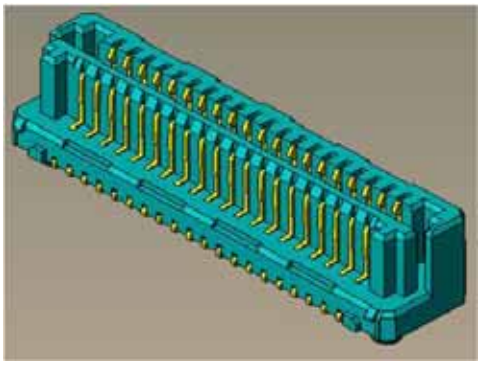
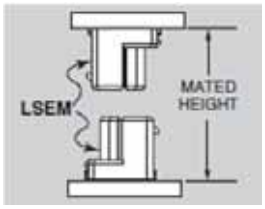
High Speed Characterization Report

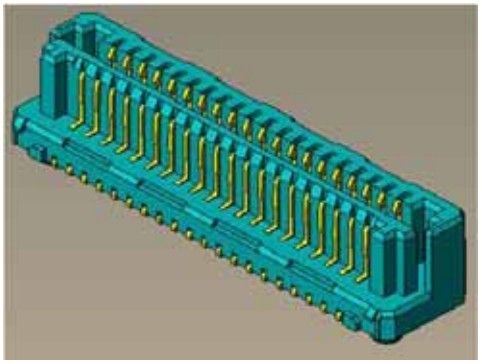
LSEM-150-03.0-L-DV-A-N-TR





Mates with

LSEM-150-03.0-L-DV-A-N-TR



Description:

High Speed Hermaphroditic Strip
Vertical Surface Mount, 0.8mm (.0315") Centerline,
6.0mm Board-to-Board Stack Height

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: 3/16/2012

Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

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Connector Overview

Samtec’s High Speed Hermaphroditic interconnect is a self-mating system ideal for rugged applications. The system is polarized and fully shrouded when mated. LSEM is a double row contacts system available in 20, 30, 40, and 50 contacts per row. Stack heights available are 6mm through 10mm at 1mm increments. 12mm is the largest stack height available. The data in this report is applicable only to a 6mm stack height.

Connector System Speed Rating

High Speed LSEM Hermaphrodictic, Board-to-Board,0.8mm (.0135”) Pitch, 6mm (0.2362”) Stack Height

Case	Signaling	Speed Rating
1	Single-Ended:	**9.5 GHz/ 19Gbps**
	Differential:	**12.5 GHz/ 25Gbps**

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			
Case	**Test Parameter**	**Configuration**	
1	**Insertion Loss**	GSG	3dB @ 9.513 GHz
	Return Loss	GSG	>10dB to 8.150 GHz
	Near-End Crosstalk	GAQG	< -20dB to 0.863 GHz
		GAGQG	< -20dB to 20.000 GHz
		Xrow, GAG to GQG	< -20dB to 9.188 GHz
	Far-End Crosstalk	GAQG	< -20dB to 5.500 GHz
		GAGQG	< -20dB to 9.388 GHz
		Xrow, GAG to GQG	< -20dB to 9.175 GHz

Table 2 - Differential Connector System Performance			
Case	**Test Parameter**	**Configuration**	
1	**Insertion Loss**	GSSG	3dB @ 12.125 GHz
	Return Loss	GSSG	>10dB to 8.563 GHz
	Near-End Crosstalk	GAAQQG	< -20dB to 20.000 GHz
		GAAGQQG	< -20dB to 20.000 GHz
		Xrow, GAAG to GQQG	< -20dB to 20.000 GHz
	Far-End Crosstalk	GAAQQG	< -20dB to 20.000 GHz
		GAAGQQG	< -20dB to 20.000 GHz
		Xrow, GAAG to GQQG	< -20dB to 15.500 GHz

