequencies. In this report, parameters presented in the Frequency Domain are Insertion Loss, Return Loss, Near-End and Far-End Crosstalk, and Mode Conversion. Other parameters or formats, such as VSWR or S-Parameters, may be available upon request. Please contact our Signal Integrity Group at sig@samtec.com for more information.

Frequency performance characteristics for the SUT are generated from network analyzer measurements.

Time Domain Data

Time Domain parameters indicate Impedance mismatch versus length, and signal propagation time in a pulsed signal environment.

The measured S-Parameters from the network analyzer are post-processed using Agilent ADS to obtain the time domain response. Time Domain procedure is provided in [Appendix E](#) of this report. Parameters or formats not included in this report may be available upon request. Please contact our Signal Integrity Group at sig@samtec.com for more information.

In this report, propagation delay is defined as the signal propagation time through the cable assembly, mating connectors, and connector footprint. It also includes 1 mm of PCB trace on each connector side. Delay is measured at 100 picoseconds signal rise-time. Delay is calculated as the difference in time measured between the 50% amplitude levels of the input and output pulses.

Data for other configurations may be available. Please contact our Signal Integrity Group at sig@samtec.com for further information.

Additional information concerning test conditions and procedures is in the appendices of this report. Further information may be obtained by contacting our Signal Integrity Group at sig@samtec.com.

Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Appendix A – Frequency Domain Responses

Differential Application – Insertion Loss

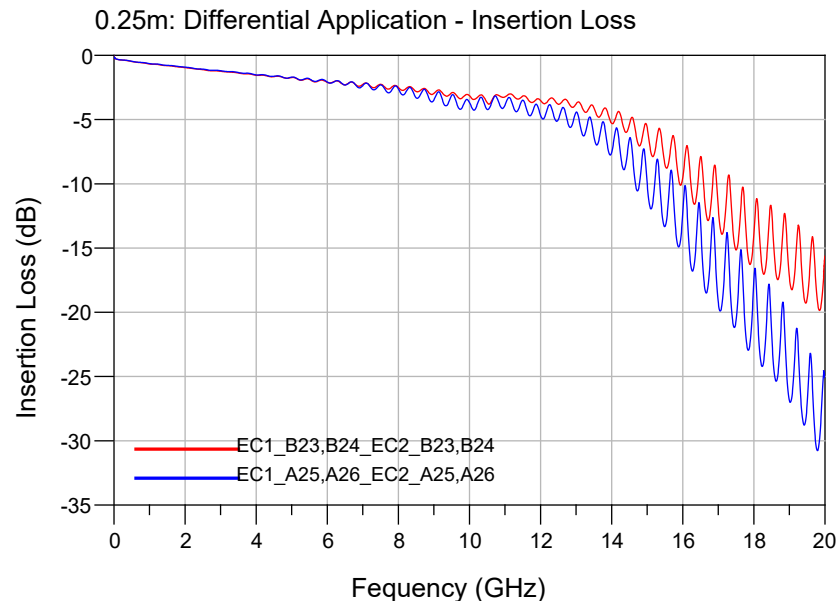


Figure 9

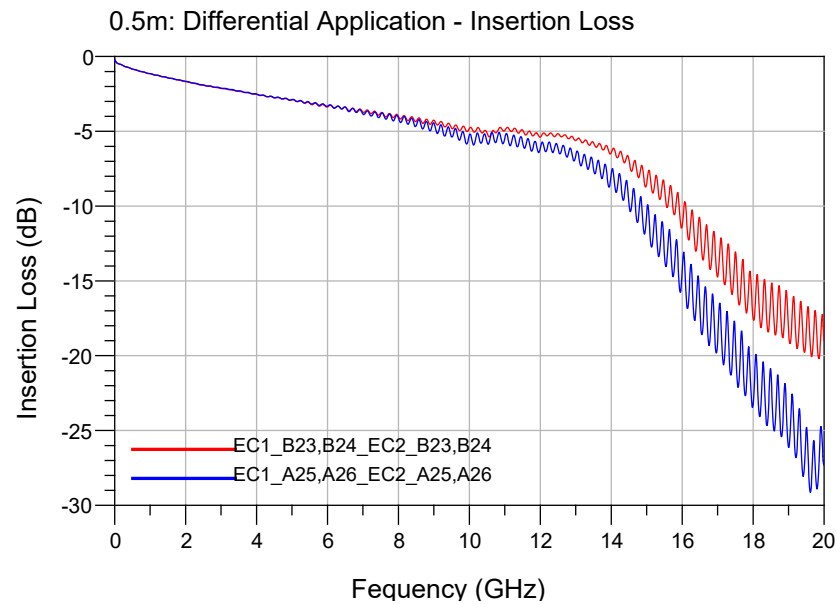
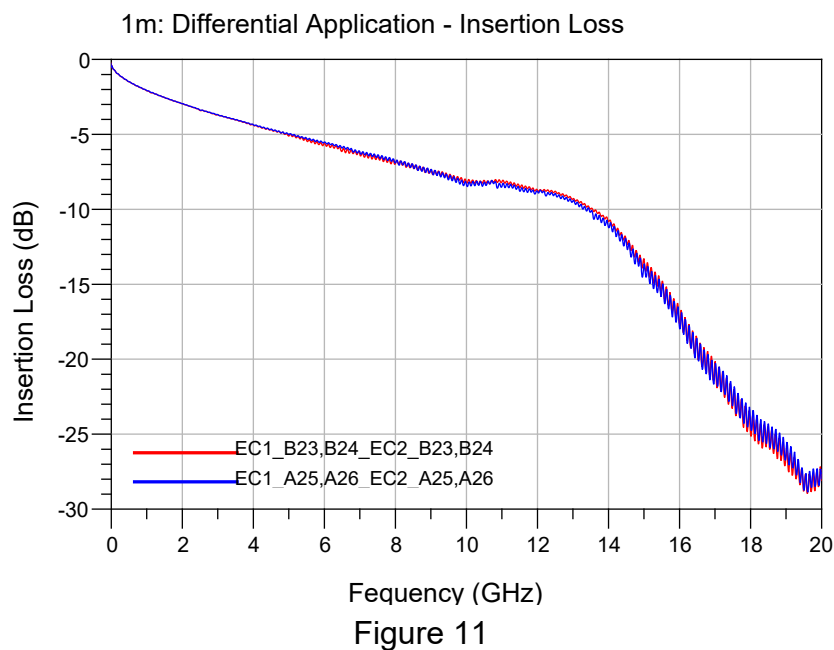


