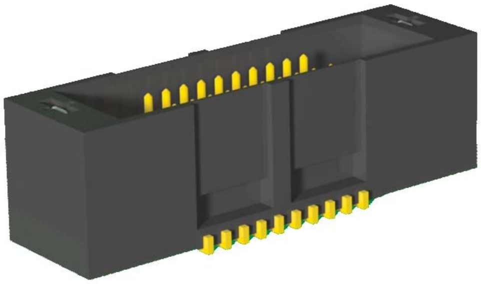
High Speed Characterization Report

TEM-150-02-03.0-H-D-A-X



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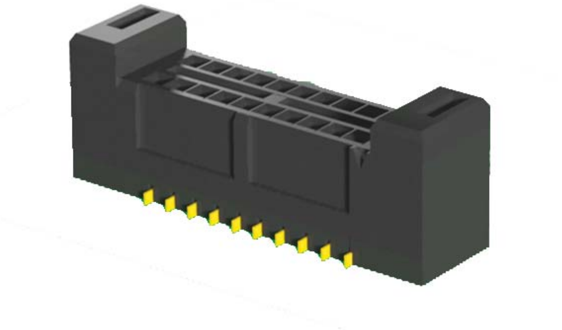
SEM-150-02-03.0-H-D-A-X



Description:

Micro Tiger Eye™, Parallel Board-to-Board, 0.8mm Pitch, 6mm (0.236”) Stack Height

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Series: TEM/SEM
Description: Micro Tiger Eye™ Board-to-Board 0.8mm Pitch, 6 mm (0.236") stack height

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Connector Overview

Micro Tiger Eye™ 0.8mm (.0315") pitch interfaces (TEM/SEM Series) are available with up to 100 I/Os and with standard board-to-board spacing of 6mm (0.236"), 7mm (0.276"), and 10mm (0.394") between boards. The data in this report is applicable only to the 6mm (0.236") board-to-board stack height version.

Connector System Speed Rating

TEM/SEM Series Micro Tiger Eye™ Board-to-Board 0.8mm Pitch, 6 mm (0.236") stack

Signaling	Speed Rating
Single-Ended:	**12GHz/ 24Gbps**
Differential:	**17GHz/ 34Gbps**

The Speed Rating is based on the -3 dB insertion loss point of the connector system. The -3 dB point can be used to estimate usable system bandwidth in a typical, two-level signaling environment.

To calculate the Speed Rating, the measured -3 dB point is rounded-up to the nearest half-GHz level. The up rounding corrects for a portion of the test board's trace loss, since a short length of trace loss included in the loss data in this report. The resulting loss value is then doubled to determine the approximate maximum data rate in Gigabits per second (Gbps).

For example, a connector with a -3 dB point of 7.8 GHz would have a Speed Rating of 8 GHz/ 16 Gbps. A connector with a -3 dB point of 7.2 GHz would have a Speed Rating of 7.5 GHz/ 15 Gbps.

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Frequency Domain Data Summary

Table 1 - Single-Ended Connector System Performance

Test Parameter	Configuration	
Insertion Loss	GSG	-3dB @ 11.75GHz
Return Loss	GSG	-16.20dB @ 11.75GHz
Near-End Crosstalk	GAQG	-18.91dB @ 11.75GHz
	GAGQG	-20.12dB @ 11.75GHz
	Xrow, GAG to GQG	-22.52dB @ 11.75GHz
Far-End Crosstalk	GAQG	-15.22dB @ 11.75GHz
	GAGQG	-19.05dB @ 11.75GHz
	Xrow, GAG to GQG	-18.74dB @ 11.75GHz

Table 2 - Differential Connector System Performance

Test Parameter	Configuration	
Insertion Loss	GSSG	-3dB @ 16.81GHz
Return Loss	GSSG	-8.49dB @ 16.81GHz
Near-End Crosstalk	GAAQQG	-24.25dB @ 16.81GHz
	GAAGQQG	-16.78dB @ 16.81GHz
	Xrow, GAAG to GQQG	-22.08dB @ 16.81GHz
Far-End Crosstalk	GAAQQG	-22.02dB @ 16.81GHz
	GAAGQQG	-19.23dB @ 16.81GHz
	Xrow, GAAG to GQQG	-33.91dB @ 16.81GHz

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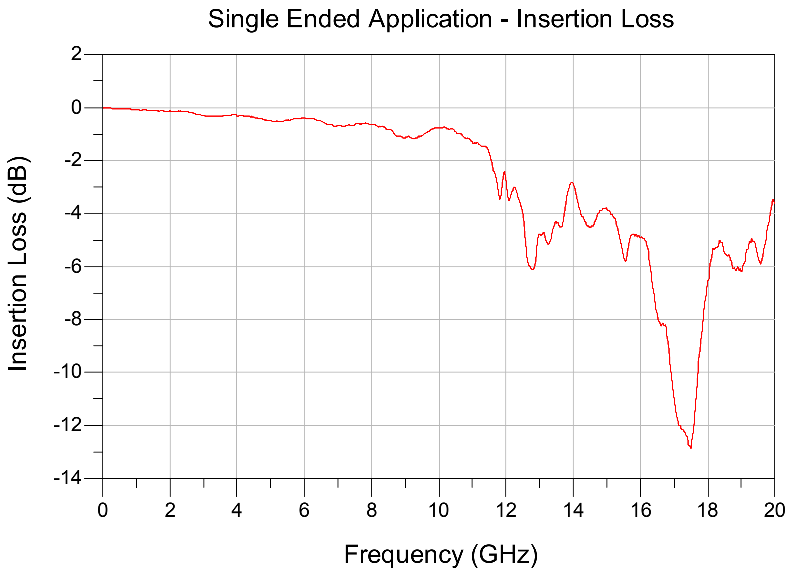
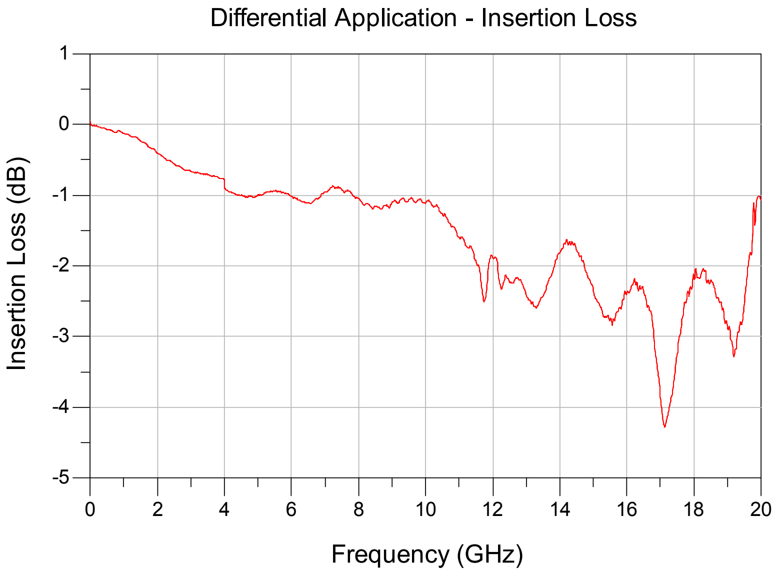
Bandwidth Chart – Single-Ended & Differential Insertion Loss

TEM/ SEM Connector Series





Series: TEM/SEM
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Time Domain Data Summary

Table 3 - Single-Ended Impedance (Ω)

Signal Risetime	35 ps	50 ps	100 ps	250 ps	500 ps
Maximum Impedance	54.5	53.9	53.6	52.8	51.7
Minimum Impedance	39.7	40.8	43.9	47.5	49.0

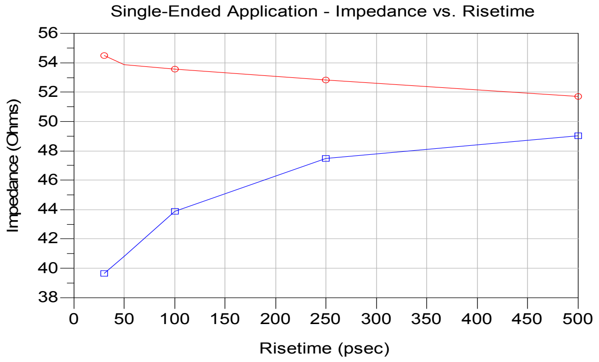

Table 4 - Differential Impedance (Ω)

