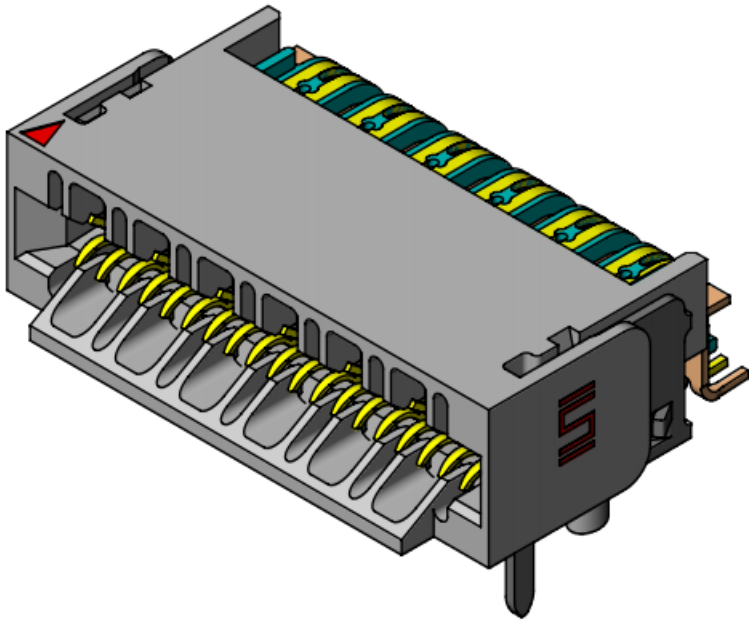
High Speed Characterization Report

UEC5-019-2-X-D-RA-1



Description:
28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Samtec Inc.
520 Park East Blvd.
New Albany IN 47151-1147 USA

WWW.SAMTEC.COM
1-800-SAMTEC-9 (US & Canada)
SIG@samtec.com

Phone: 812-944-6733
Fax: 812-948-5047
Report Revision: 11/1/2017

Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Table of Contents

Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Connector Overview

The UEC5-2 series the 28G+ FireFly™ micro high-speed edge card connector. It is one part of a two-piece system; mating with both copper and optical FireFly™ cable assemblies. At the time of testing, the UEC5-2 maximum position count is 19 positions per row. The data in this report is applicable to UEC5 connector mated to 1.6mm thick card.

Frequency Domain Data Summary

Table 1 - Differential Connector System Performance

Test Parameter	Driver	Receiver	
Insertion Loss	Edge-Card_A8A9	UEC5_A8A9	3dB@ 23.9 GHz
	Edge-Card_B8B9	UEC5_B8B9	3dB@ 31.8 GHz
Return Loss	Edge-Card_A8A9	Edge-Card_A8A9	>10dB to 14.6 GHz
	Edge-Card_B8B9	Edge-Card_B8B9	>10dB to 14.1 GHz
Near-End Crosstalk	Edge-Card_A8A9	Edge-Card_A5A6	<-20dB to 40 GHz
	Edge-Card_A8A9	Edge-Card_A14A15	<-20dB to 40 GHz
	Edge-Card_A8A9	Edge-Card_B5B6	<-20dB to 40 GHz
	Edge-Card_A8A9	Edge-Card_B8B9	<-20dB to 40 GHz
	Edge-Card_A8A9	Edge-Card_B14B15	<-20dB to 40 GHz
	Edge-Card_B8B9	Edge-Card_B5B6	<-20dB to 40 GHz
	Edge-Card_B8B9	Edge-Card_B14B15	<-20dB to 40 GHz
Far-End Crosstalk	Edge-Card_A8A9	UEC5_A5A6	<-20dB to 40 GHz
	Edge-Card_A8A9	UEC5_A14A15	<-20dB to 40 GHz
	Edge-Card_A8A9	UEC5_B5B6	<-20dB to 40 GHz
	Edge-Card_A8A9	UEC5_B8B8	<-20dB to 40 GHz
	Edge-Card_A8A9	UEC5_B14B15	<-20dB to 40 GHz
	Edge-Card_B8B9	UEC5_B5B6	<-20dB to 40 GHz
	Edge-Card_B8B9	UEC5_B14B15	<-20dB to 40 GHz

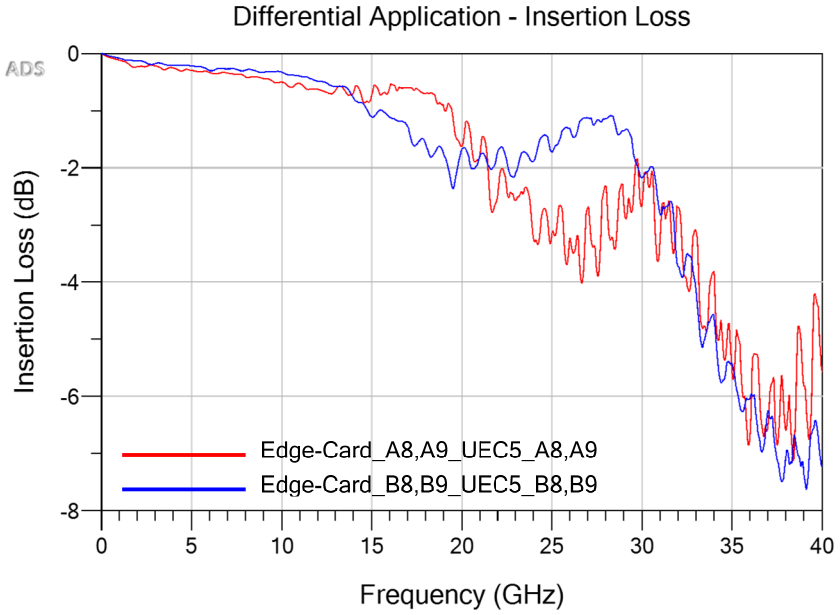
Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Pin Map:

A1				A5	A6		A8	A9					A14	A15				
G	T	T	G	S	S	G	S	S	G	T	T	G	S	S	G	T	T	G
G	T	T	G	S	S	G	S	S	G	T	T	G	S	S	G	T	T	G
B1				B5	B6		B8	B9					B14	B15				

Bandwidth Chart – Differential Insertion Loss

UEC5 Connector Series



Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Time Domain Data Summary

Table 2 - Differential Impedance (Ω) - A8A9					
Signal Rise-time	**30ps**	**50ps**	**100ps**	**250ps**	**500ps**
Maximum Impedance	109.1	108.8	108.1	105.7	102.9
Minimum Impedance	90.5	95.4	97.2	98.3	99.1

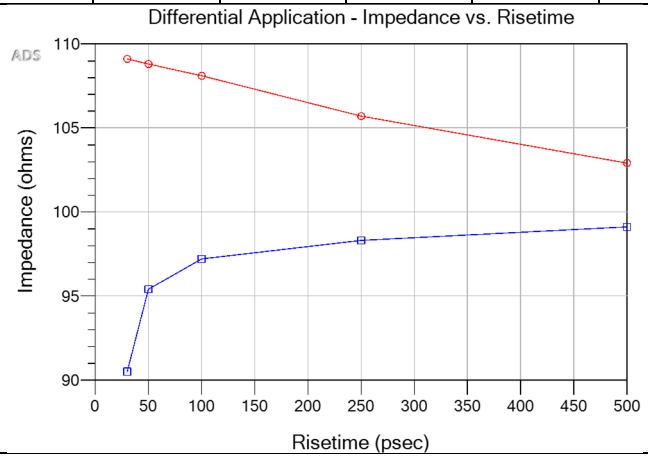
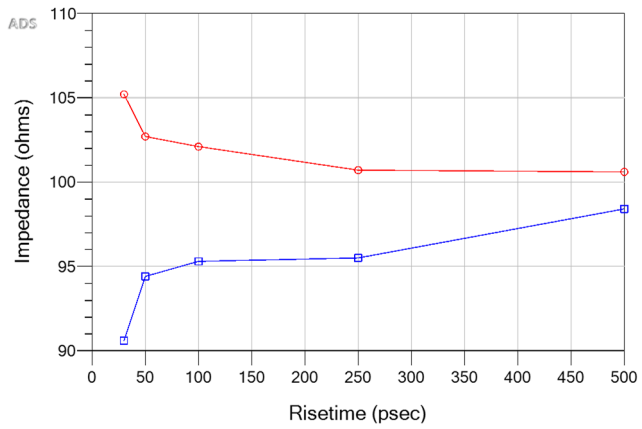


Table 3 - Differential Impedance (Ω) - B8B9					
Signal Rise-time	**30ps**	**50ps**	**100ps**	**250ps**	**500ps**
Maximum Impedance	105.2	102.7	102.1	100.7	100.6
Minimum Impedance	90.6	94.4	95.3	95.5	98.4



Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

	Table 4 - Differential Crosstalk (%)					
Input(t_r)	**Driver**	**Receiver**	**30ps**	**50ps**	**100ps**	**250ps**
NEXT	Edge-Card_A8A9	Edge-Card_A5A6	0.8	0.7	0.5	0.3
	Edge-Card_A8A9	Edge-Card_A14A15	<0.1	<0.1	<0.1	<0.1
	Edge-Card_A8A9	Edge-Card_B5B6	<0.1	<0.1	<0.1	<0.1
	Edge-Card_A8A9	Edge-Card_B8B9	0.1	0.1	0.1	<0.1
	Edge-Card_A8A9	Edge-Card_B14B15	<0.1	<0.1	<0.1	<0.1
	Edge-Card_B8B9	Edge-Card_B5B6	0.4	0.3	0.2	0.1
	Edge-Card_B8B9	Edge-Card_B14B15	<0.1	<0.1	<0.1	<0.1
FEXT	Edge-Card_A8A9	UEC5_A5A6	0.2	0.1	0.1	<0.1
	Edge-Card_A8A9	UEC5_A14A15	<0.1	<0.1	<0.1	<0.1
	Edge-Card_A8A9	UEC5_B5B6	<0.1	<0.1	<0.1	<0.1
	Edge-Card_A8A9	UEC5_B8B9	0.1	<0.1	<0.1	<0.1
	Edge-Card_A8A9	UEC5_B14B15	<0.1	<0.1	<0.1	<0.1
	Edge-Card_B8B9	UEC5_B5B6	0.2	0.1	<0.1	<0.1
	Edge-Card_B8B9	UEC5_B14B15	<0.1	<0.1	<0.1	<0.1

Table 5 - Propagation Delay (Mated Connector)	
Differential (A8A9)	74 ps
Differential (B8B9)	57 ps

Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Characterization Details

This report presents data that characterizes the signal integrity response of a connector pair 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 connector pair 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 connector'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 connectors 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 differentially driven scenarios.