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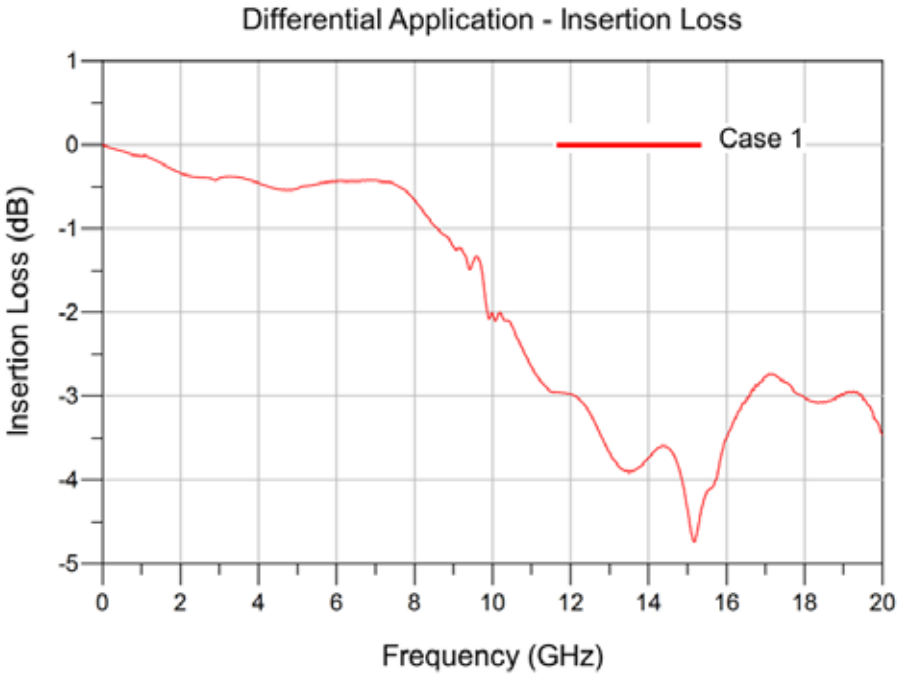
Bandwidth Chart – Single-Ended & Differential Insertion Loss

LSEM Hermaphrodictic Series



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Time Domain Data Summary

Table 3 – Single-End Impedance (Ω)						
Case	**Signal Risetime**	**30 ps**	**50 ps**	**100 ps**	**250 ps**	**500 ps**
1	**Maximum Impedance**	62.3	56.7	51.8	51.1	50.4
	Minimum Impedance	41.3	45.8	48.9	49.8	48.9