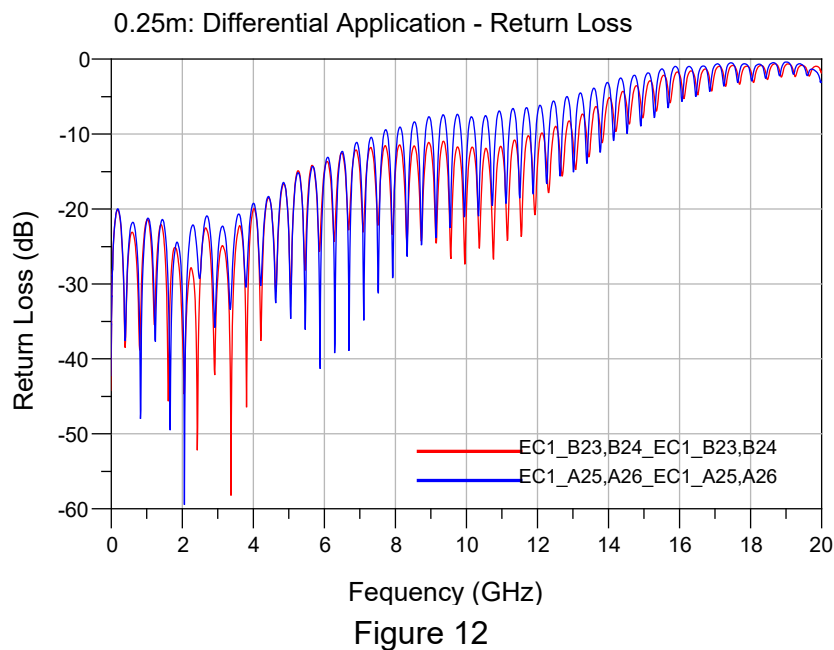
Figure 10

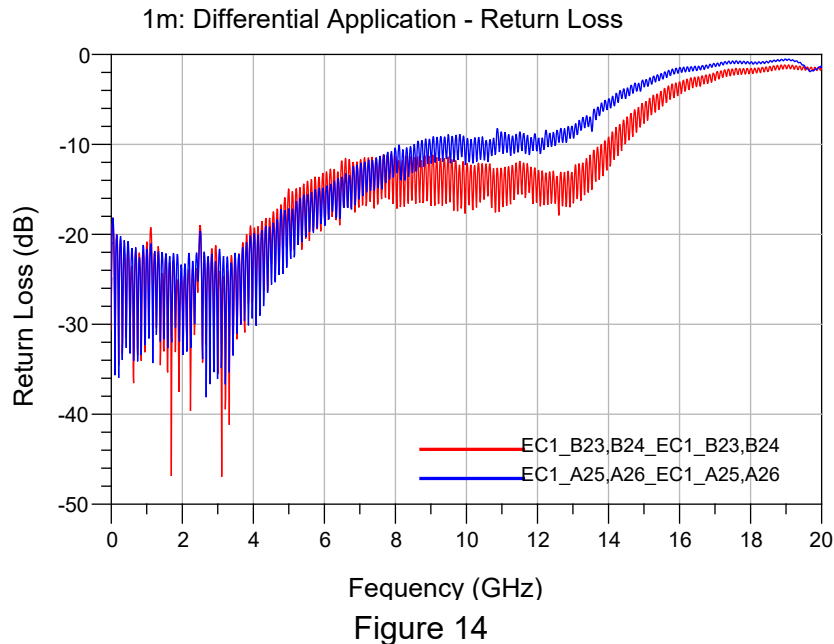
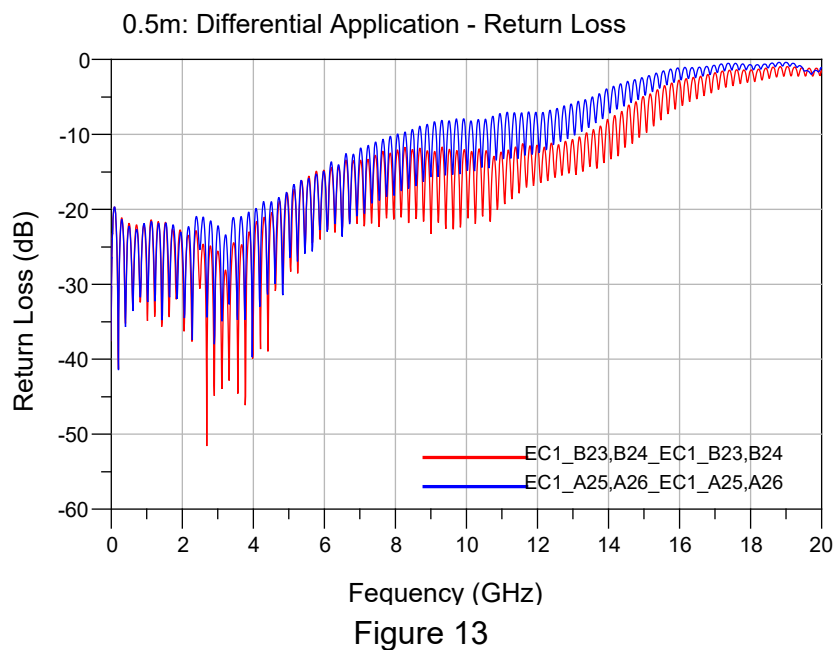
Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable, End 2: PCIe Edge Card



Differential Application – Return Loss



Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Differential Application – NEXT Configurations

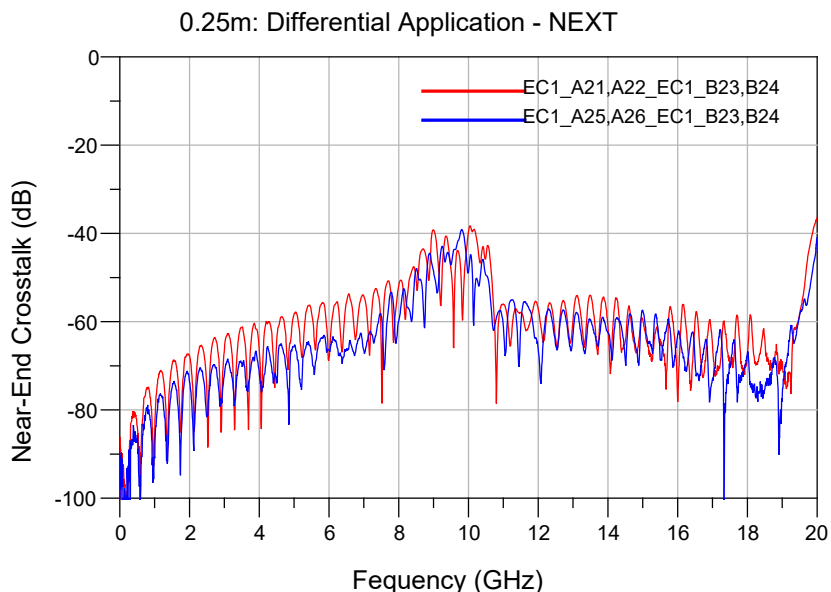


Figure 15

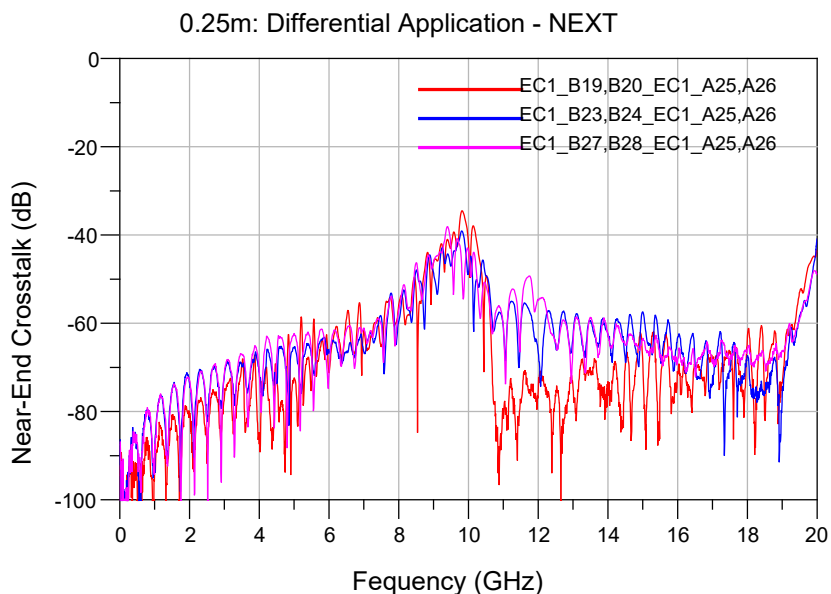
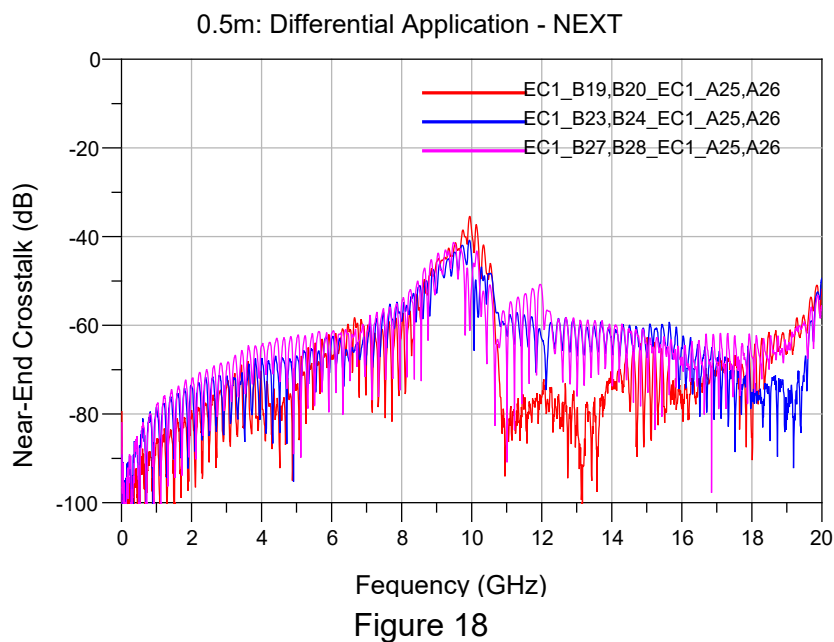
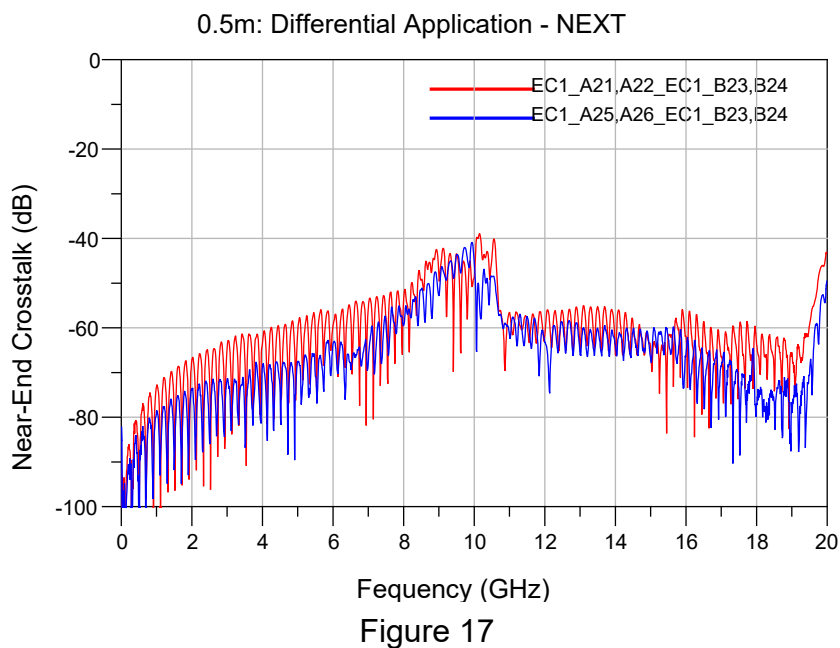