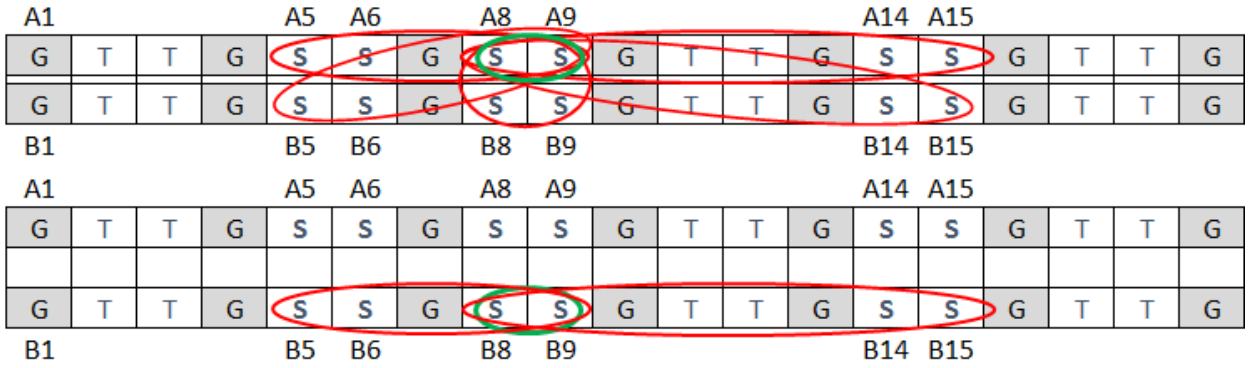
Connector Signal to Ground Ratio

Samtec connectors 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 connectors, a ground plane or blade, or an outer shield, is used as the signal return, while in others, connector 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 connector. Therefore, care must be taken when choosing signal/ground ratios in cost or density-sensitive applications.

Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

For this connector, the following array configurations were evaluated:



Differential Impedance (denoted by green circles)**:**

- GSSG (Ground-positive Signal-negative Signal-Ground)

Differential Crosstalk (denoted by red circles)**:**

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

Only one differential pair was driven for crosstalk measurements.
Other configurations can be evaluated upon request. Please contact sig@samtec.com for more information.

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

Signal Edge Speed (Rise Time):
In pulse signaling applications, the perceived performance of the interconnect can vary significantly depending on the edge rate or rise time of the exciting signal. For this report, the fastest rise time used was 30 ps. Generally, this should demonstrate the worst-case performance.

In many systems, the signal edge rate will be significantly slower at the connector than at the driver launch point. To estimate interconnect performance at other edge rates, data is provided for several rise times between 30ps and 500ps. For this report, measured rise times were at 10%-90% signal levels.

Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Frequency Domain Data

Frequency Domain parameters are helpful in evaluating the connector 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, and Near-End and Far-End Crosstalk. 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 directly from network analyzer measurements.

Time Domain Data

Time Domain parameters indicate impedance mismatch versus length, signal propagation time and crosstalk in a pulsed signal environment. The measured S-Parameters from the network analyzer are post-processed using Keysight Advanced Design System to obtain the time domain response. The 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 connector and connector footprint. It includes 2.55mm of PCB trace on each side. Delay was 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.

Crosstalk or coupled noise data is provided for various signal configurations. All measurements are single disturber. Crosstalk is calculated as a ratio of the input line voltage to the coupled line voltage. The input line is sometimes described as the active or drive line. The coupled line is sometimes described as the quiet or victim line. Crosstalk ratio is tabulated in this report as a percentage. Measurements are made at both the near-end and far-end of the SUT.

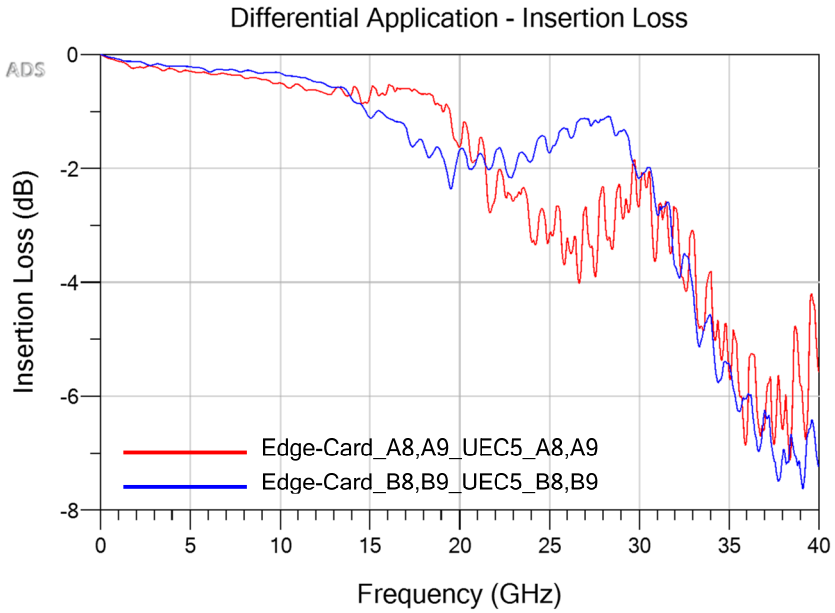
Data for other configurations may be available. Please contact our Signal Integrity Group at sig@samtec.com for further information.

As a rule of thumb, 10% crosstalk levels are often used as a general first pass limit for determining acceptable interconnect performance. But modern system crosstalk tolerance can vary greatly. For advice on connector suitability for specific applications, please contact our Signal Integrity Group at sig@samtec.com.
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.

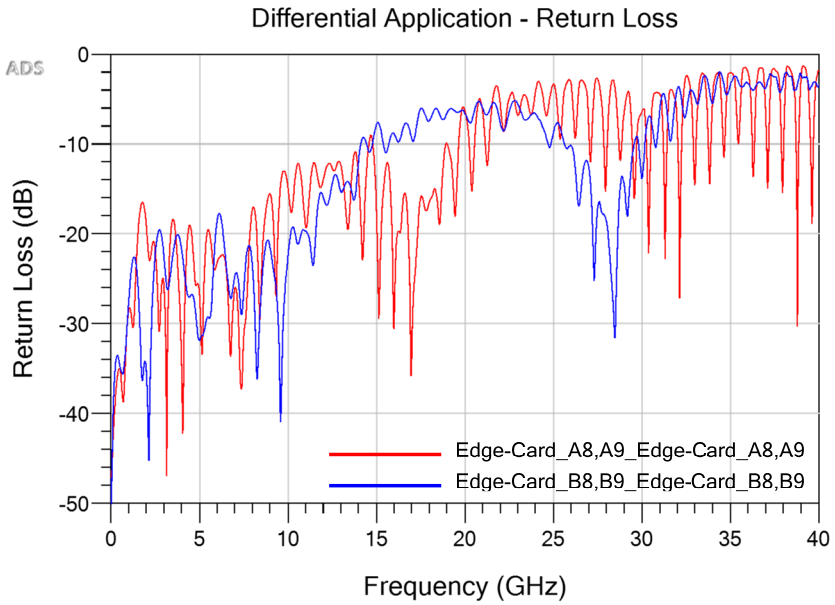
Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Appendix A – Frequency Domain Response Graphs