Signal Risetime	35 ps	50 ps	100 ps	250 ps	500 ps
Maximum Impedance	101.8	100.9	100.8	100.7	100.6
Minimum Impedance	56.0	63.9	73.7	86.1	92.5

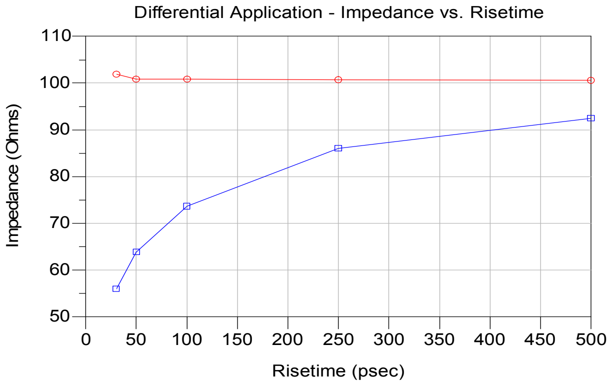

Table 5 - Single-Ended Crosstalk (%)

Input(t_r)		30±5ps	50 ps	100 ps	250 ps	500 ps
NEXT	GAQG	17.8	17.0	13.4	6.6	3.4
	GAGQG	4.9	2.5	1.5	0.8	0.5
	Xrow	3.0	2.6	1.8	0.8	0.4
FEXT	GAQG	6.3	4.6	2.3	1.0	0.5
	GAGQG	5.1	3.6	1.6	0.6	0.3
	Xrow	1.0	0.5	0.1	0.1	< 0.1

Table 6 - Differential Crosstalk (%)

Input(t_r)		30±5ps	50 ps	100 ps	250 ps	500 ps
NEXT	GAAQQG	5.6	5.3	4.1	2.1	1.1
	GAAGQQG	1.2	0.6	0.3	0.2	0.1
	Xrow	0.6	0.5	0.4	0.2	0.1
FEXT	GAAQQG	1.7	1.4	1.0	0.5	0.2
	GAAGQQG	1.2	0.8	0.4	0.1	< 0.1
	Xrow	0.6	0.5	0.3	0.2	0.1

Table 7 - Propagation Delay (Mated Connector)

Single-Ended	69 ps
Differential	72 ps

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 both differential and single-ended drive 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. However, 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.

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For this connector, the following array configurations are evaluated:

Single-Ended Impedance**:**
- GSG (ground-signal-ground)

Single-Ended Crosstalk**:**
- Electrical “worst case”: GAQG (ground-active-quiet-ground)
- Electrical “best case”: GAGQG (ground-active-ground-quiet-ground)
- Across row: Xrow$_{se}$ (from one row of terminals to the other row)

Differential Impedance**:**
- GSSG (Ground-positive signal-negative signal-ground)

Differential Crosstalk**:**
- Electrical “worst case”: GAAQQG (ground-active-active-quiet-quiet-ground)
- Electrical “best case”: GAAGQQG (ground-active-active-ground-quiet-quiet-ground)
- Across row: Xrow$_{diff}$ (from one row of terminals to the other row)

Only one single-ended signal or 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. However, 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 35 +/-5 ps. Generally, this should demonstrate 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 30 ps and 1.0 ns.

For this report, measured rise times were at 10%-90% signal levels.

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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 Agilent Advanced Design System to obtain the time domain response. Time Domain data 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 80 mils of PCB trace on each end of the connector. Delay is measured at 35 ± 5 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. However, 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 located in the appendices of this report. Further information may be obtained by contacting our Signal Integrity Group at sig@samtec.com.

Series: TEM/SEM
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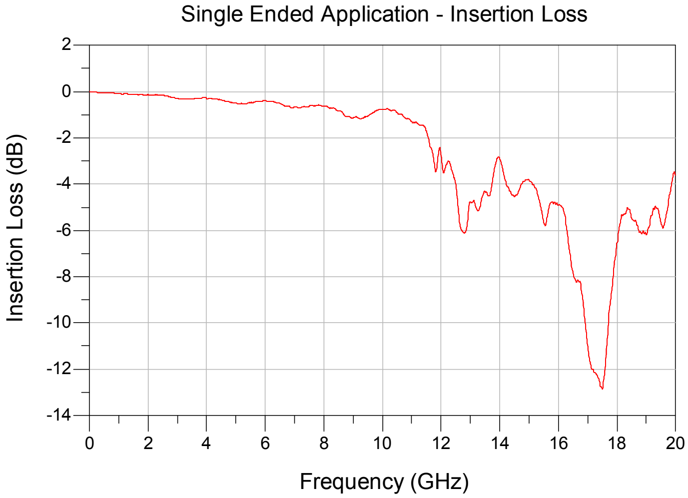
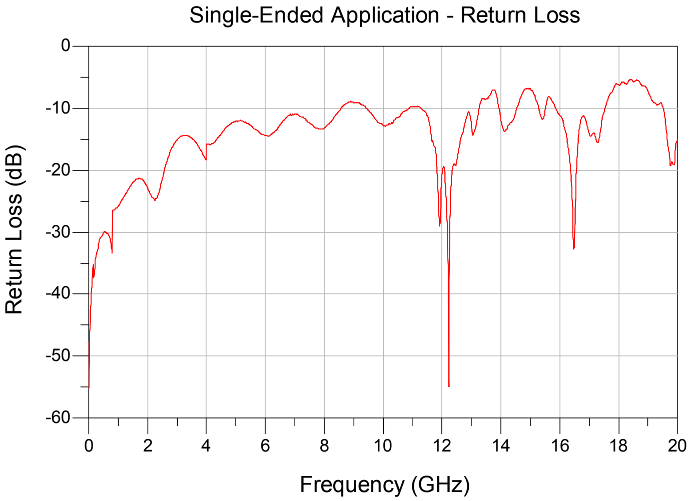
Appendix A – Frequency Domain Response Graphs

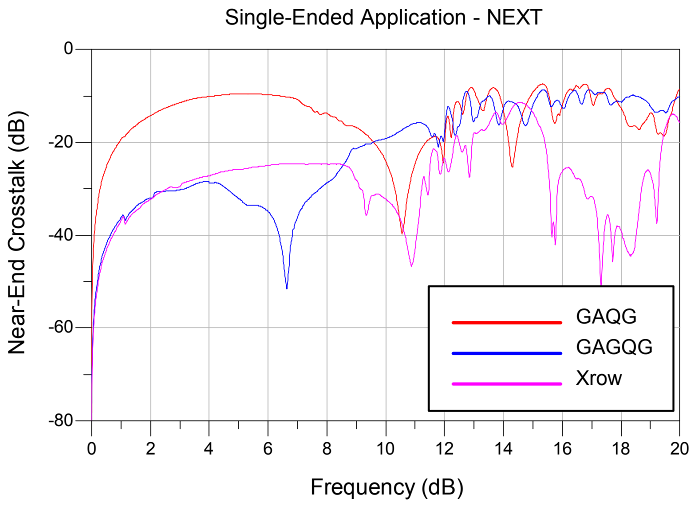
Single-Ended Application – Insertion Loss