Figure 16

Series: PCIe-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable, End 2: PCIe Edge Card



Series: PCIe-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable, End 2: PCIe Edge Card

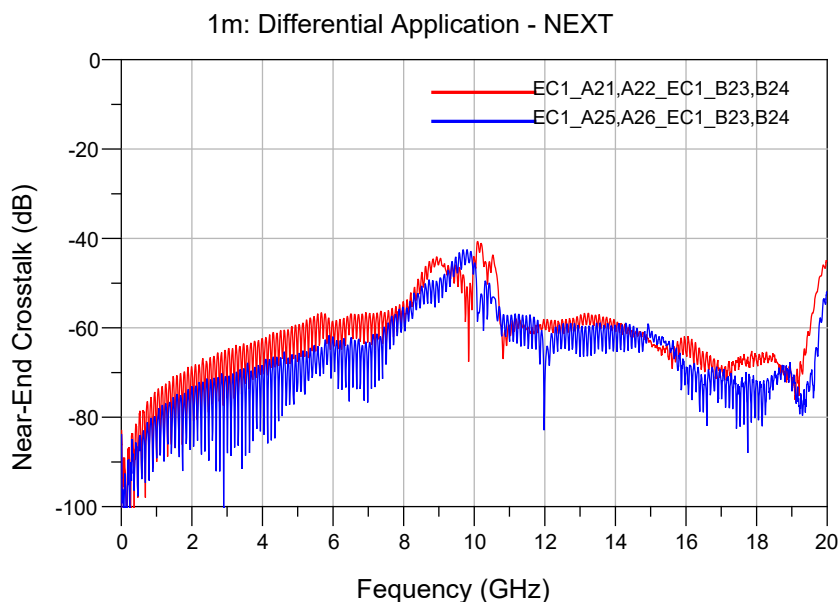


Figure 19

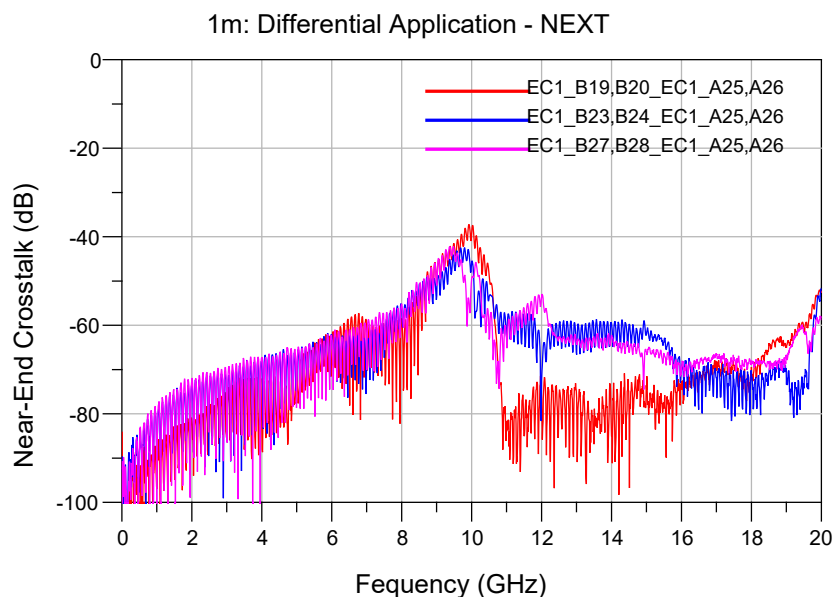


Figure 20

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Differential Application – FEXT Configurations

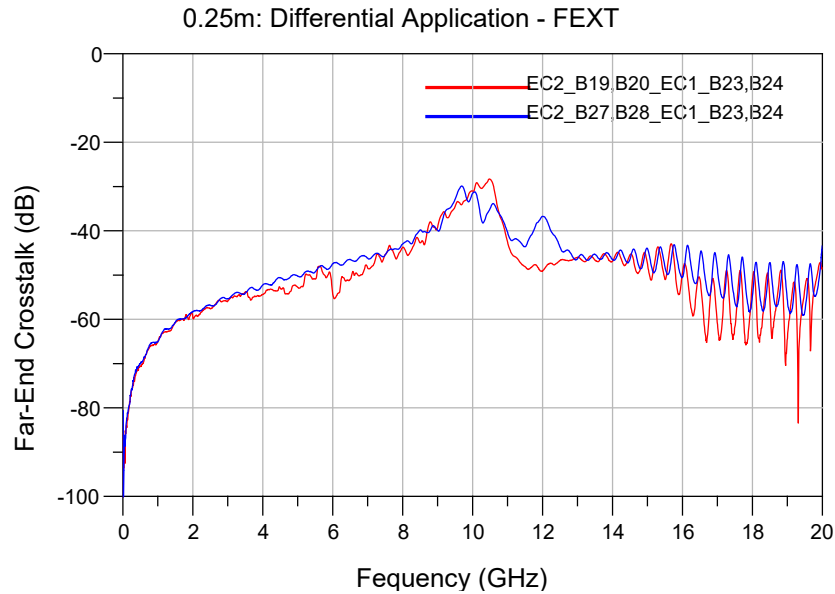


Figure 21

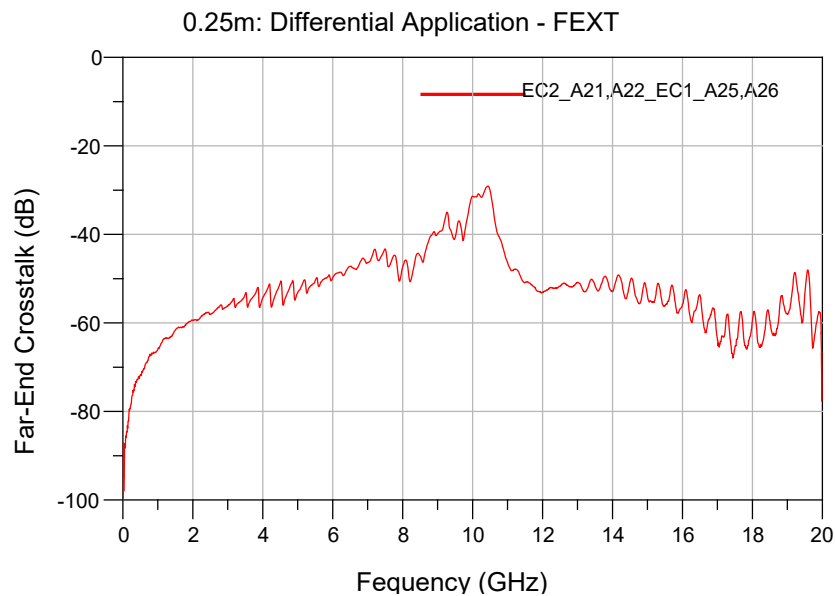


Figure 22

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

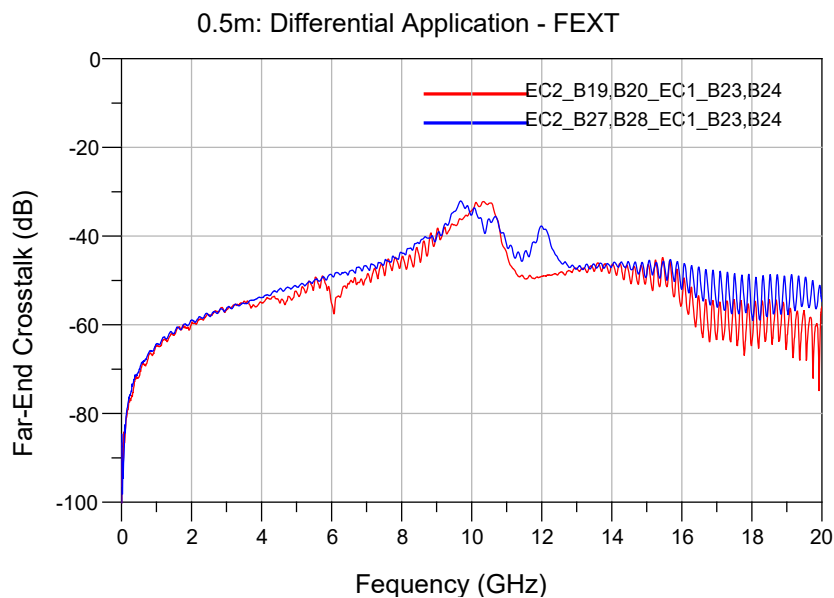


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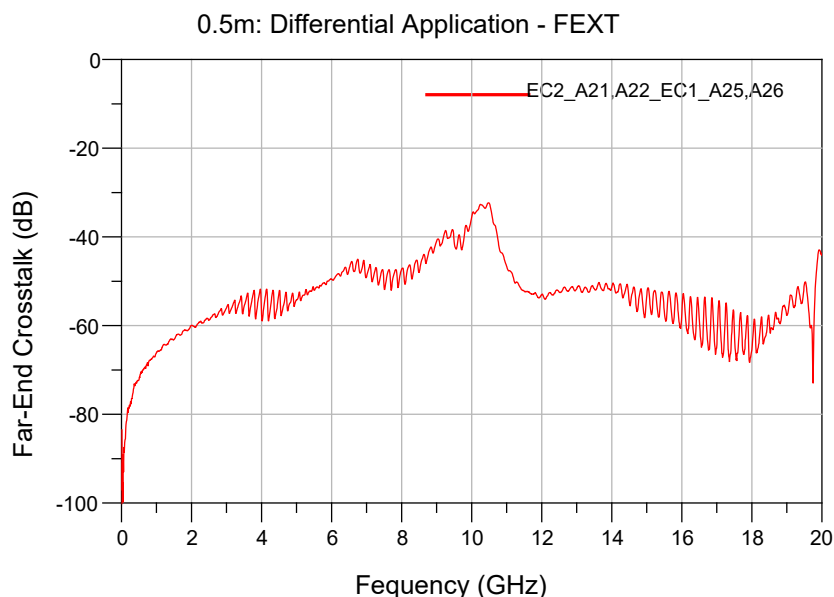