Differential Application – Insertion Loss

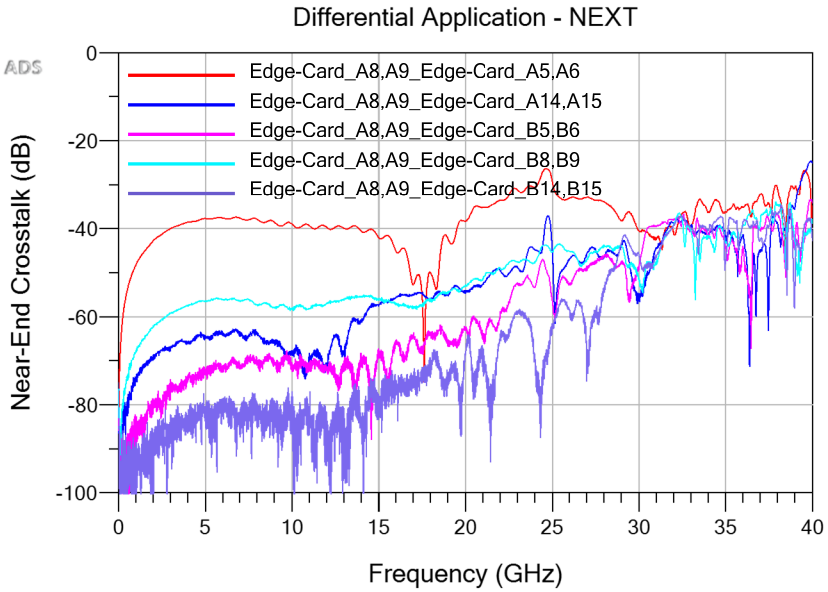


Differential Application – Return Loss

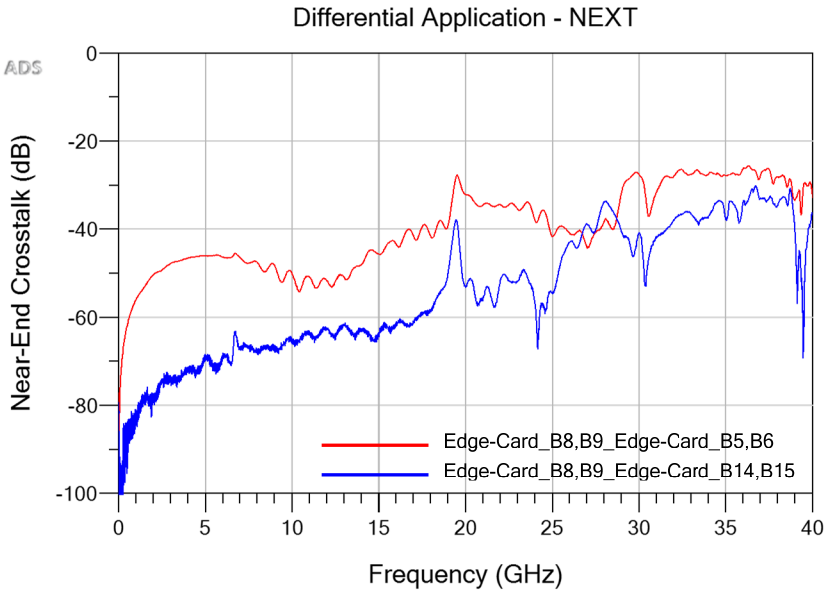


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Differential Application – NEXT Configurations (Source – A8,A9)

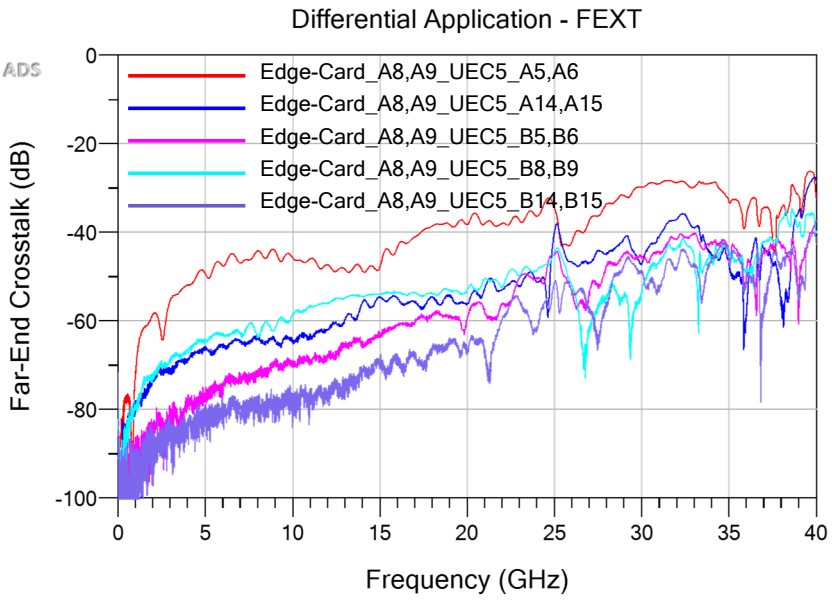


Differential Application – NEXT Configurations (Source = B8,B9)

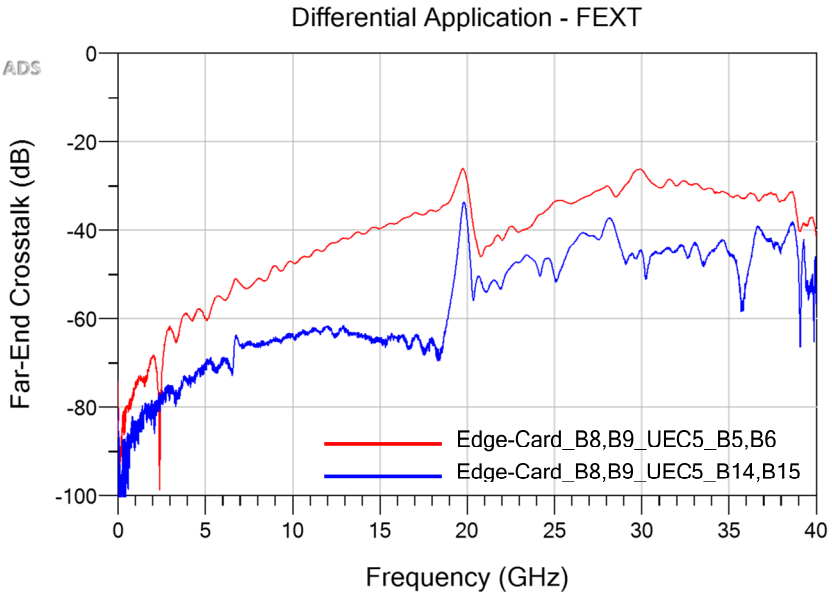


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Differential Application – FEXT Configurations (Source = A8,A9)



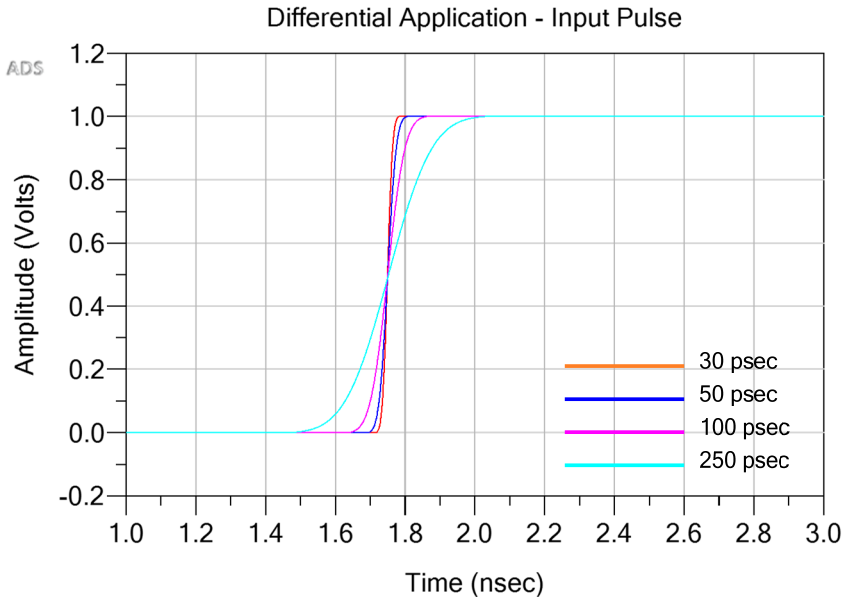
Differential Application – FEXT Configurations (Source = B8,B9)



Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

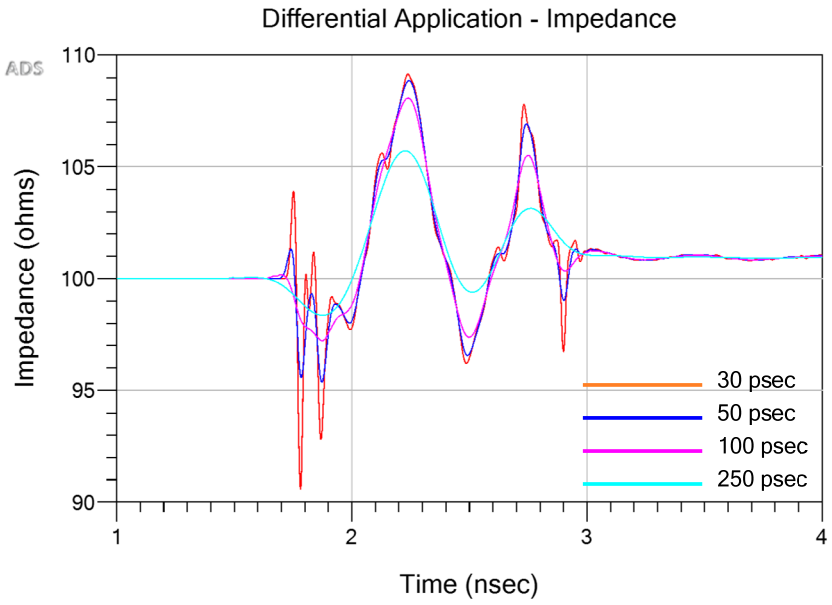
Appendix B – Time Domain Response Graphs