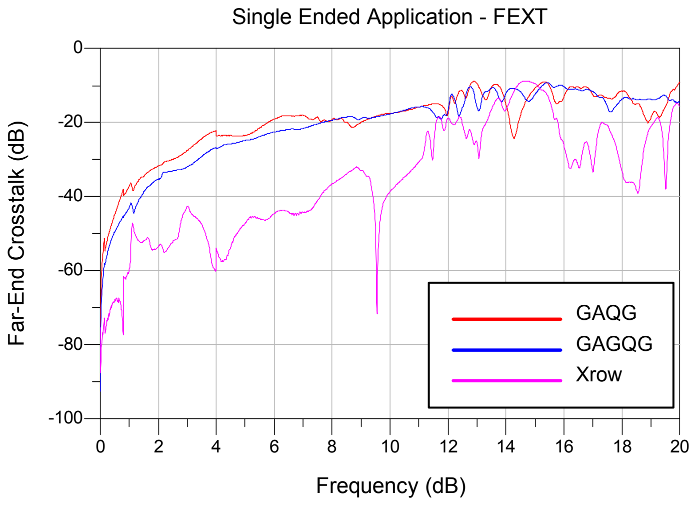
Single-Ended Application – Return Loss



Single-Ended Application – NEXT Configurations

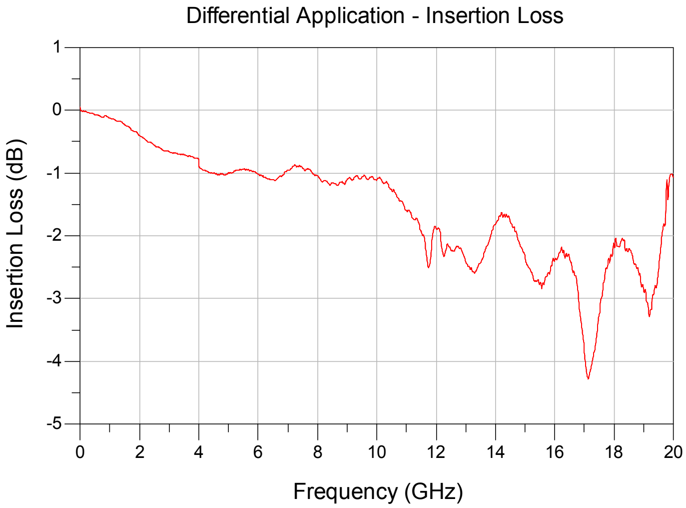


Single-Ended Application – FEXT Configurations

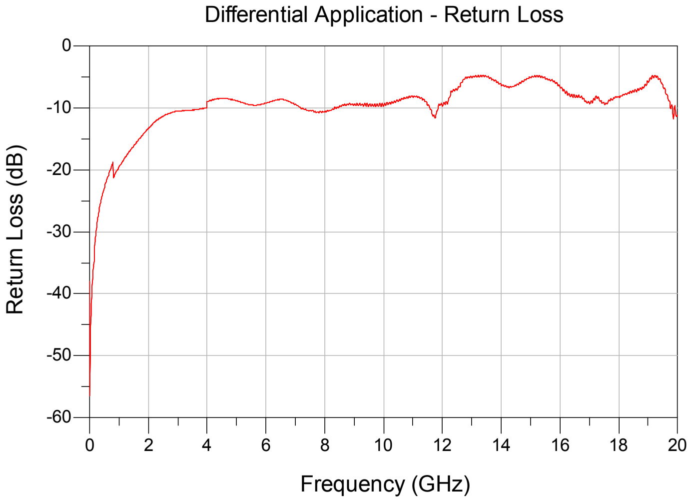


Series: TEM/SEM
Description: Micro Tiger Eye™ Board-to-Board 0.8mm Pitch, 6 mm (0.236”) stack height

Differential Application – Insertion Loss

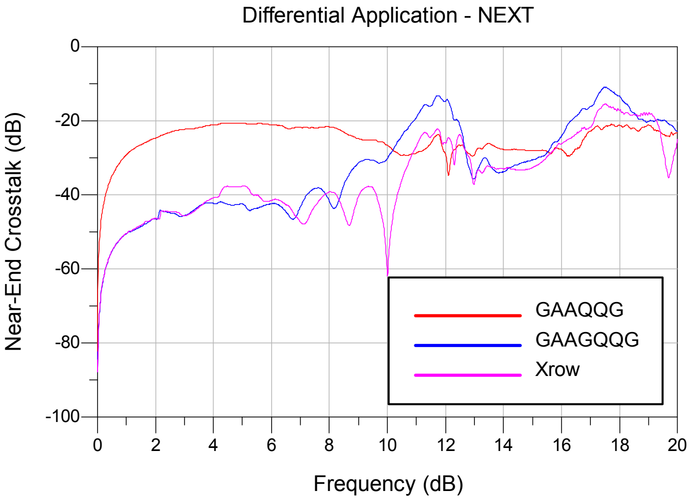


Differential Application – Return Loss

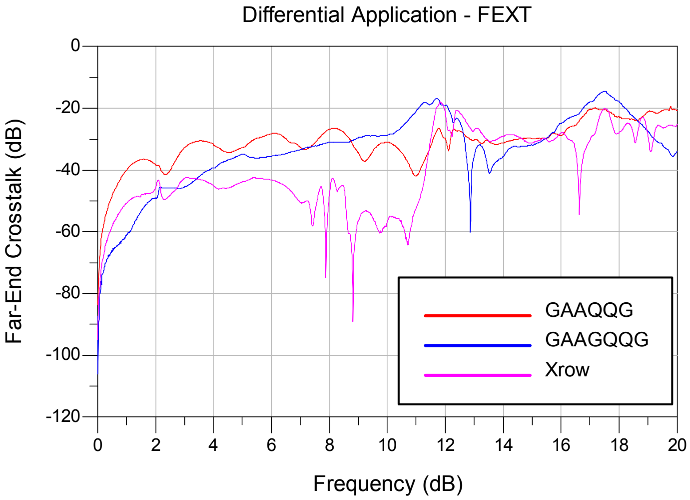


Series: TEM/SEM
Description: Micro Tiger Eye™ Board-to-Board 0.8mm Pitch, 6 mm (0.236”) stack height

Differential Application – NEXT Configurations



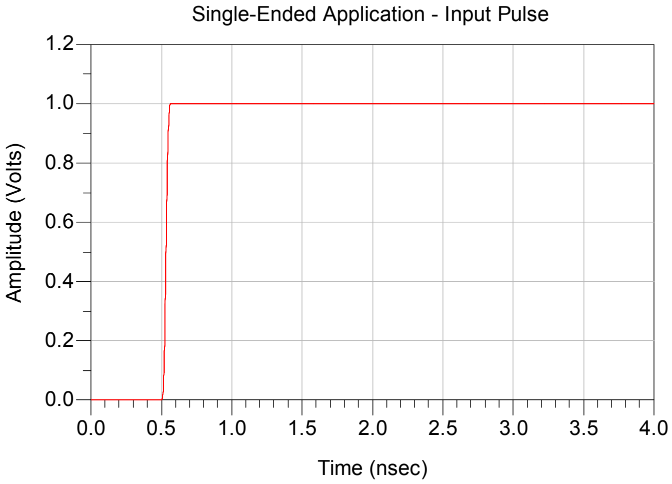
Differential Application – FEXT Configurations



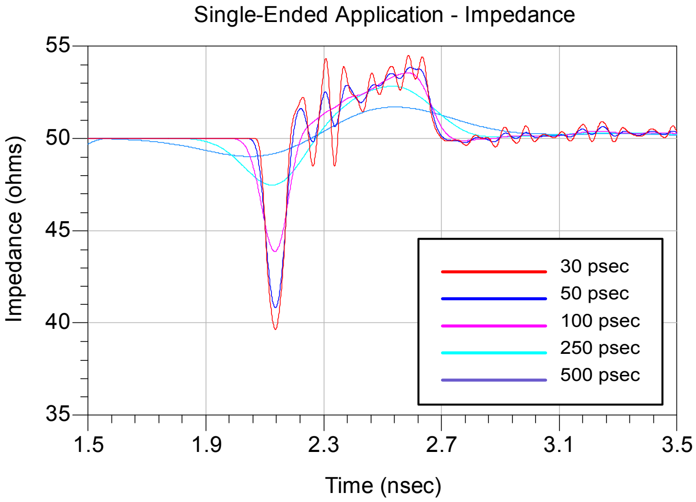
Series: TEM/SEM
Description: Micro Tiger Eye™ Board-to-Board 0.8mm Pitch, 6 mm (0.236”) stack height