Figure 24

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

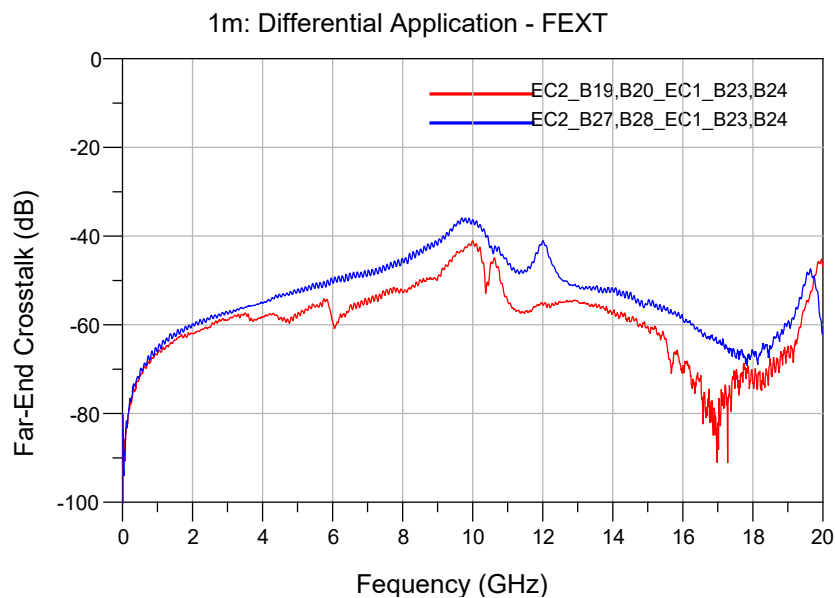


Figure 25

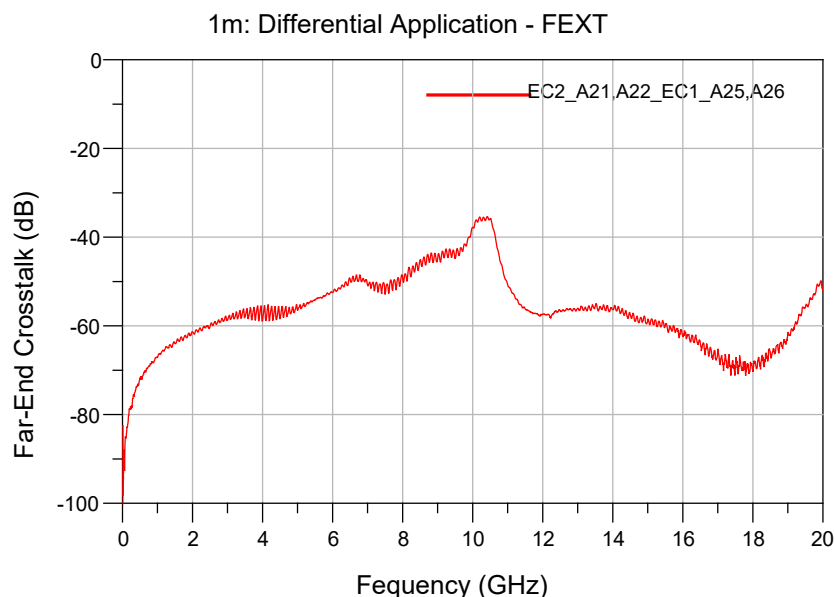


Figure 26

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Differential Application – Differential to Common Mode Conversion

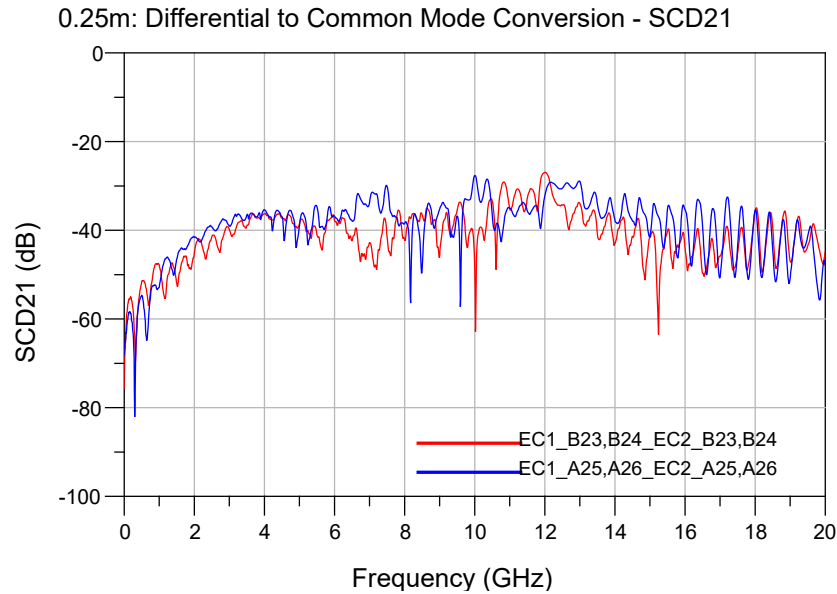


Figure 27

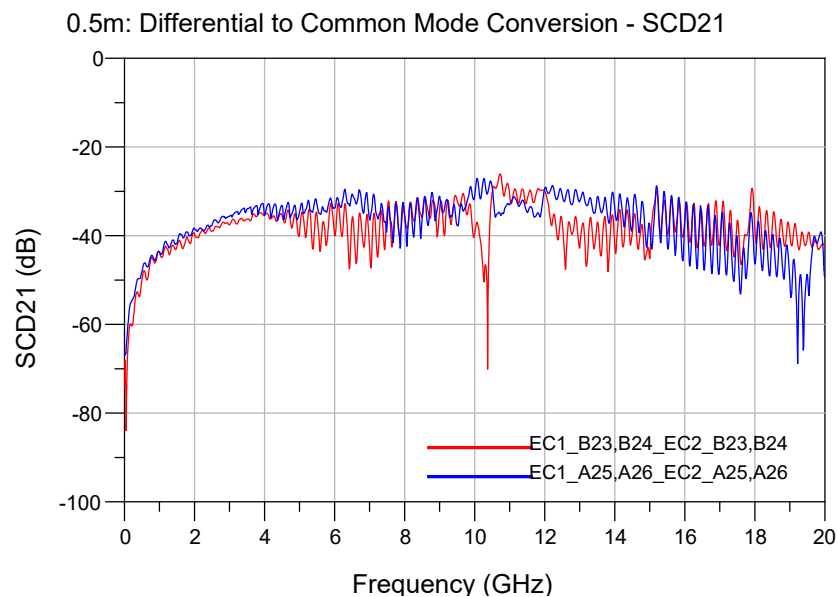


Figure 28

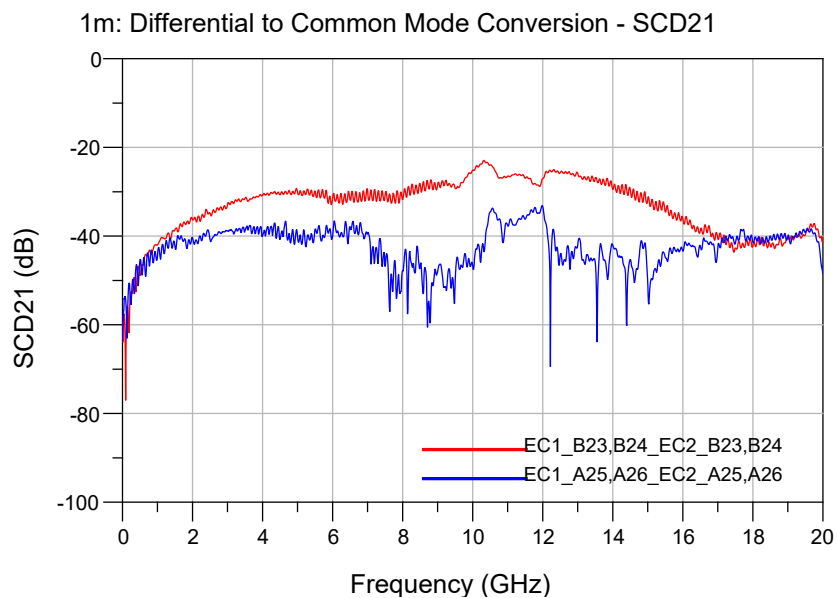
Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Figure 29