Differential Application – Input Pulse

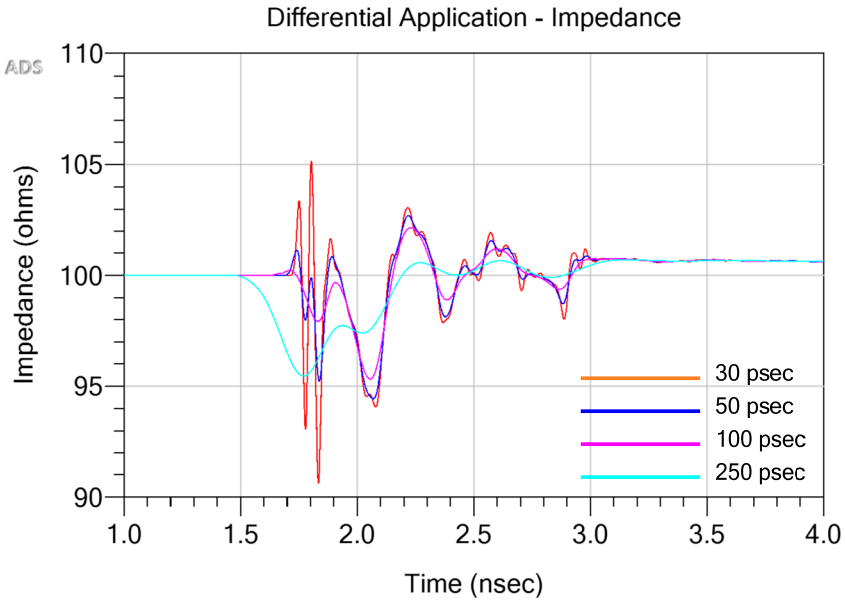


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Differential Application – Impedance, Edge-Card_A8A9_UEC5_A8A9

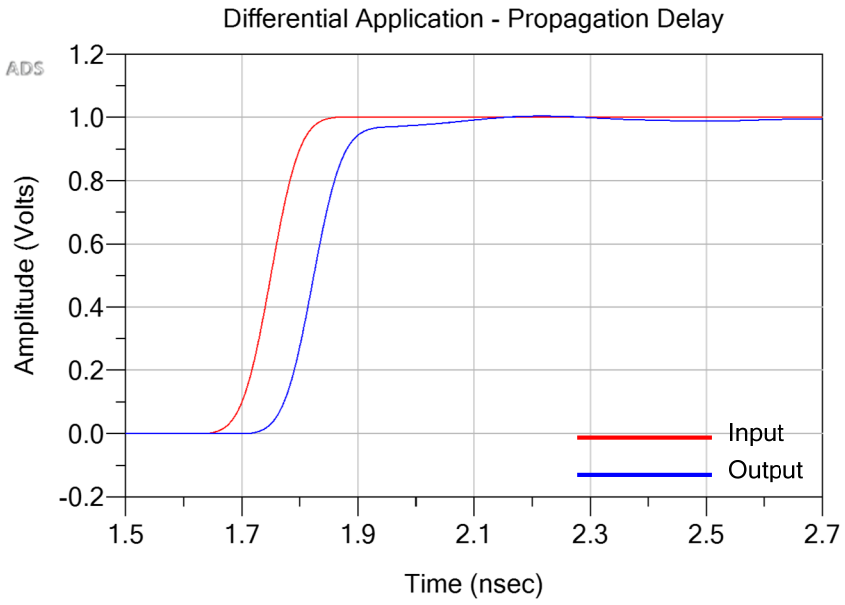


Differential Application – Impedance, Edge-Card_B8B9_UEC5_B8B9

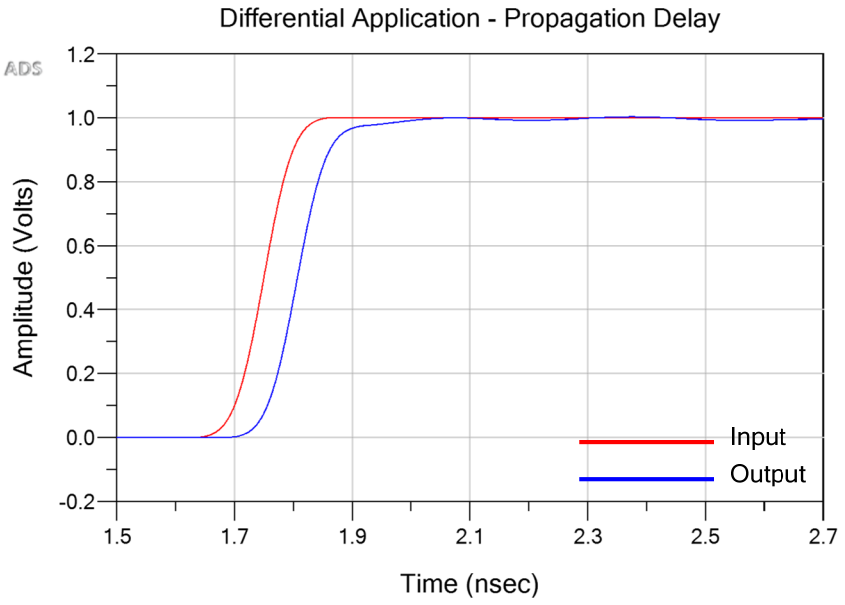


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Differential Application – Propagation Delay, Edge-Card_A8A9_UEC5_A8A9

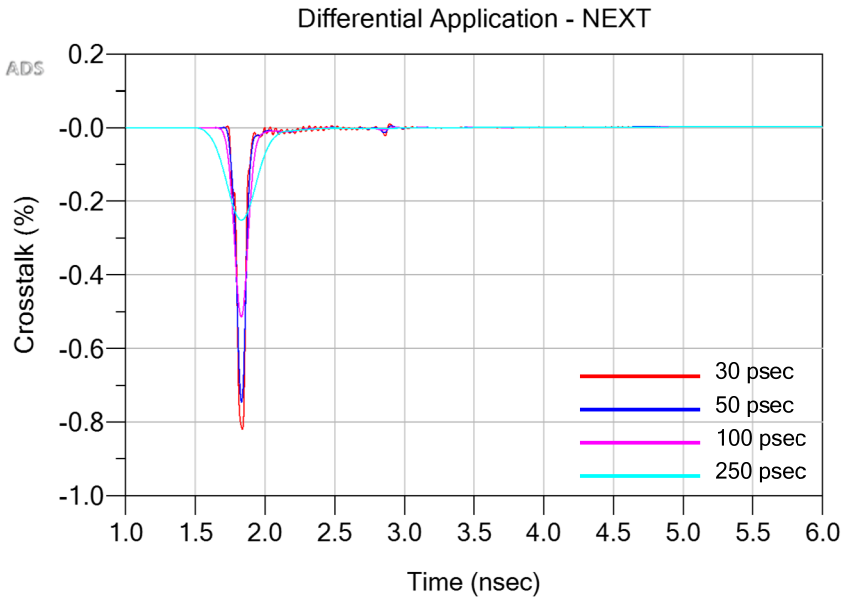


Differential Application – Propagation Delay, Edge-Card_B8B9_UEC5_B8B9

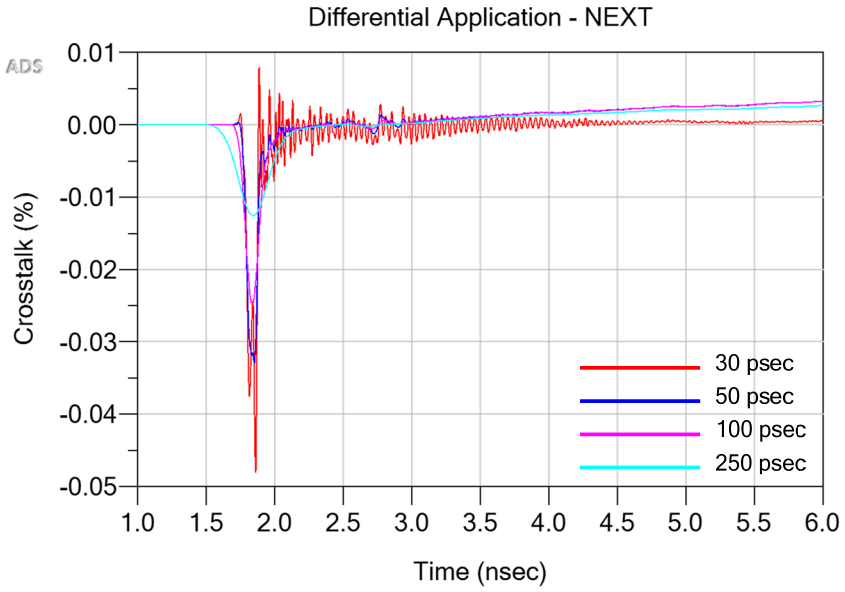


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Differential Application – NEXT, Edge-Card_A8A9_Edge-Card_A5A6