Appendix B – Time Domain Response Graphs

Single-Ended Application – Input Pulse,



Single-Ended Application – Impedance



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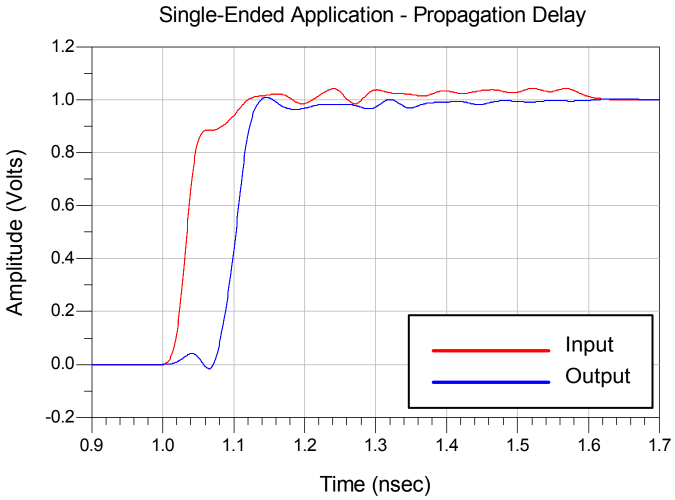
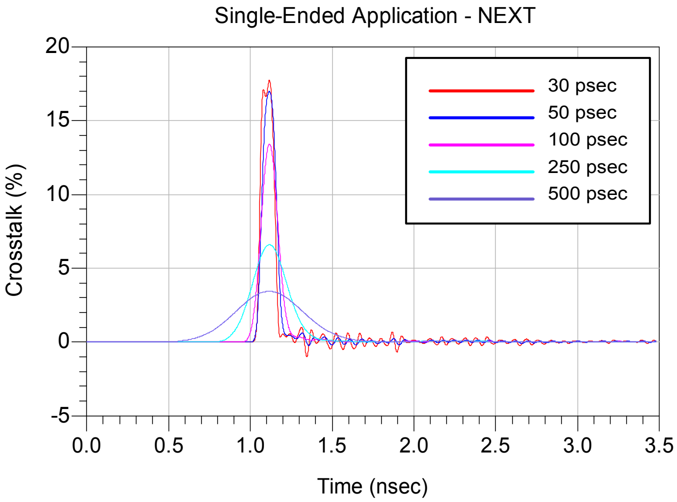
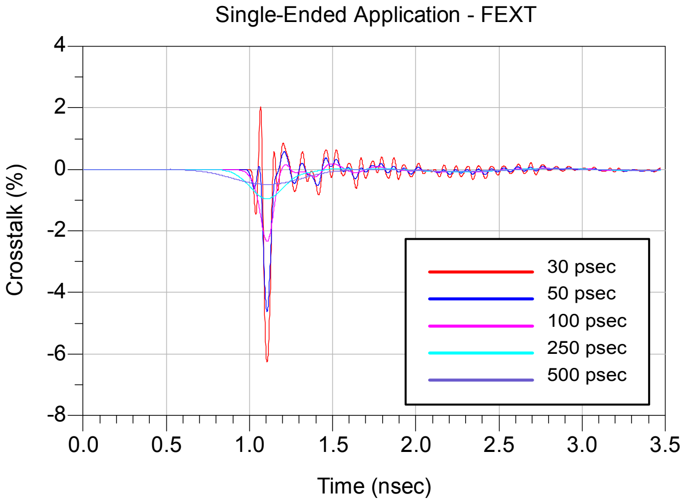
Single-Ended Application – Propagation Delay



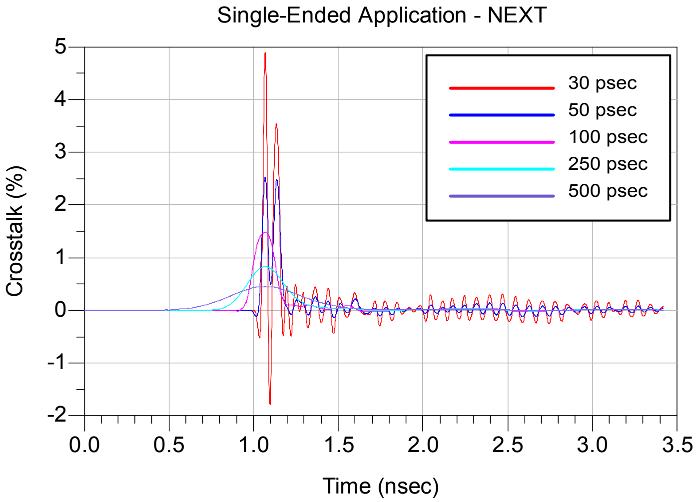
Single-Ended Application – NEXT, Worst Case Configuration



Single-Ended Application – FEXT, Worst Case Configuration



Single-Ended Application – NEXT, Best Case Configuration



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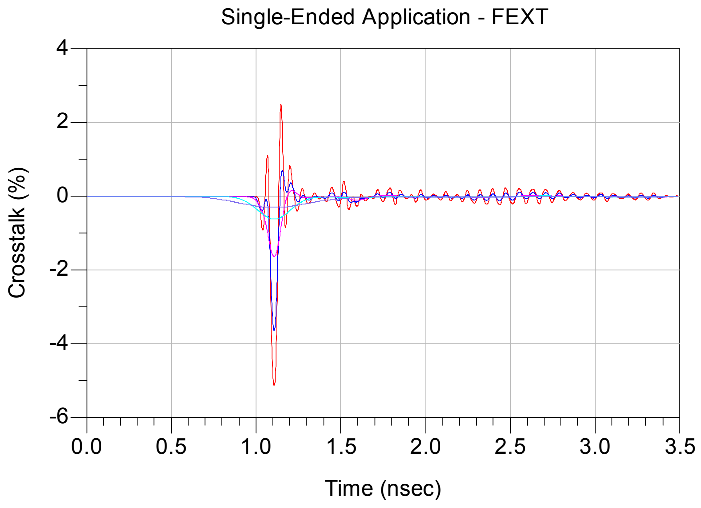
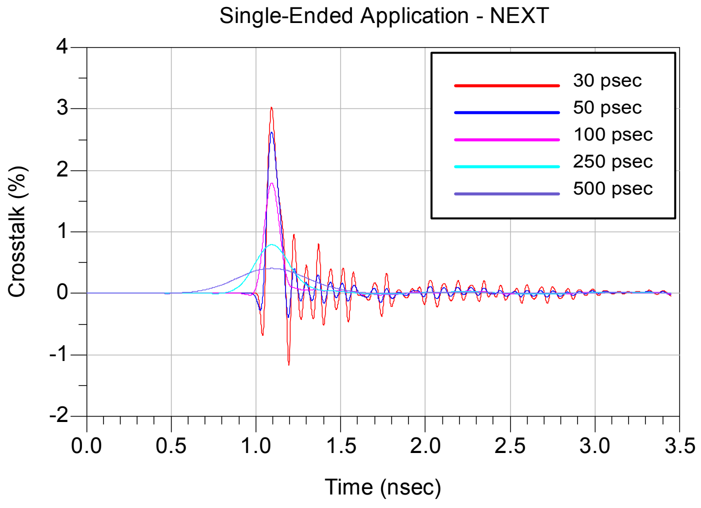
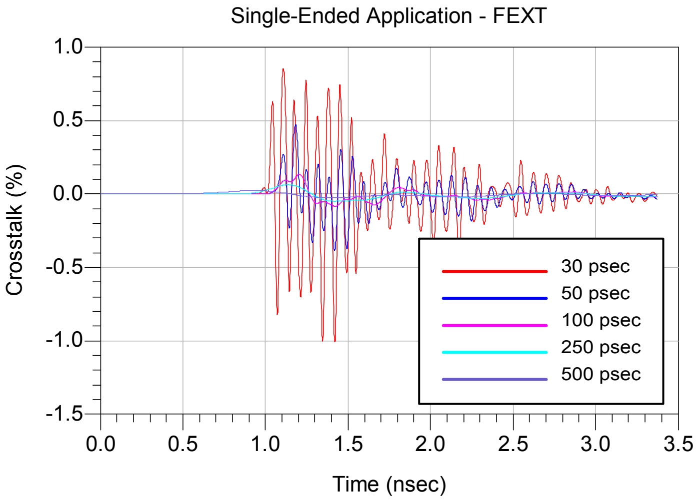
Single-Ended Application – FEXT, Best Case Configuration