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Appendix B – Time Domain Responses

Differential Application – Input Pulse

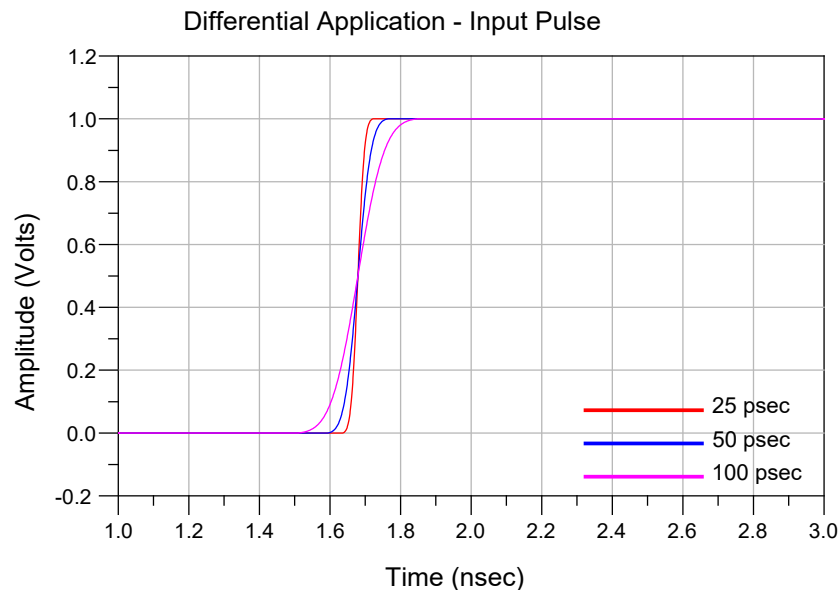


Figure 30

Differential Application – Cable Assembly Impedance

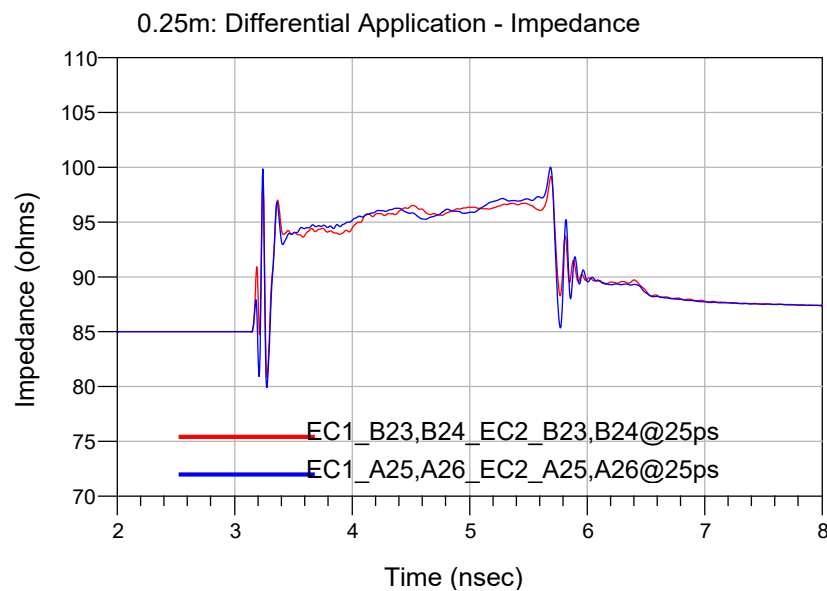


Figure 31

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

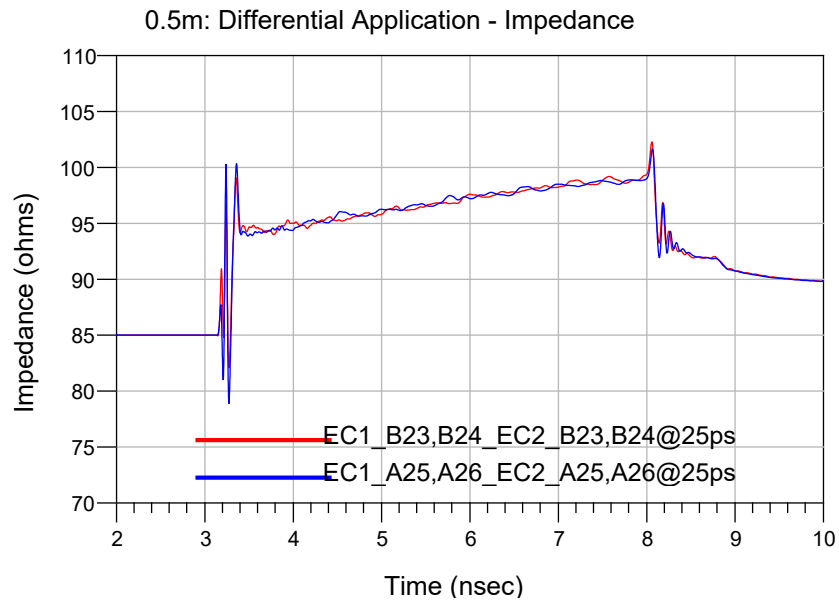