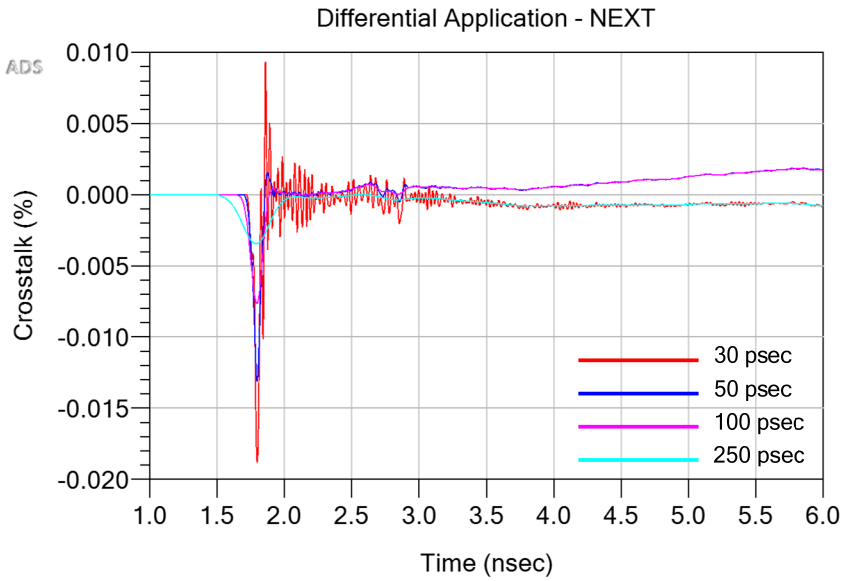


Differential Application – NEXT, Edge-Card_A8A9_Edge-Card_A14A15

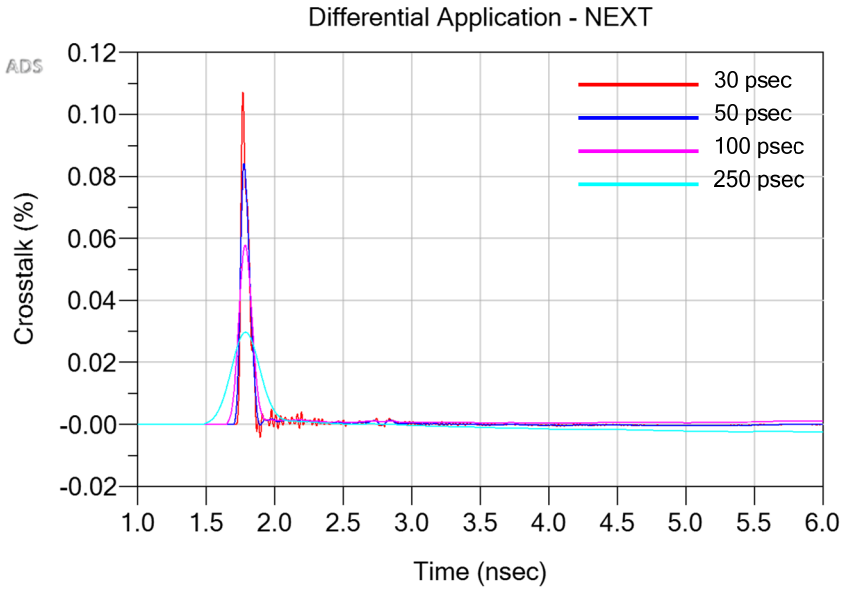


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Differential Application – NEXT, Edge-Card_A8A9_Edge-Card_B5B6

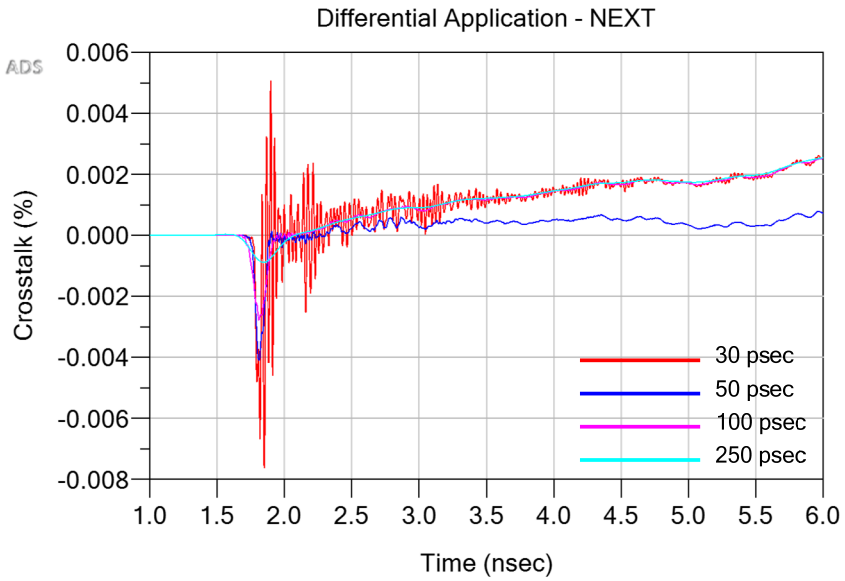


Differential Application – NEXT, Edge-Card_A8A9_Edge-Card_B8B9

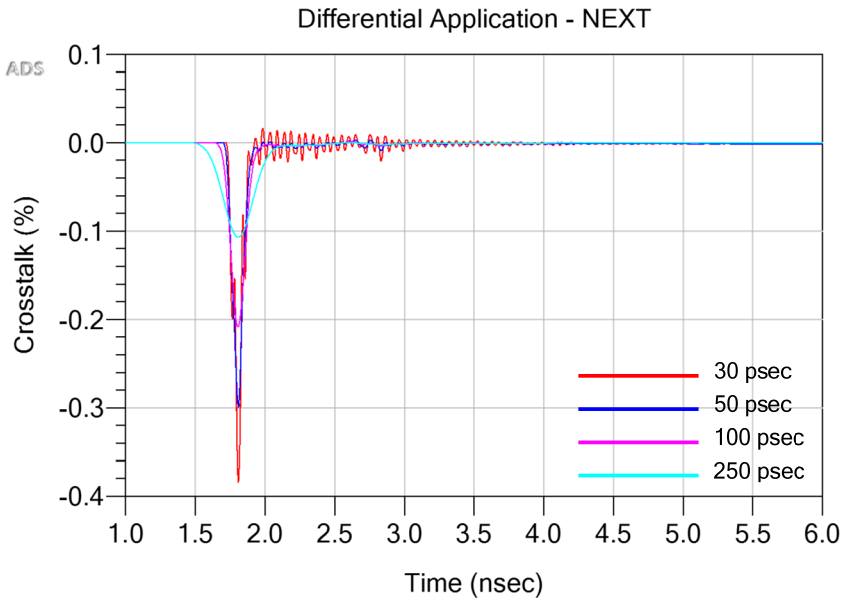


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Differential Application – NEXT, Edge-Card_A8A9_Edge-Card_B14B15

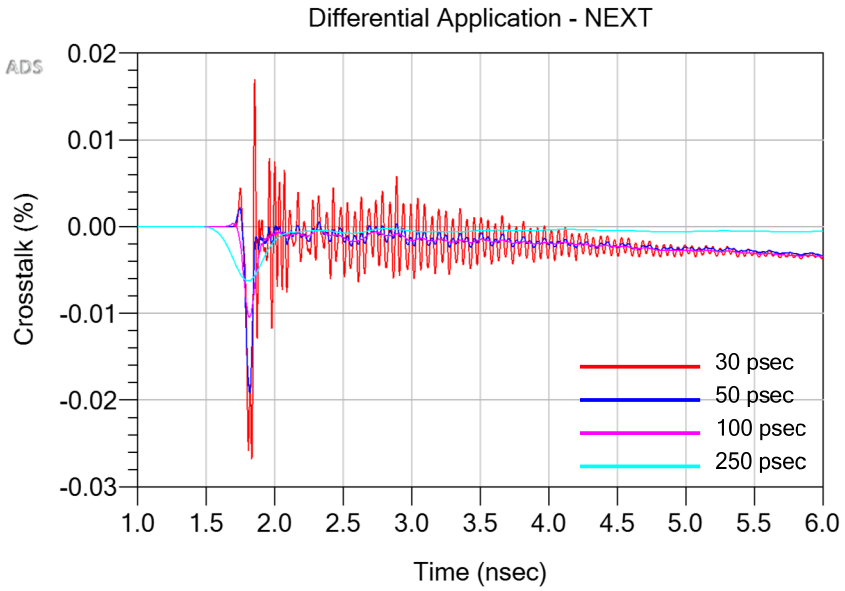


Differential Application – NEXT, Edge-Card_B8B9_Edge-Card_B5B6

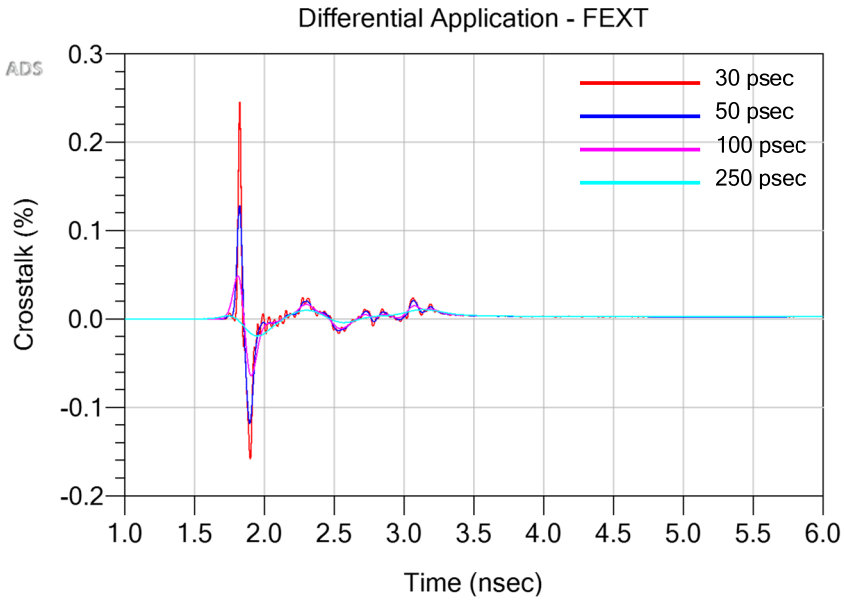


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Differential Application – NEXT, Edge-Card_B8B9_Edge-Card_B14B15