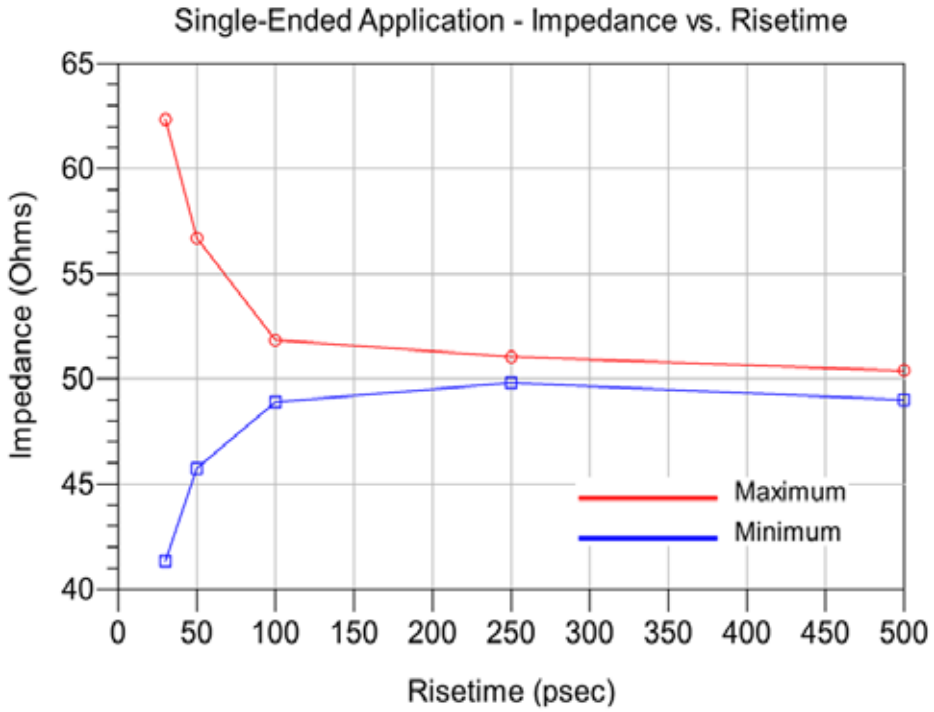

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Table 4 - Differential Impedance (Ω)						
Case	**Signal Risetime**	**30 ps**	**50 ps**	**100 ps**	**250 ps**	**500 ps**
1	**Maximum Impedance**	127.1	109.8	104.3	103.0	101.5
	Minimum Impedance	62.7	65.9	74.8	87.3	93.5
2	**Maximum Impedance**	127.0	110.1	104.3	103.0	101.5
	Minimum Impedance	62.8	66.2	75.0	87.4	93.6

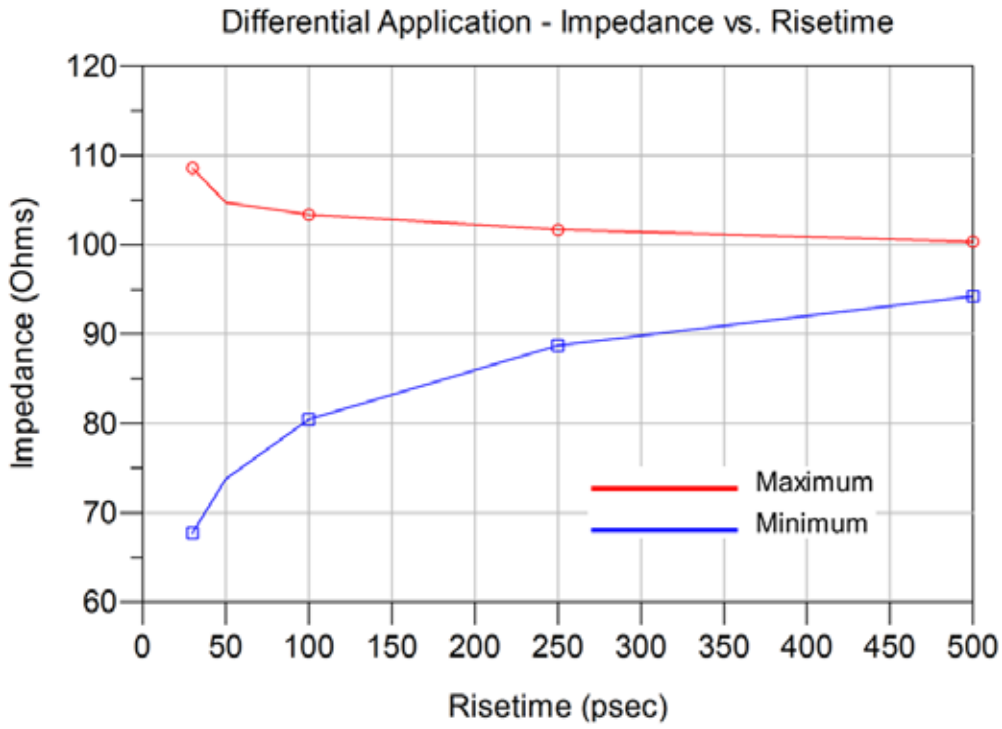

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Table 5 - Single-Ended Crosstalk (%)							
Case	**Input(tr)**		**30ps**	**50 ps**	**100 ps**	**250 ps**	**500 ps**
1	NEXT	GAQG	18.5	17.5	14.0	7.2	3.8
		GAGQG	3.0	2.5	1.9	1.0	0.5
		Xrow	3.5	2.9	2.0	1.0	0.5
	FEXT	GAQG	5.9	4.3	2.7	1.2	0.7
		GAGQG	4.4	2.9	1.4	0.5	0.2
		Xrow	3.2	1.5	0.4	0.2	0.1