Figure 32

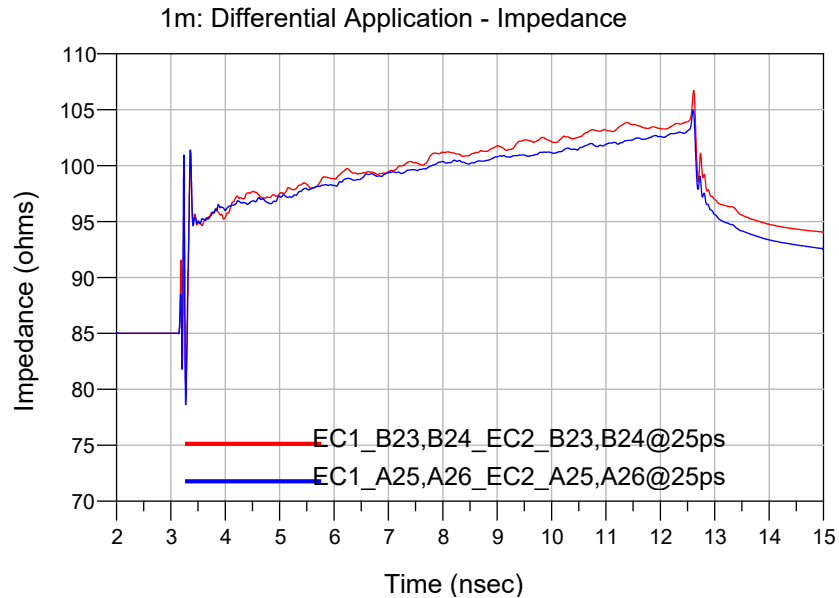
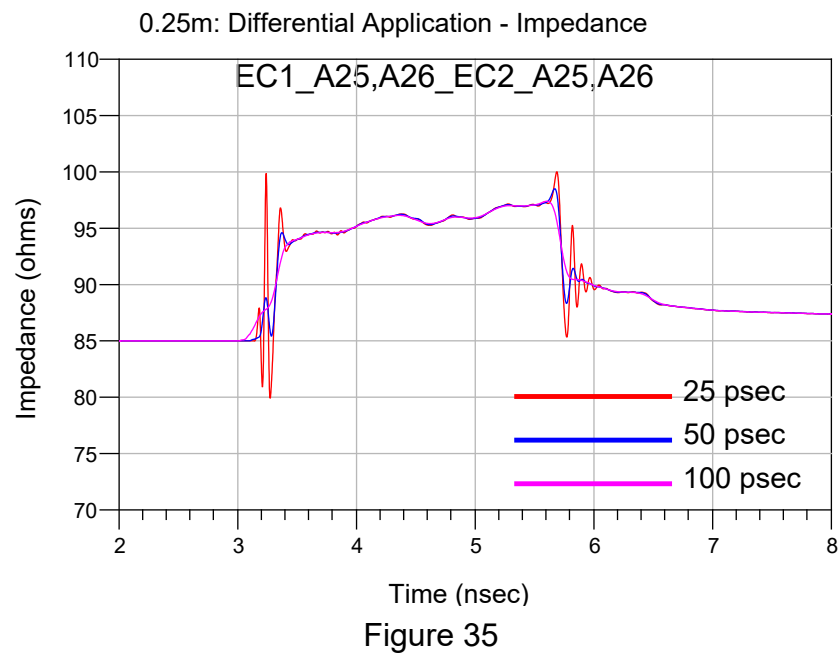
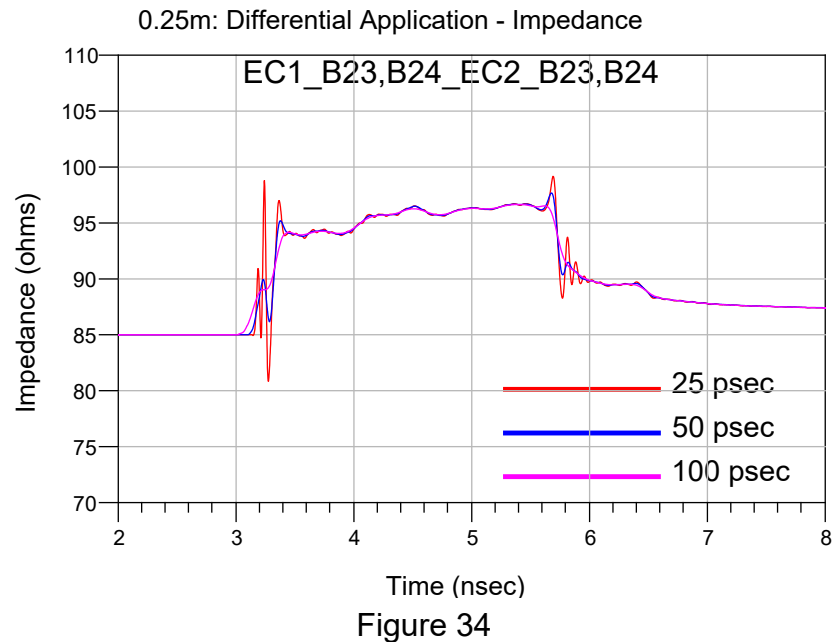
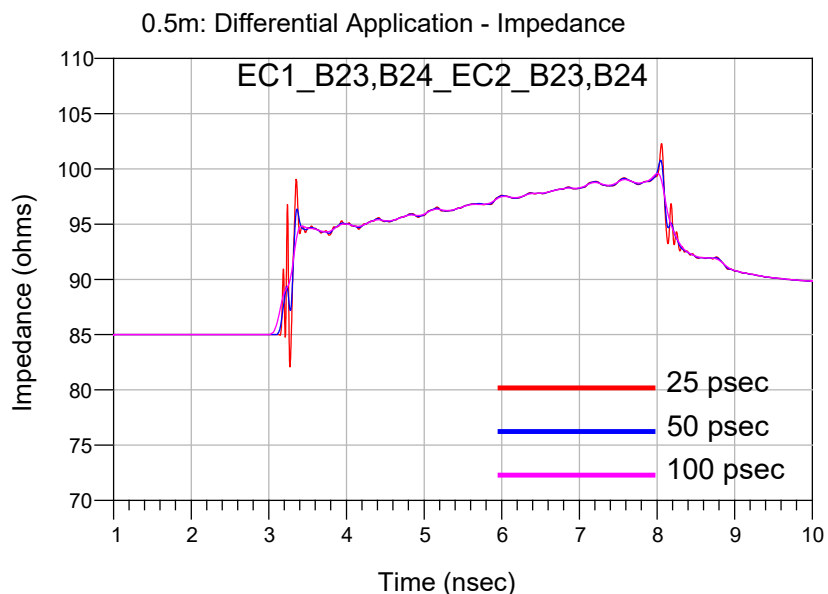
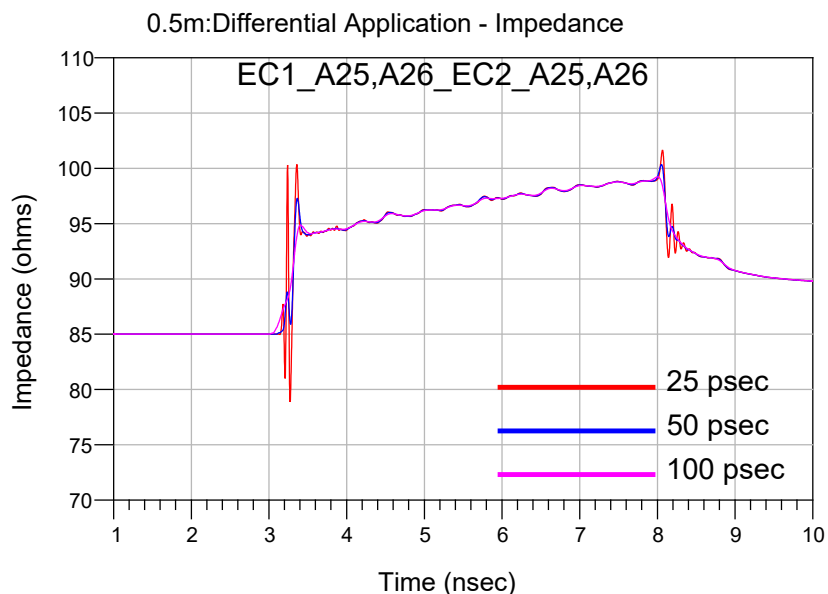
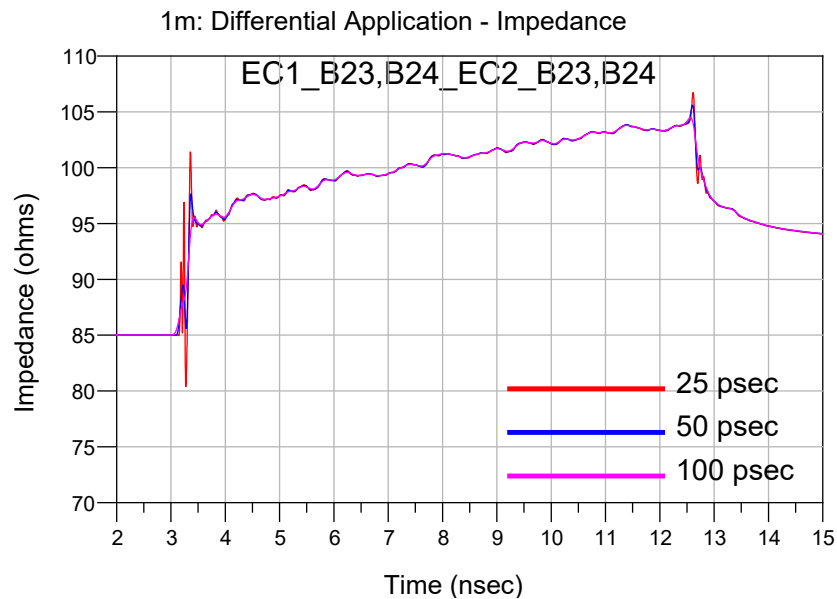
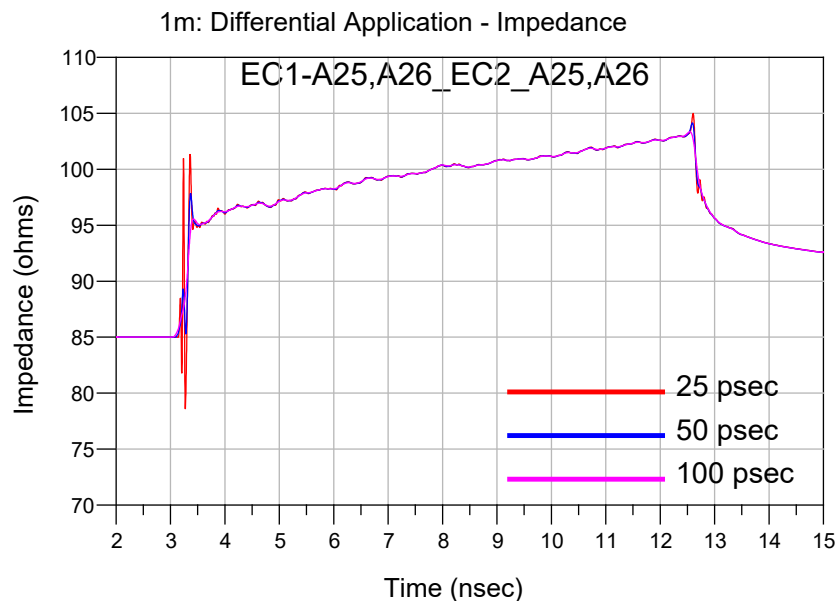
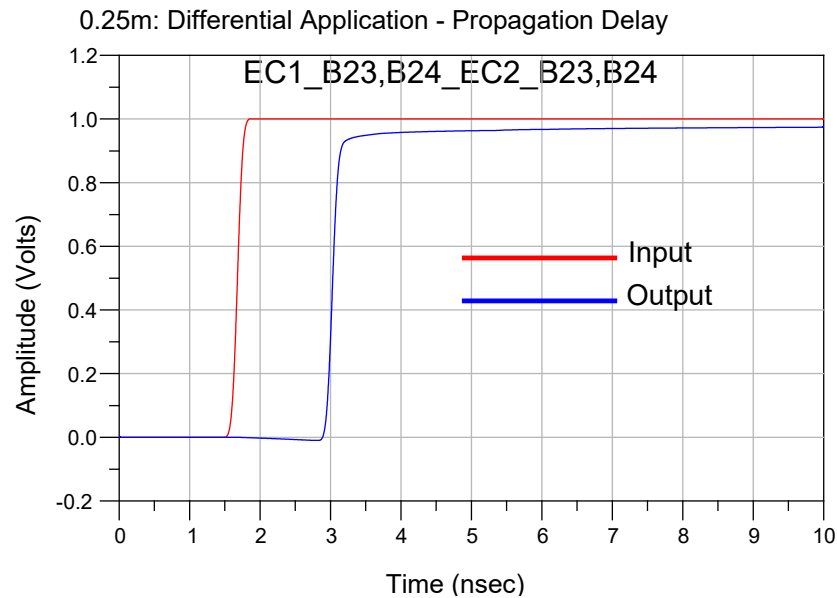
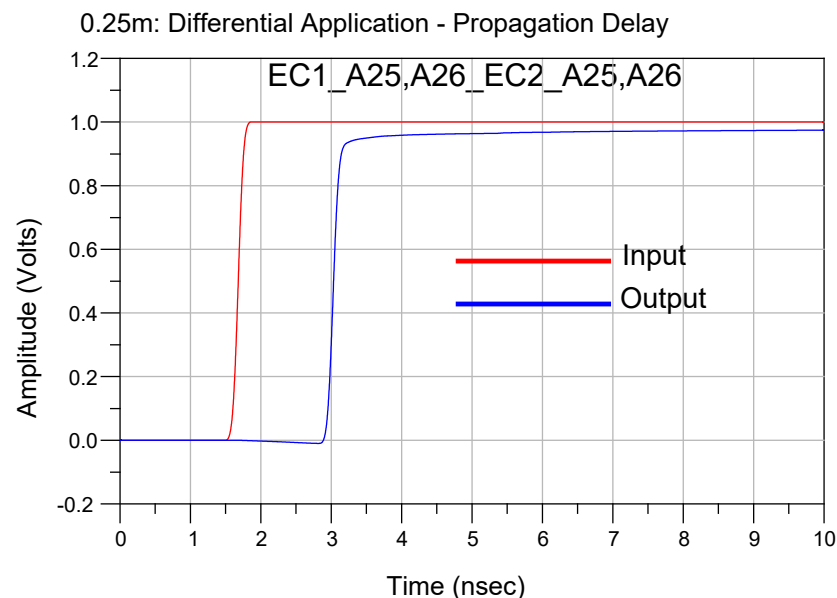