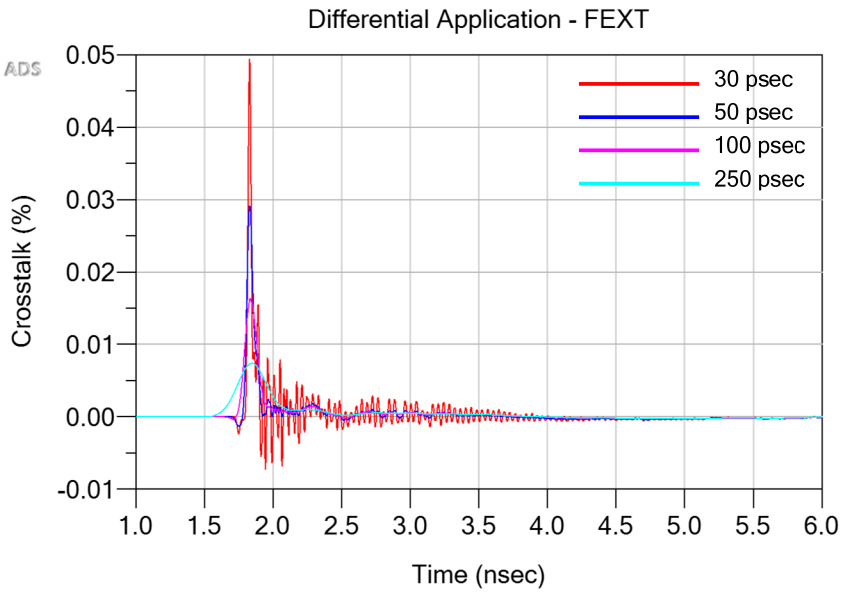


Differential Application – FEXT, Edge-Card_A8A9_UEC5_A5A6

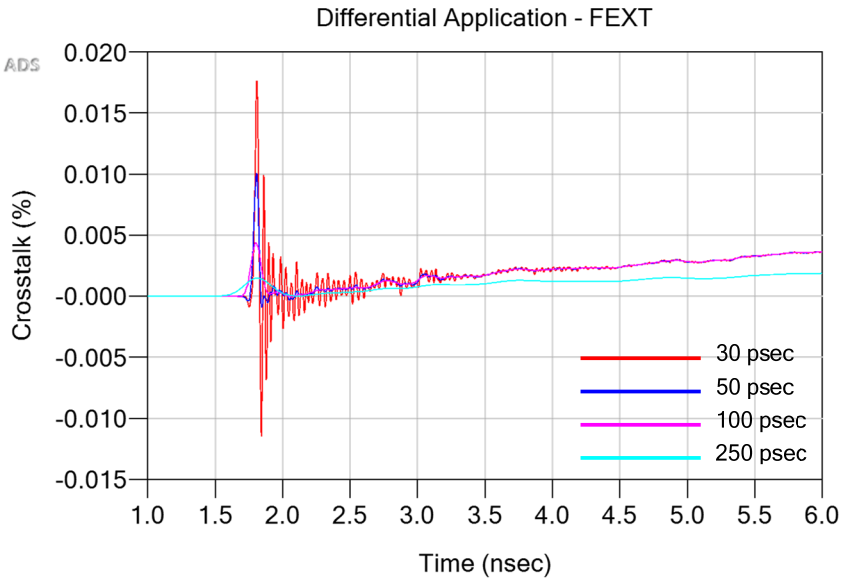


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Differential Application – FEXT, Edge-Card_A8A9_UEC5_A14A15

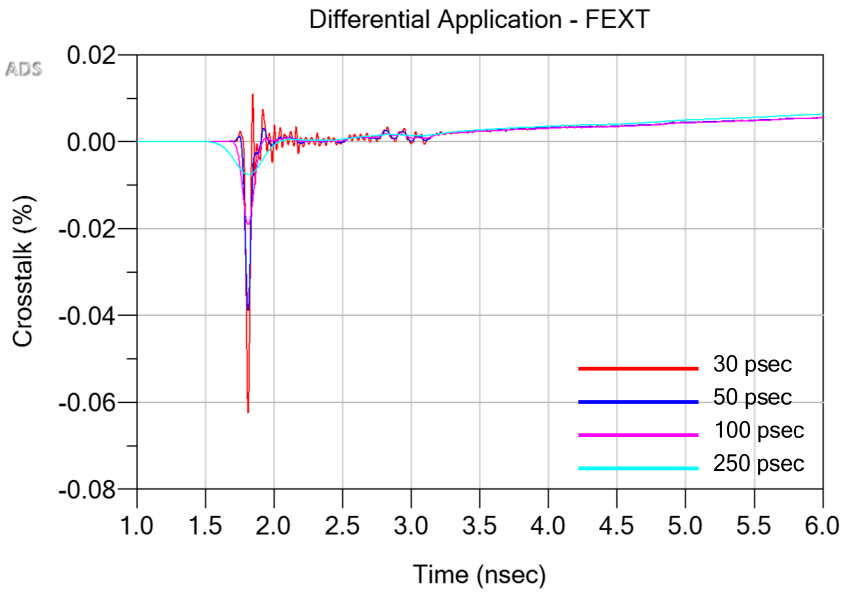


Differential Application – FEXT, Edge-Card_A8A9_UEC5_B5B6

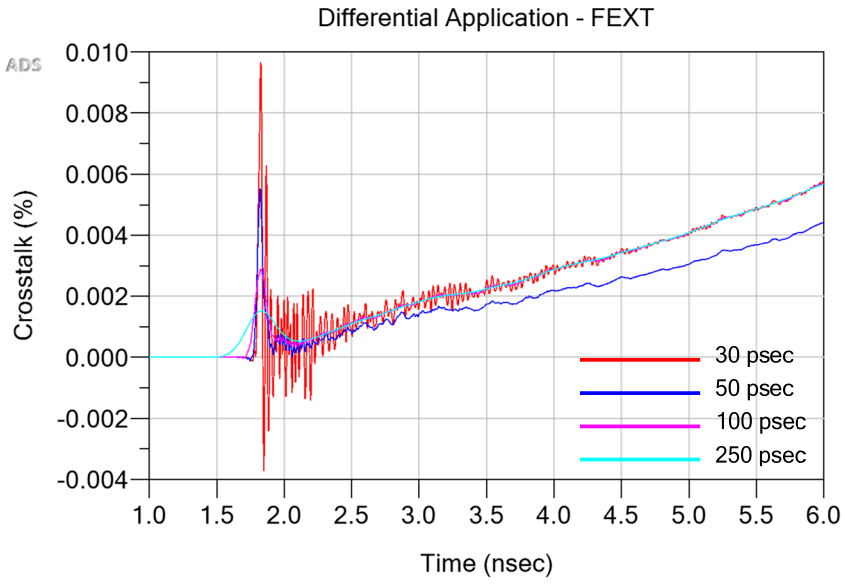


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Differential Application – FEXT, Edge-Card_A8A9_UEC5_B8B9

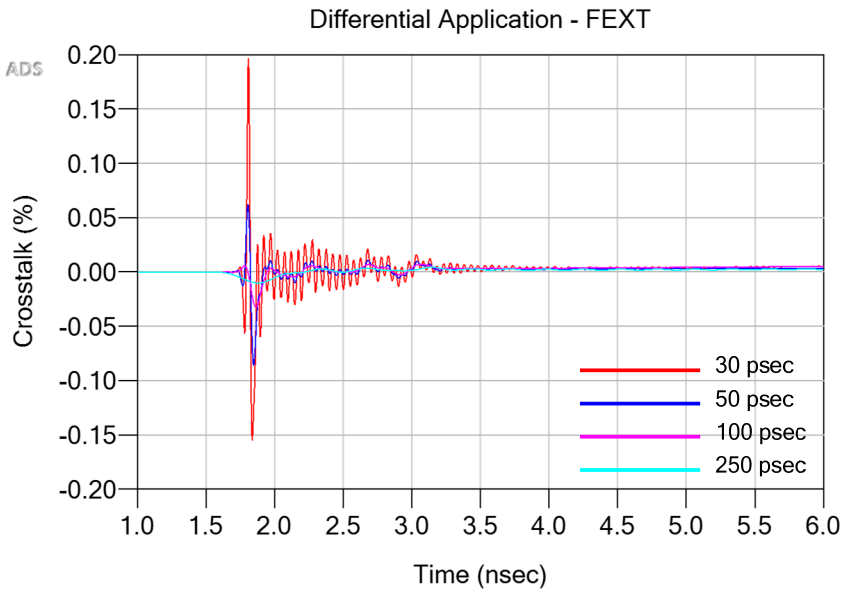


Differential Application – FEXT, Edge-Card_A8A9_UEC5_B14B15

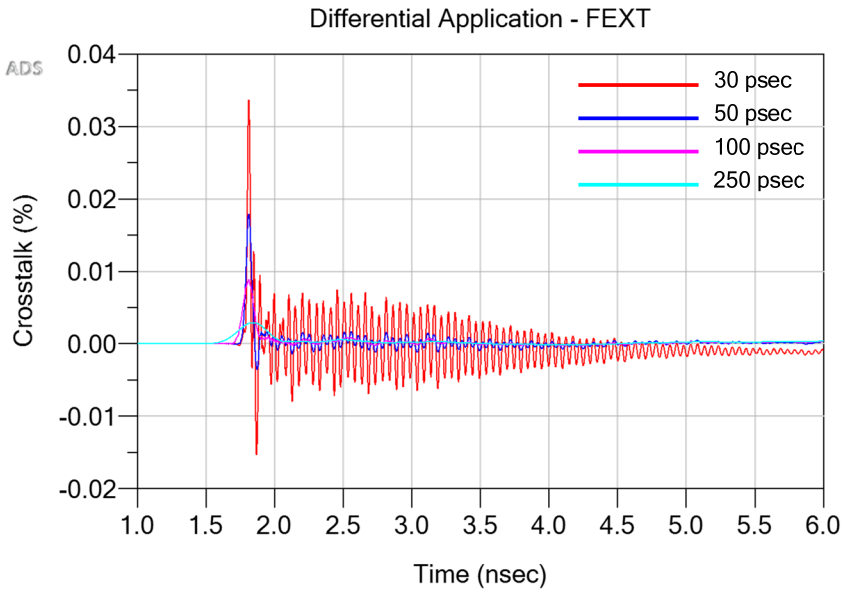


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Differential Application – FEXT, Edge-Card_B8B9_UEC5_B5B6