Single-Ended Application – NEXT, Across Row Configuration

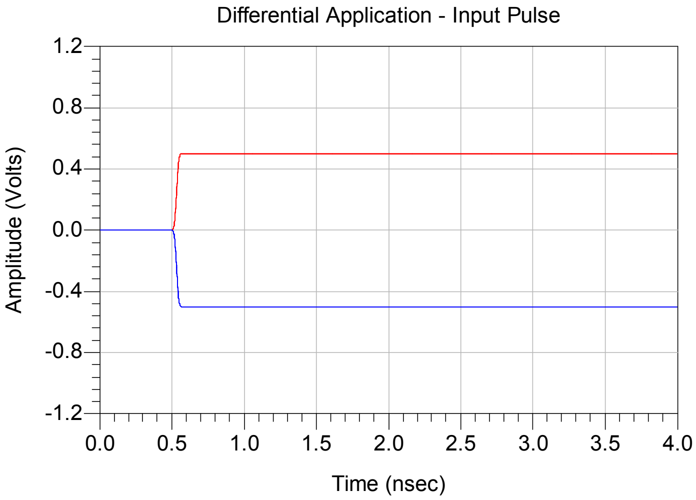


Single-Ended Application – FEXT, Across Row Configuration



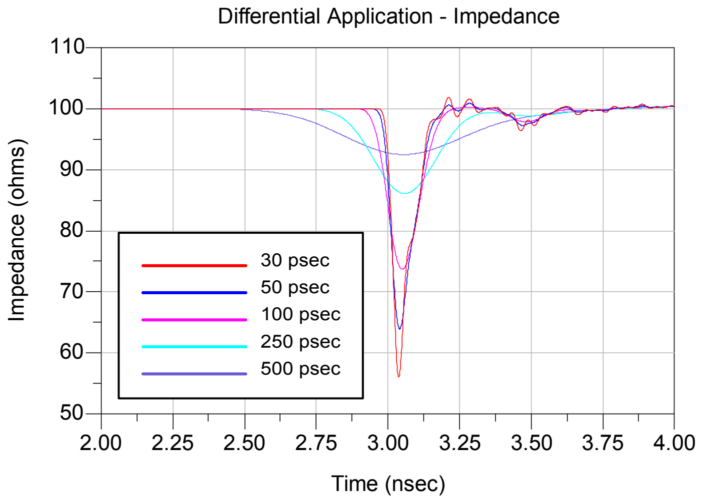
Series: TEM/SEM
Description: Micro Tiger Eye™ Board-to-Board 0.8mm Pitch, 6 mm (0.236”) stack height

Differential Application – Input Pulse

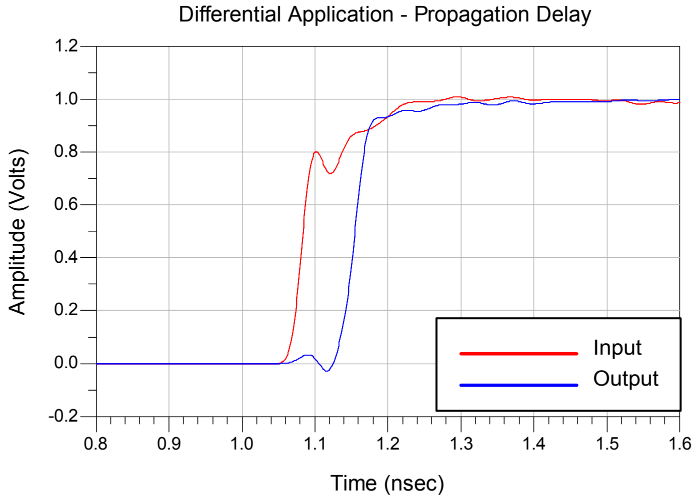


Series: TEM/SEM
Description: Micro Tiger Eye™ Board-to-Board 0.8mm Pitch, 6 mm (0.236”) stack height

Differential Application – Impedance

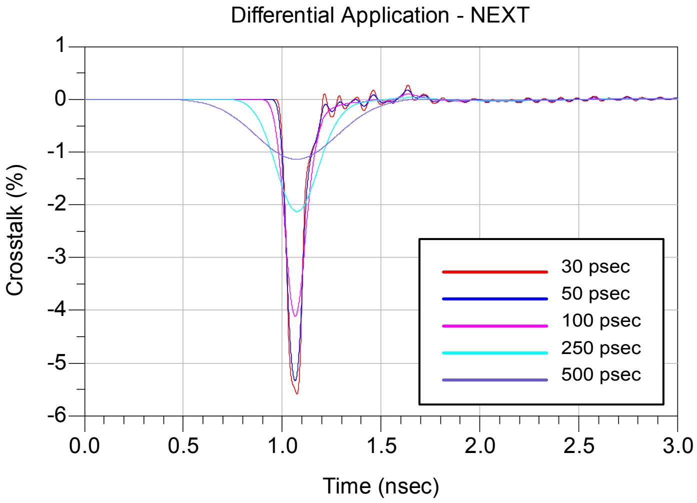


Differential Application – Propagation Delay

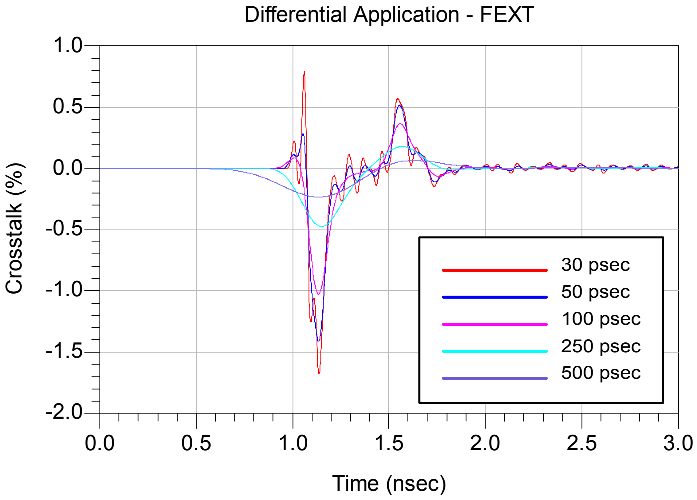


Series: TEM/SEM
Description: Micro Tiger Eye™ Board-to-Board 0.8mm Pitch, 6 mm (0.236”) stack height

Differential Application – NEXT, Worst Case



Differential Application – FEXT, Worst Case



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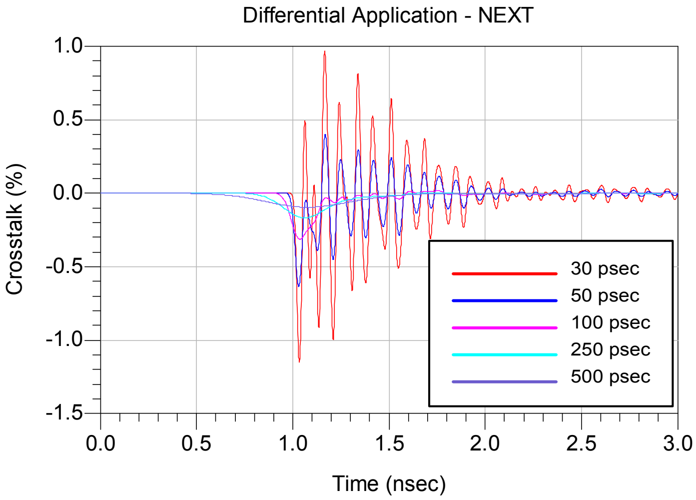
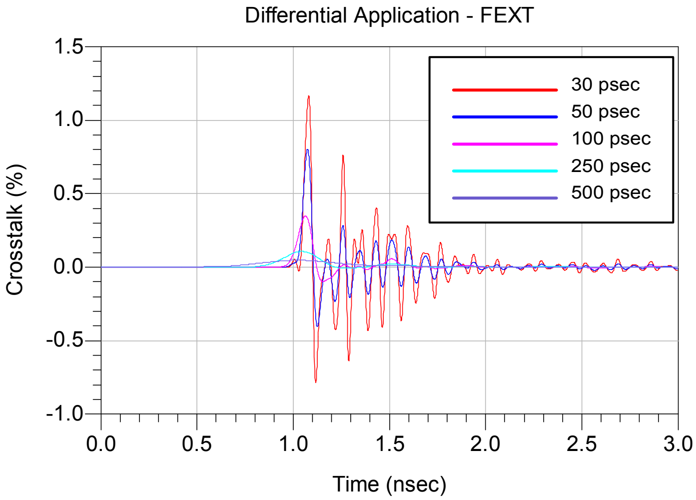
Differential Application – NEXT, Best Case