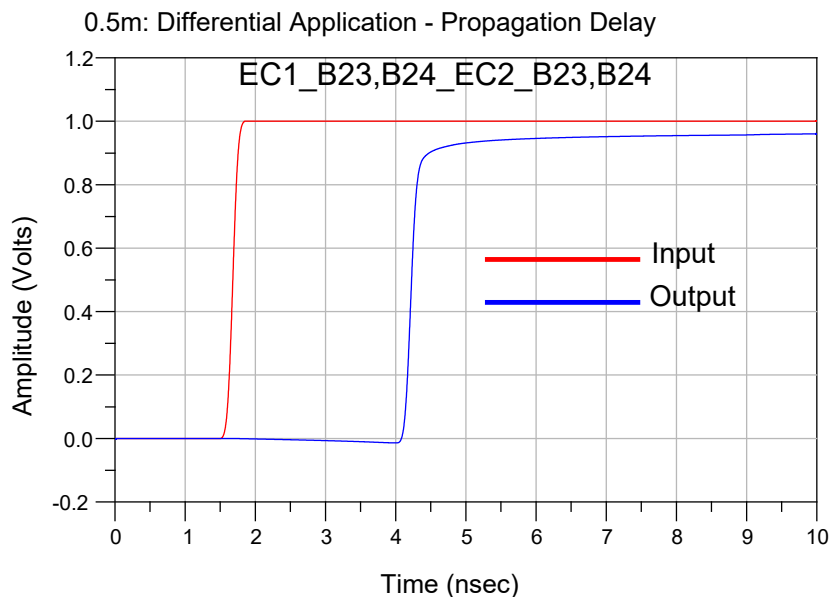
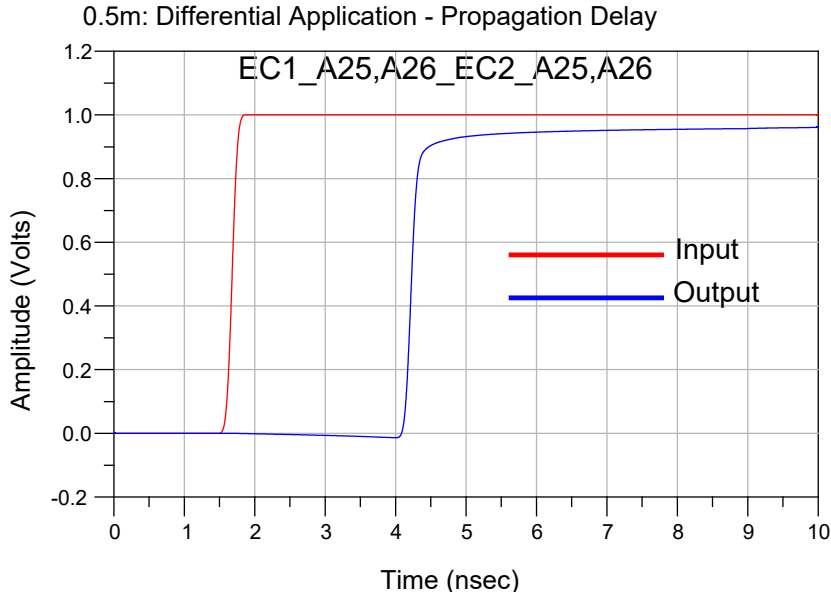
Figure 33

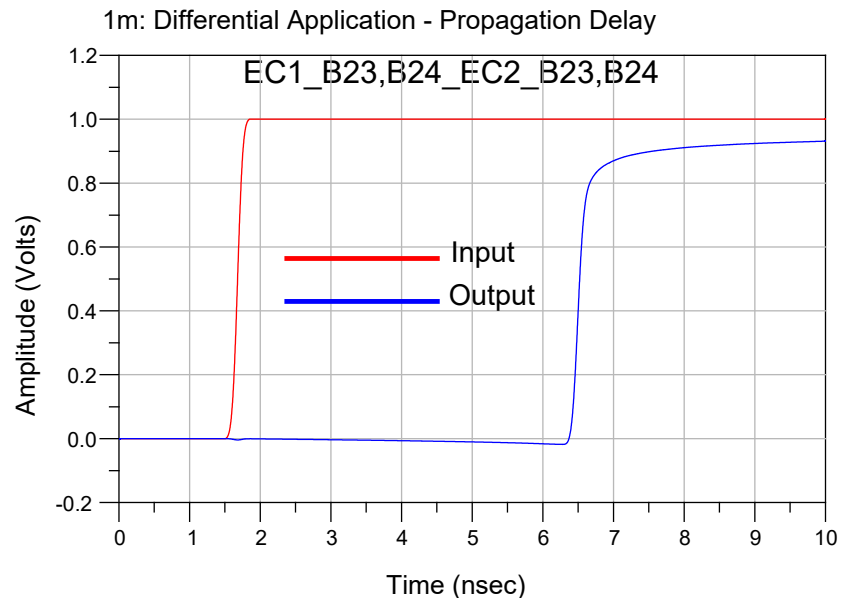
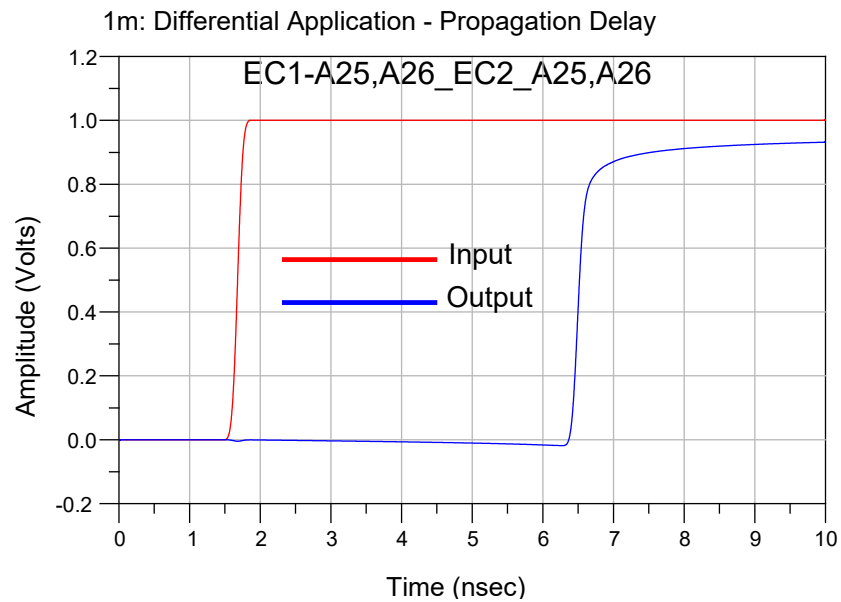
Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card**Differential Application – Cable assembly Impedance**

Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card**Figure 36****Figure 37**

Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card**Figure 38****Figure 39**

Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card**Differential Application – Propagation Delay****Figure 40****Figure 41**

Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card**Figure 42****Figure 43**

Series: PCIEC-G4**Description:** PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card**Figure 44****Figure 45**

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable, End 2: PCIe Edge Card

Appendix C – Product and Test System Descriptions

Product Description

Product test samples are PCI Express® 4.0 Cable Assemblies. The part numbers are PCIEC-G4-064-0250-C1, PCIEC-G4-064-0500-C1 and PCIEC-G4-064-1000-C1. They mate with PCIE-G4-04-01-F-DV. A photo of the mated test article mounted to SI test boards is shown below.