Differential Application – FEXT, Edge-Card_B8B9_UEC5_B14B15



Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Appendix C – Product and Test System Descriptions

Product Description

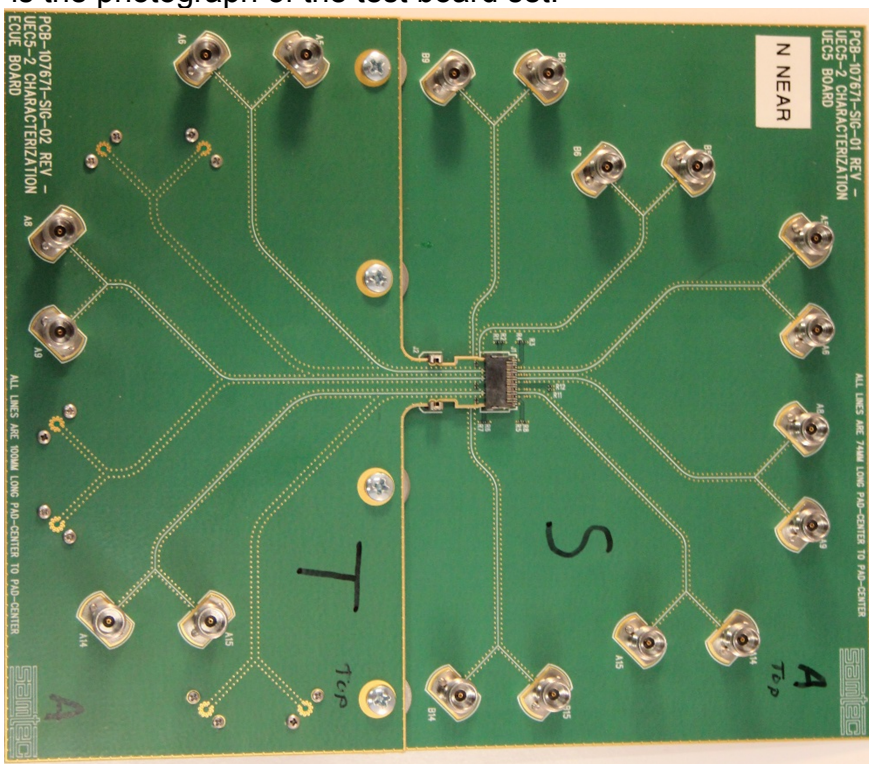
Product test samples are low profile right-angle surface mount UEC5 Series connectors. The part number is UEC5-019-2-X-D-RA-1. The UEC5 Series connectors use a Rugged Edge Rate® contact system. Each connector has two rows of contacts evenly spaced on a 0.5mm (.020") pitch. A photo of the test articles mounted to SI test boards is shown below.

Test System Description

The test fixtures are composed of four-layer FR-4 material with 50Ω signal trace and pad configurations designed for the electrical characterization of Samtec high speed connector products. A PCB mount SMA connector is used to interface the VNA test cables to the test fixtures. Optimization of the SMA launch was performed using full wave simulation tools to minimize reflections. Two test fixtures are specific to the UEC5 series connector set and identified by part numbers PCB-107671-SIG-01 and PCB-107671-SIG-02. Calibration standards specific to the UEC5 series are located on PCB-107671-SIG-99.

PCB-107671-SIG-XX Test Fixtures

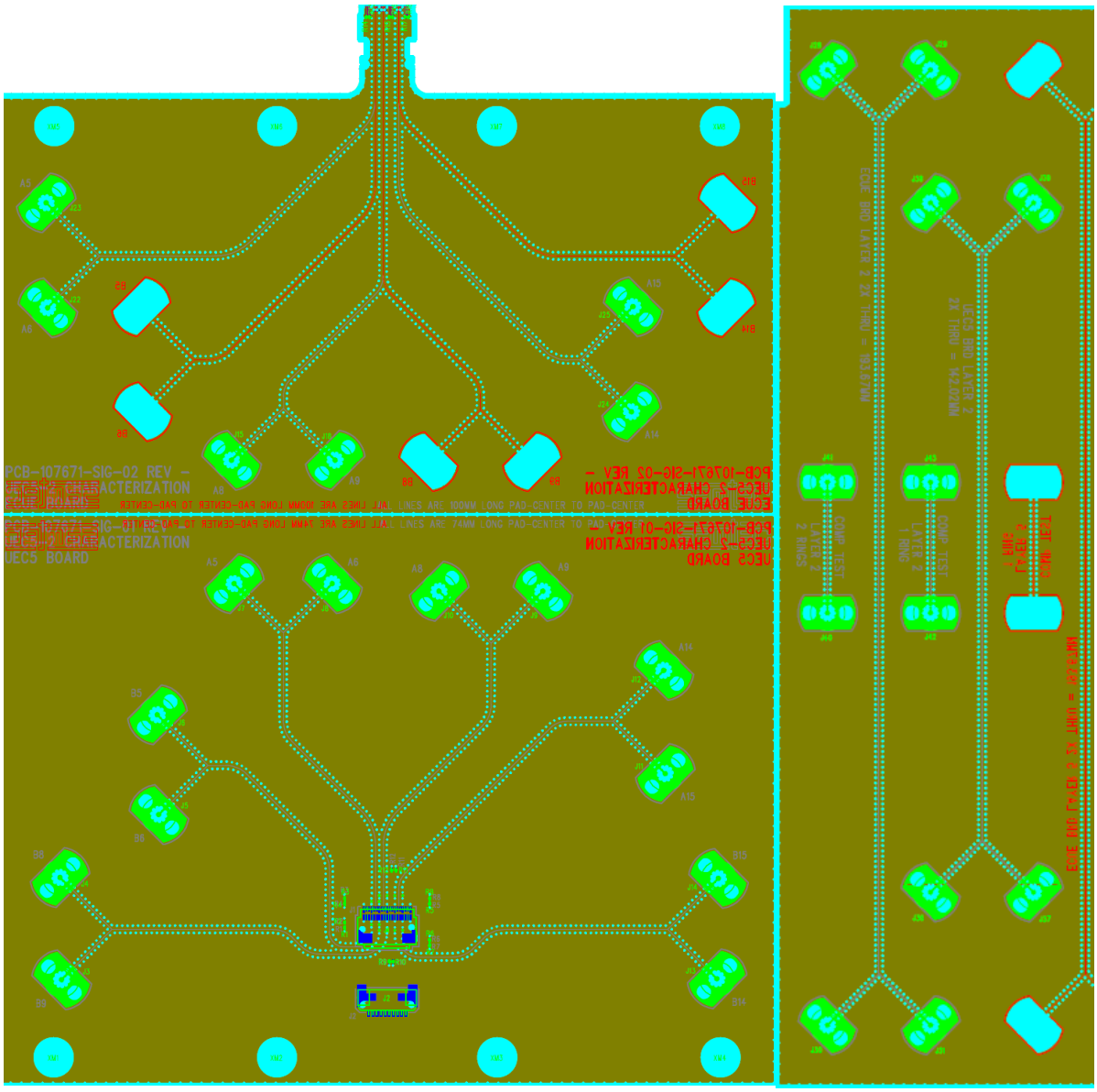
Shown below is the photograph of the test board set.



Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

PCB-107671-SIG-XX PCB Layout Panel

Artwork of the PCB design is shown below.