Differential Application – FEXT, Best Case



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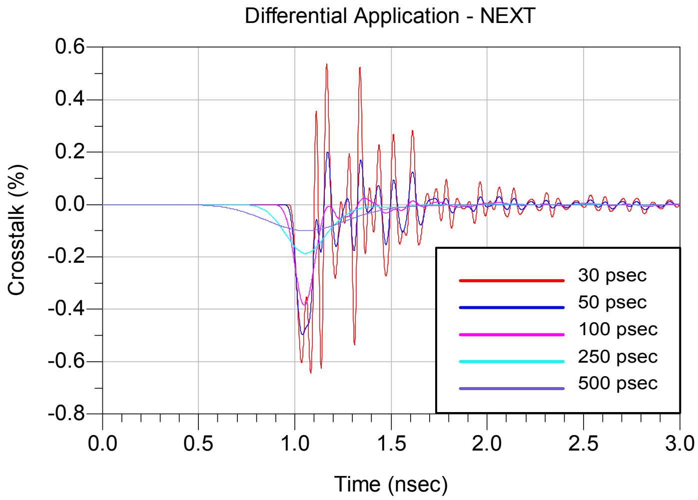
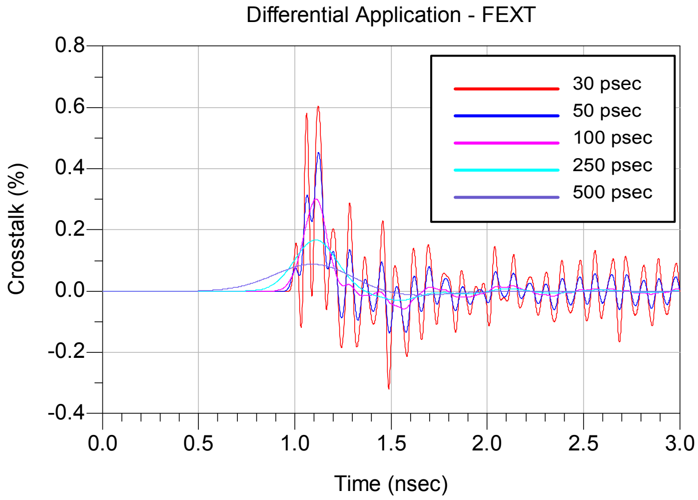
Differential Application – NEXT, Across Row Case



Differential Application – FEXT, Across Row Case



Appendix C – Product and Test System Descriptions

Product Description

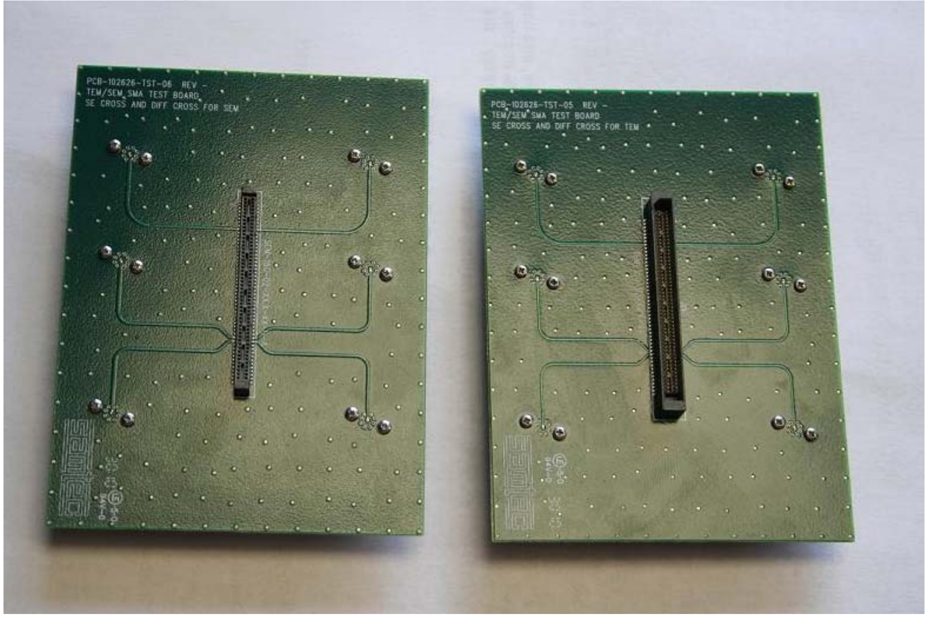
Product test samples are 6mm (0.236”) stack height TEM/SEM Series connectors. The part numbers are TEM-150-02-03.0-H-A and SEM-150-02-03.0-H-A. The TEM/SEM Series connector are surface mount products. The SEM Series socket uses a Tiger Eye™ contact system. Each connector has two rows of contacts evenly spaced on a 0.8mm (0.0315) 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. Six test fixtures are specific to the 6mm TEM/SEM Series connector set and identified by part numbers PCB-102626-TST-01 to PCB-102626-06. Calibration standards specific to the TEM/SEM Series are located on the calibration board PCB-102626-TST-23. To keep trace lengths short, three different test board sets were required to access the necessary signal pins.

PCB-102626-TST –XX Test Fixtures

Shown below is a photograph of one of the three test board sets.



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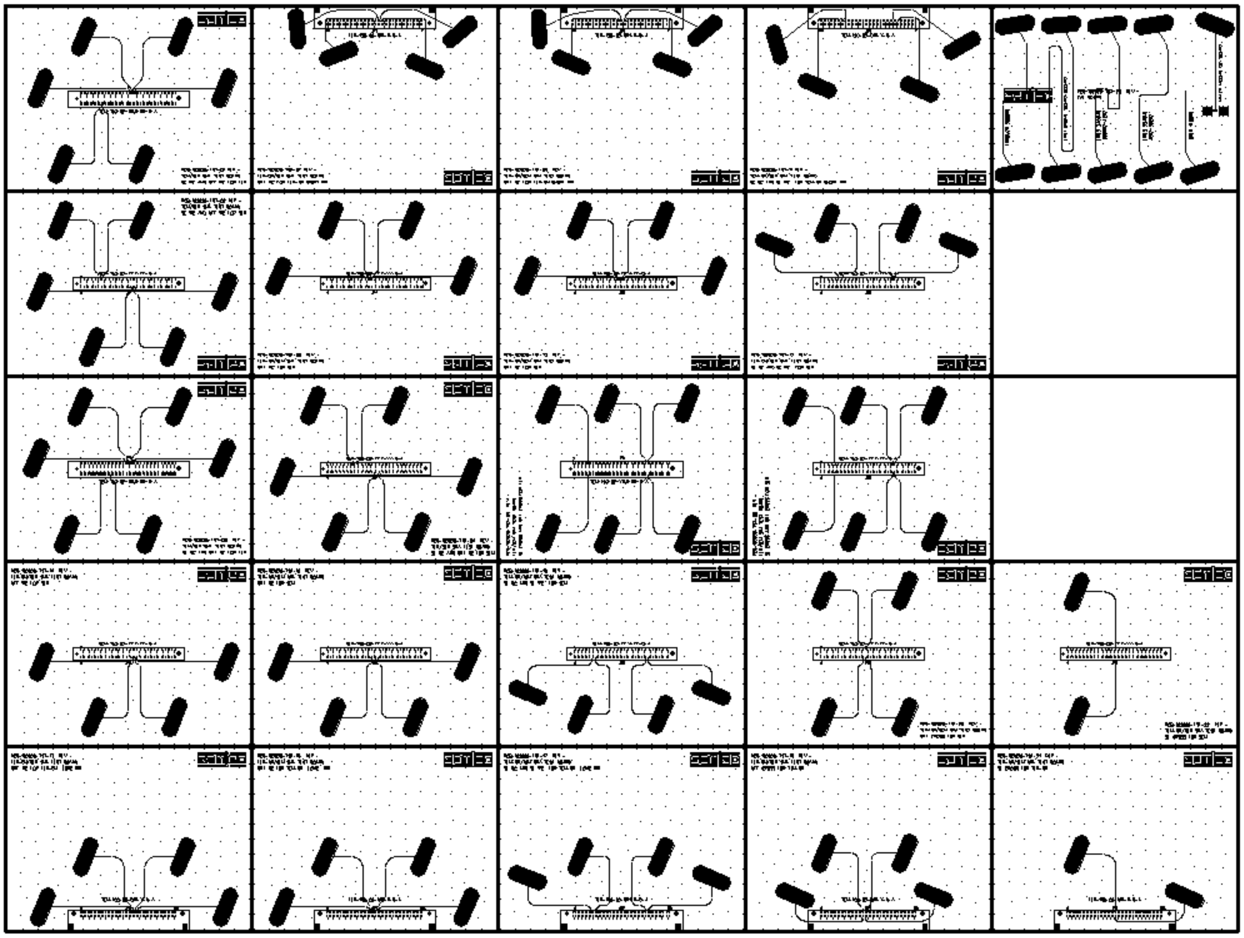
PCB-102626-TST-XX PCB Layout Panel

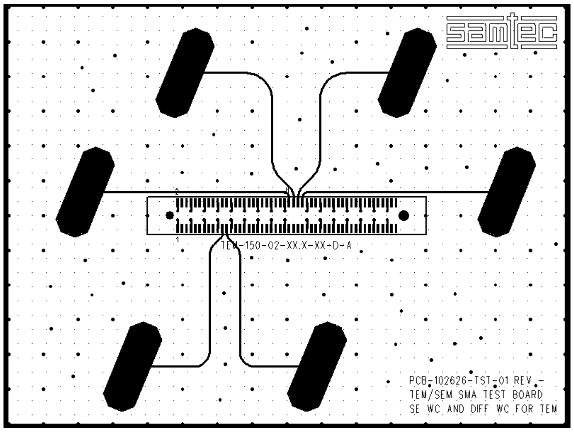
Artwork of the PCB design is shown below. Additional boards for the right angle version of the TEM Series header are included which is why there are 22 individual test boards on the panel rather than the 6 used in this report for the 6mm vertical TEM/SEM Series mated set.