Table 6 - Differential Crosstalk (%)							
Case	**Input(tr)**		**30ps**	**50 ps**	**100 ps**	**250 ps**	**500 ps**
1	NEXT	GAAQQG	5.3	5.0	4.2	2.3	1.3
		GAAGQQG	0.6	0.5	0.3	0.2	0.1
		Xrow	0.9	0.7	0.5	0.2	0.1
	FEXT	GAAQQG	1.1	0.9	0.7	0.3	0.2
		GAAGQQG	1.1	0.8	0.4	0.1	<0.1
		Xrow	0.5	0.3	0.1	<0.1	<0.1

Table 7 - Propagation Delay (Mated Connector)		
Case 1	**Single-Ended**	90 ps
	Differential	88 ps

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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. 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.

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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 case": GAG to GQG (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 case": GAAG to GQQG (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. 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 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.

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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 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 80 mils of PCB trace on the TEM-DH connector side and 77.5 mils of PCB trace on the SEM connector side. Delay is measured at 30 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.

Series: LSEM
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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.

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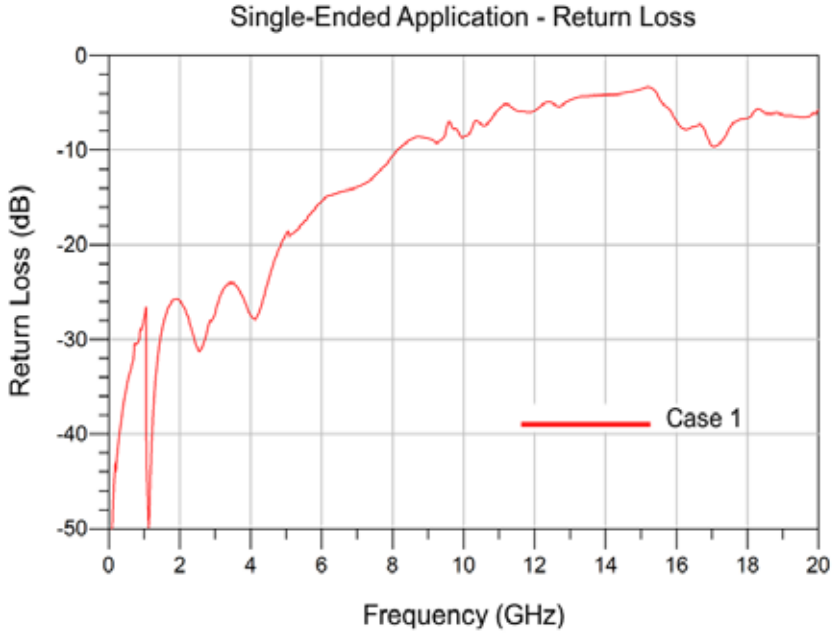
Appendix A – Frequency Domain Response Graphs