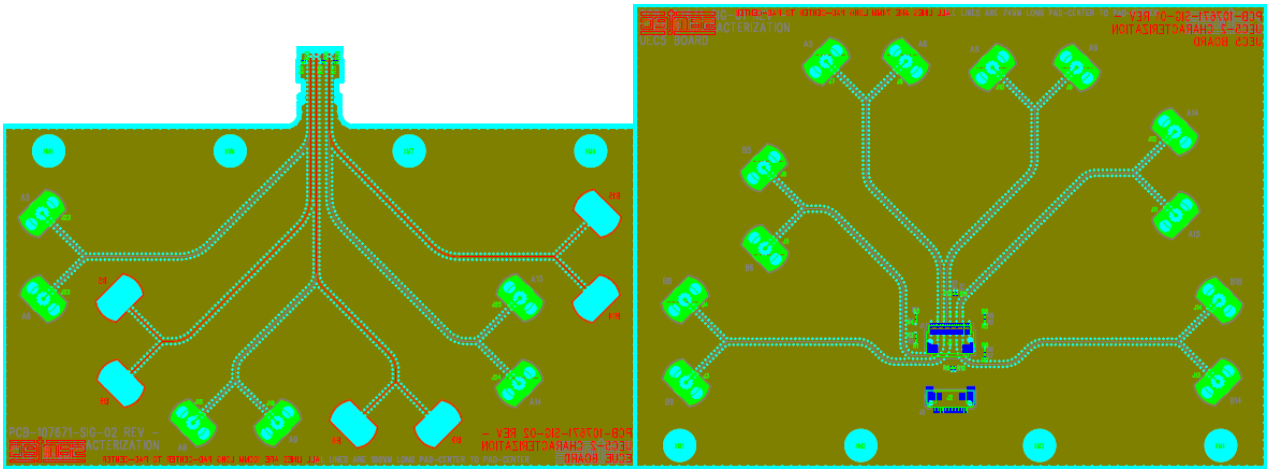


Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

PCB Fixtures

The test fixtures used are as follows:

PCB-107671-SIG-01 – UEC5 Series Test Board
PCB-107870-SIG-02 – UEC5 Series Edge Card



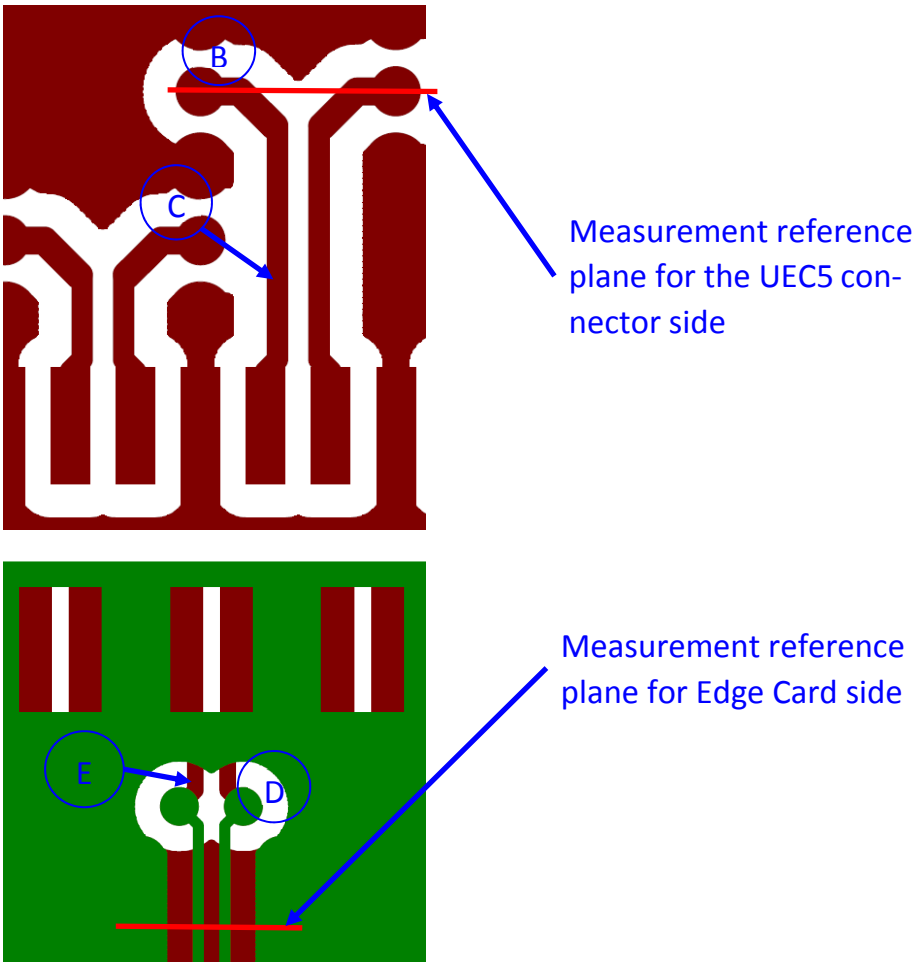
Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Measured from the edge of the pad to the SMA, all traces on the UEC5 socket board are length matched to 73.56 mm and all traces on the edge card are length matched to 99.38 mm. The AFR calibration effectively removes the test board trace effects 96.835 mm for UEC5 socket board and 71.01 mm for the edge card. This means that 2.55 mm of test board trace length effects are included in the measurement at each side.

The S-Parameter measurement includes:

A- The UEC5 Series connector set
B- Test board vias, pads (footprint effects) for the UEC5 connector side.
C- 2.55 mm of test board trace.
D- Test board vias, pads (footprint effects) for the Edge Card side.
E- 2.55 mm of test board trace.

The figure below shows the location of the measurement reference plane.



Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

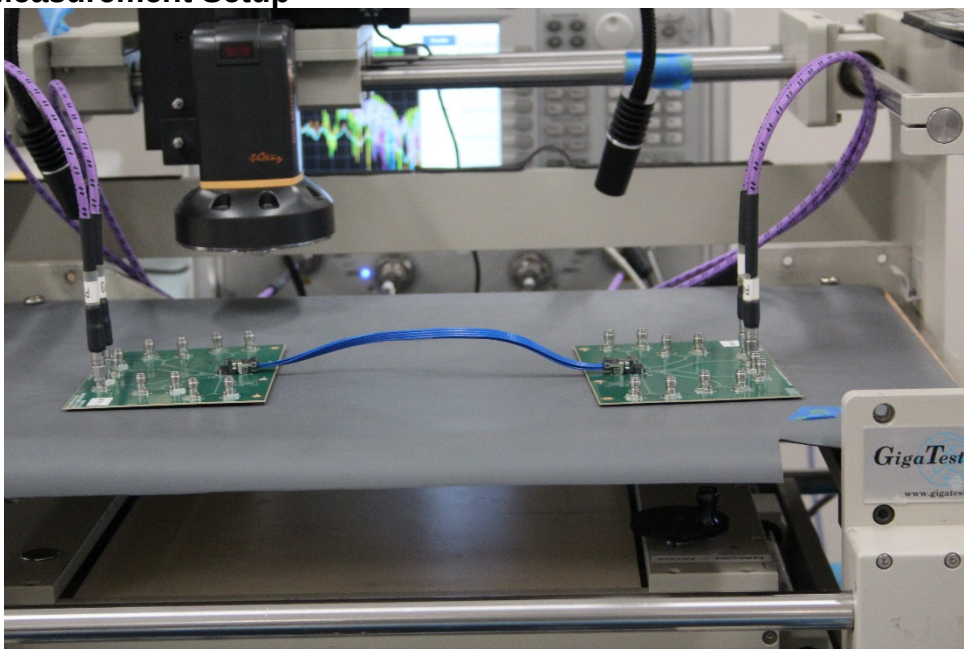
Appendix D – Test and Measurement Setup

The test instrument is the Keysight N5227A PNA-L network analyzer. Frequency domain data and graphs are obtained directly from the instrument. Post-processed time domain data and graphs are generated using convolution algorithms within Keysight ADS. The network analyzer is configured as follows:

Start Frequency – 10 MHz
Stop Frequency – 67 GHz
Number of points – 6700
IFBW – 1 KHz

With these settings, the measurement time is approximately 20 seconds.

N5227A Measurement Setup



Test Instruments

QTY	Description
1	Keysight N5230C PNA-L Network Analyzer (10 MHz to 67 GHz)
1	Keysight N4694-60003 ECAL Module (10 MHz to 67 GHz)

Test Cables & Adapters

QTY	Description
4	Gore 0F0CACB036.0-LF (DC-67 GHz)

Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

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 through 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 in order 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 band-width-limited data, such as measured with modern network analyzer.

The Time Domain responses were generated using Keysight ADS 2016. 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/Technical_Library/reference/articles/pdfs/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 connector and footprint. A step pulse is applied to the touchstone model of the connector 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 graph. The difference in time, measured at the 50% point of the step voltage is the propagation delay.

Near-End Crosstalk (TDT) & Far End Crosstalk (TDT)
A step pulse is applied to the touchstone model of the connector and the coupled voltage is monitored. The amplitude of the peak-coupled voltage is recorded and reported as a percentage of the input pulse.

Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

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 is limited. The "best case" signal mapping was tested and is presented in this report.

Series: UEC5-2
Description: 28G+ FireFly™ Edge Card Socket Assembly, 0.5mm Pitch

Appendix F – Glossary of Terms

ADS – Advanced Design Systems
BC – Best Case crosstalk configuration
DUT – Device under test, term used for TDA IConnect & Propagation Delay waveforms
FD – Frequency domain
FEXT – Far-End Crosstalk
GSG – Ground–Signal-Ground; geometric configuration
GSSG - Ground–Signal-Signal-Ground; geometric configuration
HDV – High Density Vertical
NEXT – Near-End Crosstalk
OV – Optimal Vertical
OH – Optimal Horizontal
PCB – Printed Circuit Board
PPO – Pin Population Option
SE – Single-Ended
SI – Signal Integrity
SUT – System Under Test
S – Static (independent of PCB ground)
SOLT – acronym used to define Short, Open, Load & Thru Calibration Standards
TD – Time Domain
TDA – Time Domain Analysis
TDR – Time Domain Reflectometry
TDT – Time Domain Transmission
WC – Worst Case crosstalk configuration
Z – Impedance (expressed in ohms)