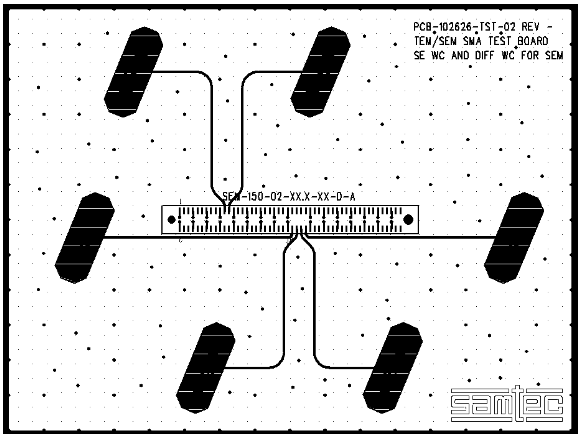


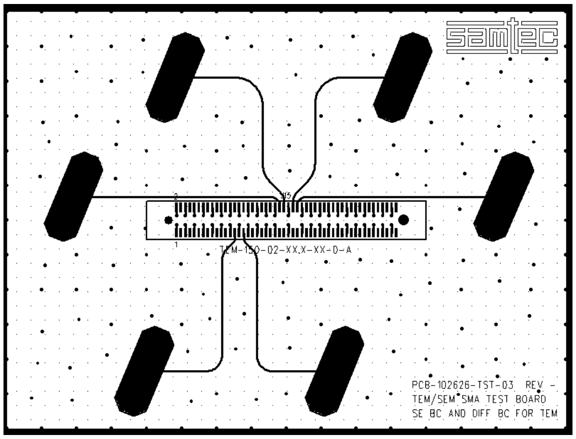
PCB Fixtures

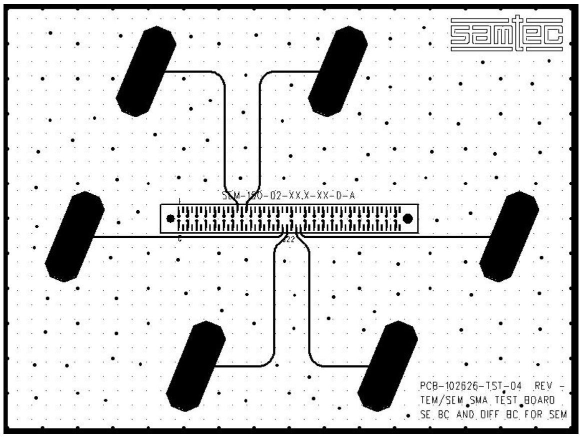
The test fixtures used are as follows:

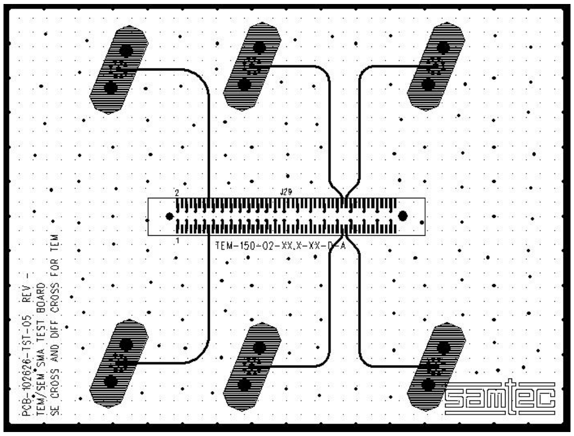
PCB-102626-TST-01 Rev – TEM Series Test Board for worst-case crosstalk
PCB-102626-TST-02 Rev – SEM Series Test Board for worst-case crosstalk
PCB-102626-TST-03 Rev – TEM Series Test Board for best-case crosstalk
PCB-102626-TST-04 Rev – SEM Series Test Board for best-case crosstalk
PCB-102626-TST-05 Rev – TEM Series Test Board for cross row crosstalk
PCB-102626-TST-06 Rev – SEM Series Test Board for cross row crosstalk

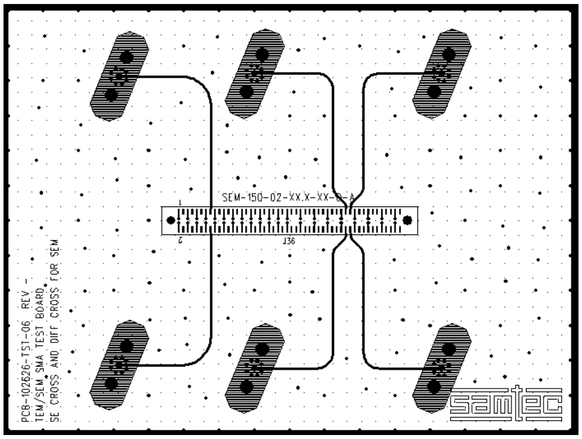








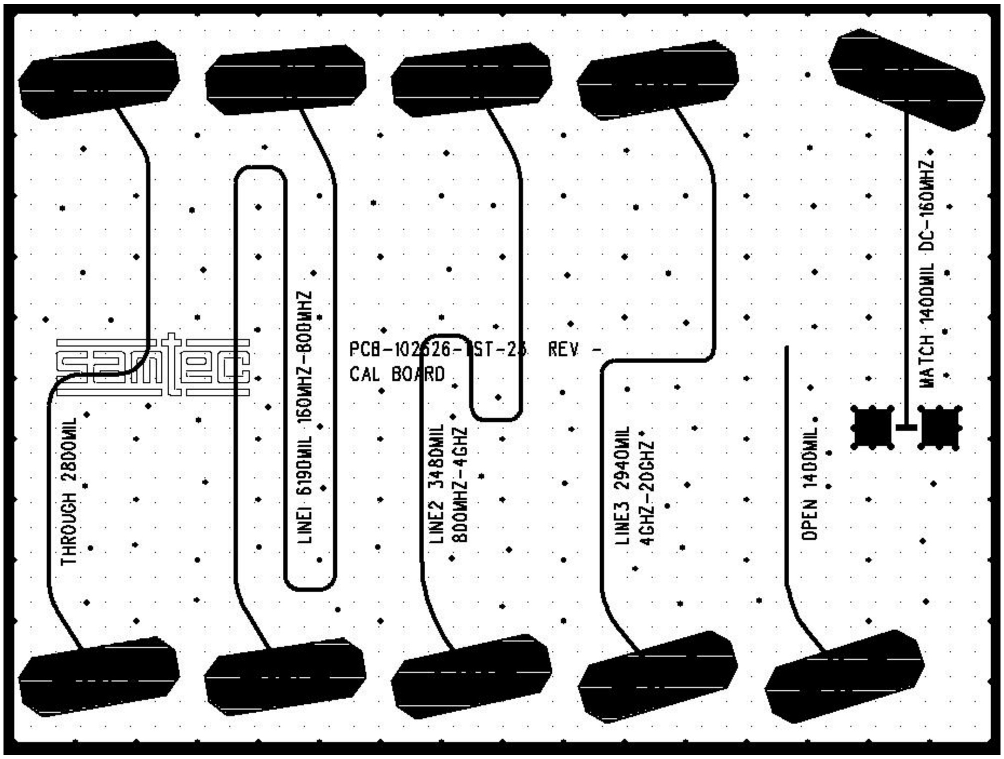

J29
TEM-150-02-XX.X-XX-D-A
PCB-102626-TST-05 REV -
TEM/SEM SMA TEST BOARD
SE CROSS AND DIFF CROSS FOR TEM


SEM-150-02-XX.X-XX-D-A
J36
PCB-102626-TST-06 REV -
TEM/SEM SMA TEST BOARD
SE CROSS AND DIFF CROSS FOR SEM

Series: TEM/SEM
Description: Micro Tiger Eye™ Board-to-Board 0.8mm Pitch, 6 mm (0.236”) stack height

Calibration Board

Test fixture losses and test point reflections were removed from the data by use of TRL calibration. The calibration board is shown below. Prior to making any measurements, the calibration board is characterized to obtain parameters required to define the calibration kit. Once a cal kit is defined, calibration using the standards on the calibration board can be performed. Finally, the device can be measured and the test board effects are automatically removed.