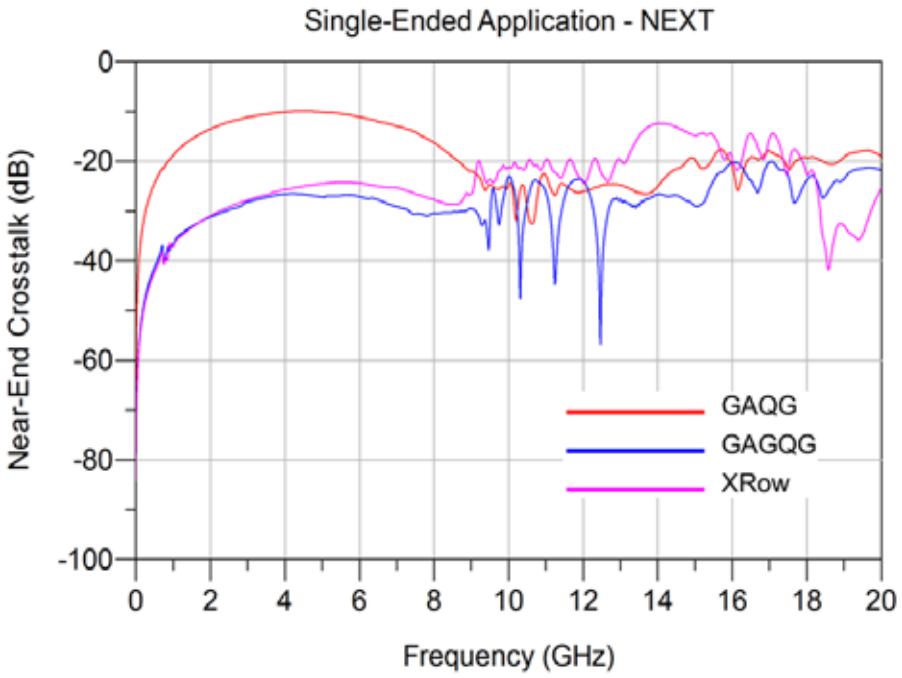
Single-Ended Application – Insertion Loss