The cable assembly terminations had a particular signal line configuration. The respective signal line numbers are shown in Table 3. There are a total of 32 positions per row, but all are not shown. Positions 1 – 11 terminate to the PVC power cable. All Side B pairs are Transmitter pairs. All Side A pairs are Receiver pairs except for pair A13-A14, which is the Reference Clock Pair.

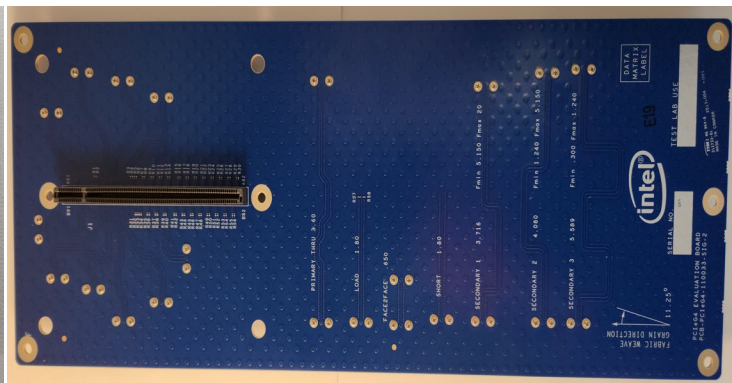
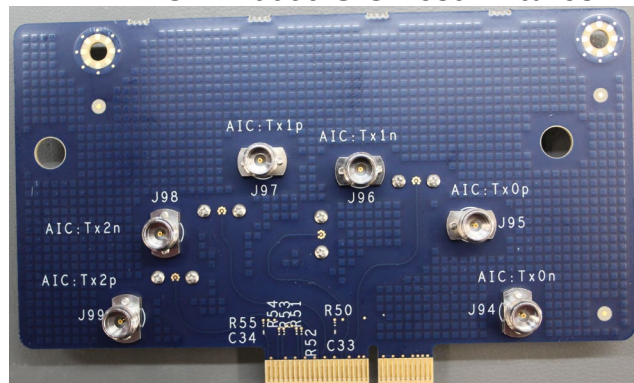
Side A	G	13	14	G	16	17	G	19	G	21	22	G	G	25	26	G	G	29	30	G	32
Side B	12	G	14	15	G	17	G	19	20	G	G	23	24	G	G	27	28	G	30	31	G

Table 3: Signal line numbers

Test System Description

The test fixtures are composed of four-layer MEGTRON6 material with 42.5Ω signal trace and pad configurations designed for the electrical characterization of Samtec high speed cable assembly products. A PCB mount 2.4mm connector is used to interface the PNA test cables to the test fixtures. Optimization of the 2.4mm launch was performed using full wave simulation tools to minimize reflections. The test fixtures and calibration kit are specific to the PCIE-G4 series connector set and the edge card and identified by part number PCB-PCIEG4-110033-SIG.

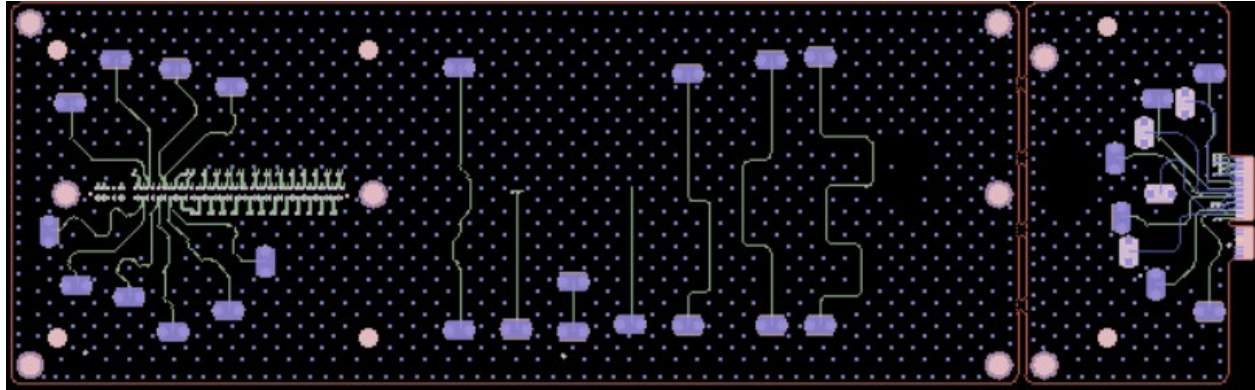
PCB-PCIEG4-110033-SIG Test Fixtures



Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Artwork of the PCB design is shown below.



Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Appendix D – Test and Measurement Setup

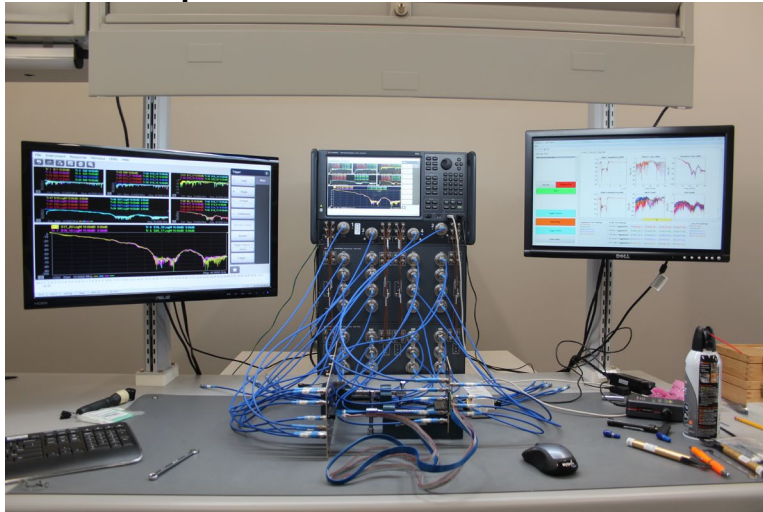
For frequency domain measurements, the test instrument is Keysight N5225B PNA-L network analyzer. Frequency domain data and figures are extracted from the instrument by AFR application. Post-processed time domain data and figures are generated using convolution algorithms within Keysight ADS. The network analyzer is configured as follows:

Start Frequency – 10 MHz

Stop Frequency – 40 GHz

IFBW – 1 KHz

N5225B Measurement Setup



Test Instruments

<u>QTY</u>	<u>Description</u>
1	Keysight N5225B PNA-L Network Analyzer (10 MHz to 67 GHz)
1	Keysight N4694-60003 ECAL Module (10 MHz to 67 GHz)

Test Cables & Adapters

<u>QTY</u>	<u>Description</u>
32	1m Junkosha 2.4mm male to female cables

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Appendix E - Frequency and Time Domain Measurements

Frequency (S-Parameter) Domain Procedures

The quality of any data taken with a network analyzer is directly related to the quality of the calibration standards and the use of proper test procedures. For this reason, extreme care is taken in the design of the AFR calibration standards, the SI test boards and the selection of the PCB vendor.

A coaxial SOLT calibration is performed using a N4694-60003 ECAL module. Then DUT measurements are performed under SOLT calibration. The measurements include the effect of test fixture. The measurements of the 2X THRU line standards are required to remove the test fixture effect.

Time Domain Procedures

Mathematically, Frequency Domain data can be transformed to obtain a Time Domain response. Perfect transformation requires Frequency Domain data from DC to infinity Hz. Fortunately, a very accurate Time Domain response can be obtained with bandwidth-limited data, such as measured with modern network analyzer.

The Time Domain responses were generated using Keysight ADS 2020. This tool has a transient convolution simulator, which can generate a Time Domain response directly from measured S-Parameters. An example of a similar methodology is provided in the Samtec Technical Note on domain transformation.

http://www.samtec.com/Documents/WebFiles/Technical_Library/Reference/Articles/tech-note_using-PLTS-for-time-domain-data_web.pdf

Propagation Delay (TDT)

The Propagation Delay is a measure of the Time Domain delay through the cable assembly and footprint. A step pulse is applied to the touchstone model of the cable assembly and the transmitted voltage is monitored. The same pulse is also applied to a reference channel with zero loss, and the Time Domain pulses are plotted on the same figure. The difference in time, measured at the 50% point of the step voltage is the propagation delay.

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Impedance (TDR)

Measurements involving digital pulses are performed using either Time Domain Reflectometer (TDR) or Time Domain Transmission (TDT) methods. The TDR method is used for the impedance measurements in this report.

The signal line(s) of the SUT's is energized with a TDR pulse and the far-end of the energized signal line is terminated in the test systems characteristic impedance (e.g.; 50Ω or 100Ω terminations). By terminating the adjacent signal lines in the test systems characteristic impedance, the effects on the resultant impedance shape of the waveform are limited.

Series: PCIEC-G4

Description: PCI Express® 4.0 Cable Assembly, Eye Speed® 34 AWG 100-ohm Twinax Cable,
End 2: PCIe Edge Card

Appendix F – Glossary of Terms

ADS – Keysight Advanced Design System

AFR – Automatic Fixture Removal

PCB – Printed Circuit Board

SUT – System Under Test

SOLT – acronym used to define Short, Open, Load & Thru Calibration Standards

TDR – Time Domain Reflectometry

TDT – Time Domain Transmission