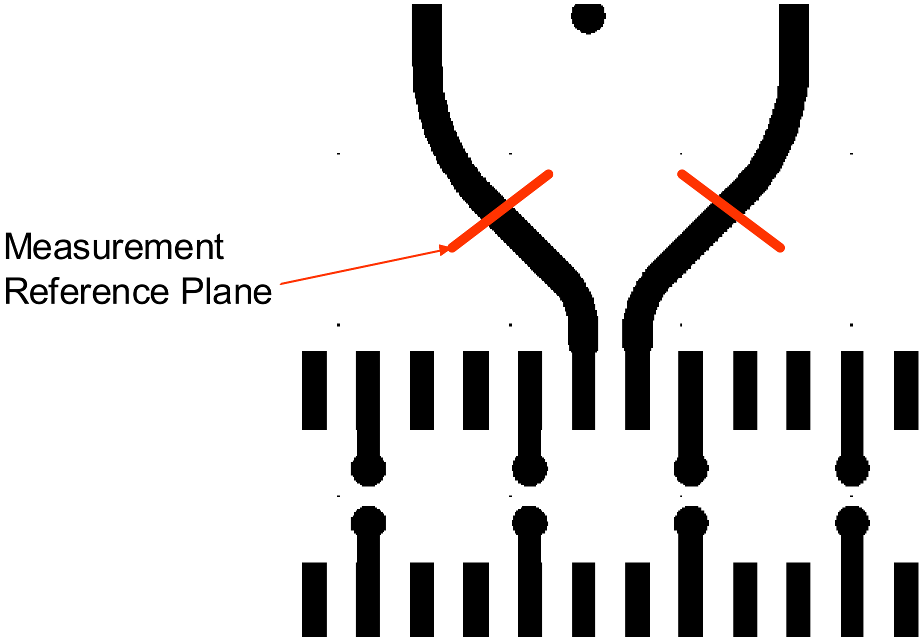
Thru line – 2800 mils
Open Reflect – 1400 mils
Line 1 – 6190 mils
Line 2 – 3480 mils
Line 3 – 2940 mils
Match – 1400 mils

Series: TEM/SEM
Description: Micro Tiger Eye™ Board-to-Board 0.8mm Pitch, 6 mm (0.236”) stack height

All traces on the test boards are length matched to 1.48”. The TRL calibration effectively removes 1.4” of test board trace effects. This means that 80 mils of test board trace length effects are include in the measurement. The S-Parameter measurement includes:

A- The TEM/SEM Series connector set
B- test board vias, pads (footprint effects)
C- 80 mils of 17 mil wide microstrip trace.

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



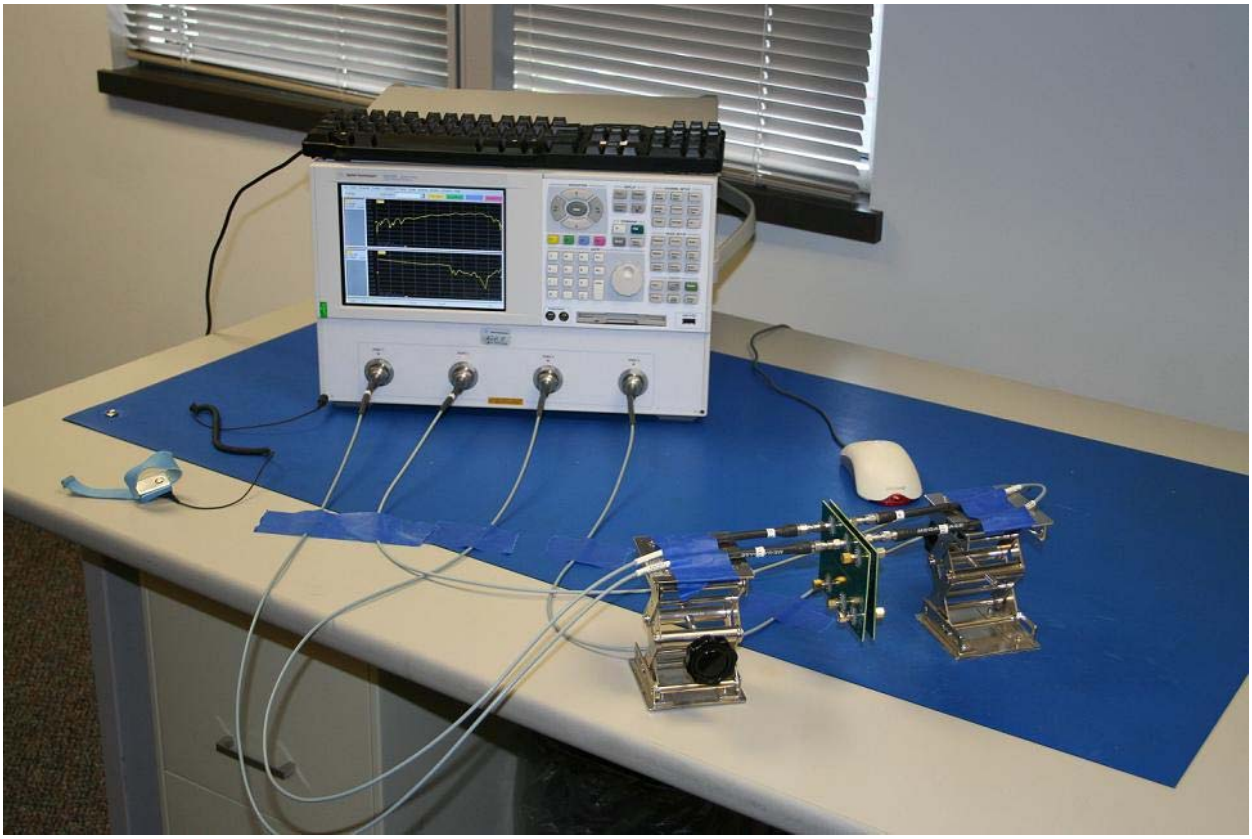
Appendix D – Test and Measurement Setup

The test instrument is the Agilent N5230A 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 Agilent ADS. The network analyzer is configured as follows:

Start Frequency – 300 KHz
Stop Frequency – 20 GHz
Number of points -1601
IFBW – 1 KHz

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

N5230A Measurement Setup



Test Instruments

QTY	Description
1	Agilent N5230A PNA-L Network Analyzer (300 KHz to 20 GHz)
1	Agilent N4433A ecal module (300 KHz to 20 GHz)

Test Cables & Adapters

QTY	Description
4	Megaphase CM40 (DC-40 GHz)

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 LRM calibration standards, the SI test boards, and the selection of the PCB vendor.

The measurement process begins with a measurement of the LRM calibration standards. A coaxial SOLT calibration is performed using an N4433A ecal module. This measurement is required in order to obtain precise values of the line standard offset delay and frequency bandwidths. Measurements of the reflect and 2x through line standard can be used to determine the maximum frequency for which the calibration standards are valid. For the TEM Series test boards, this is greater than 20 GHz.

From the LRM calibration standard measurements, a user defined calibration kit is developed and stored in the network analyzer. Calibration is then performed on all 4 ports following the calibration wizard within the Agilent N5230. This calibration is saved and can be recalled at any time. Calibration takes roughly 30 minutes to perform.

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 Agilent ADS 2009 update 1. This tool has a transient convolution simulator that 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

Impedance (TDR)
A step pulse is applied to the touchstone model of the connector and the reflected voltage is monitored. The reflected voltage is converted to a reflection coefficient and then transformed into an impedance profile. All ports of the Touchstone model are terminated in 50 ohms.

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.

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
EC6 – Edge Card with a .635mm signal pad pitch
FD – Frequency domain
FEXT – Far-End Crosstalk
GSG – Ground–Signal-Ground; geometric configuration
GSSG - Ground–Signal-Signal-Ground; geometric configuration
HDV – High Density Vertical
LEC6 – Signal Launch Edge Card with a .635 mm signal pad pitch
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)