Single-Ended Application – Return Loss

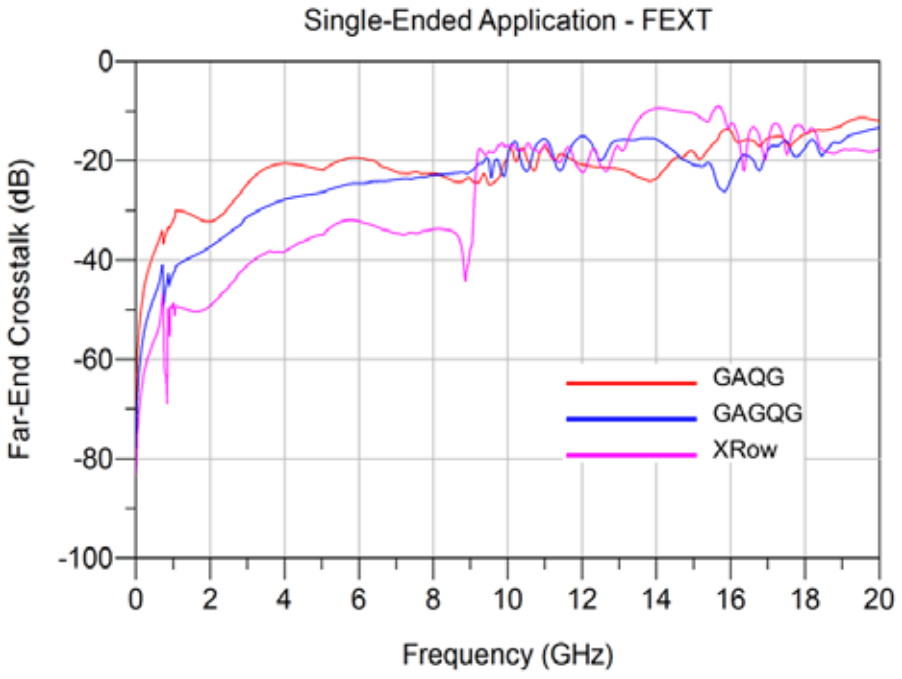


Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

Single-Ended Application – NEXT Configurations

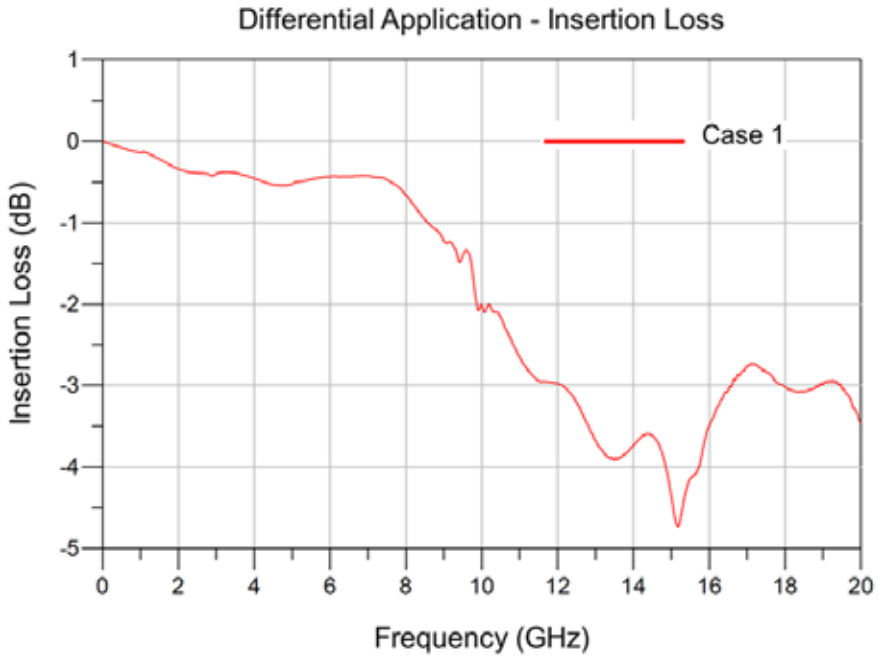


Single-Ended Application – FEXT Configurations

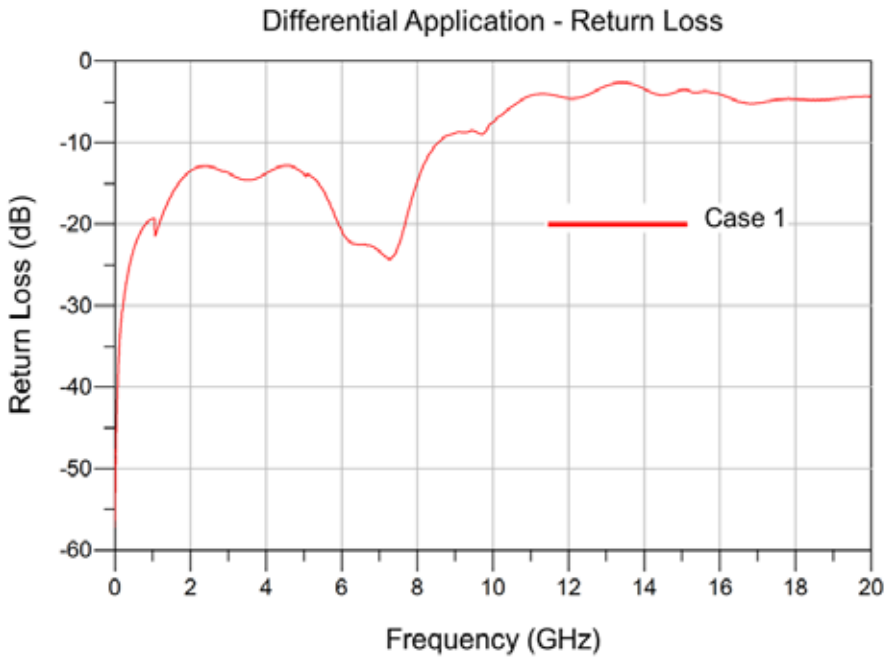


Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

Differential Application – Insertion Loss

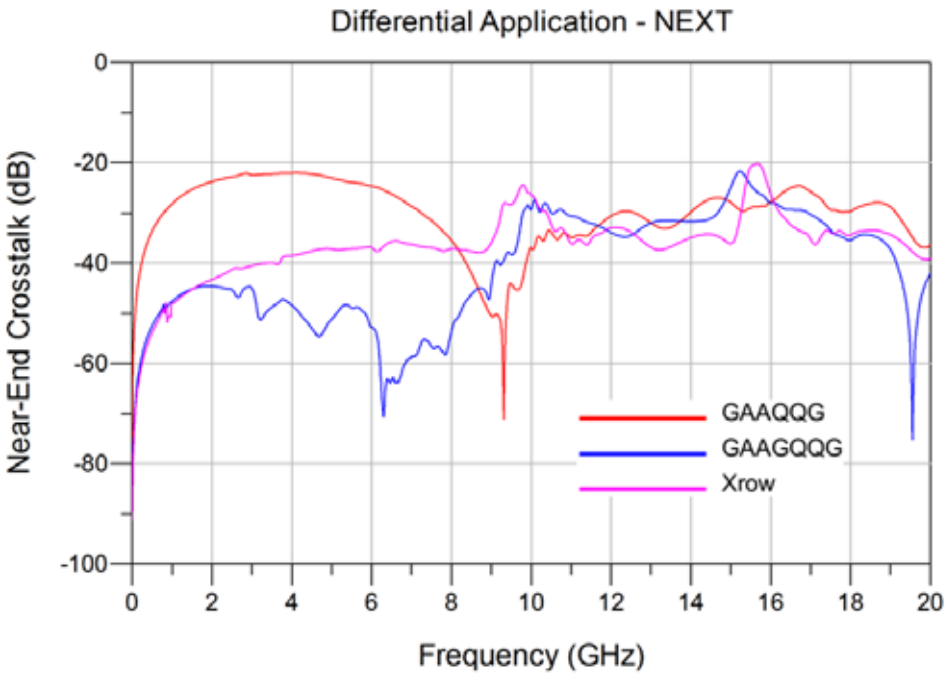


Differential Application – Return Loss

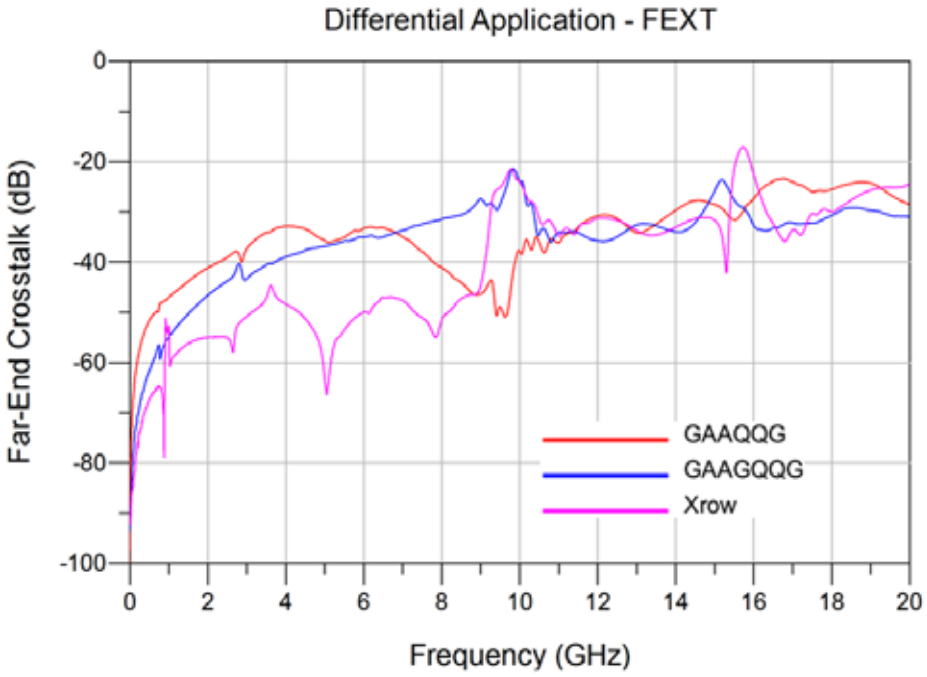


Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

Differential Application – NEXT Configurations



Differential Application – FEXT Configurations



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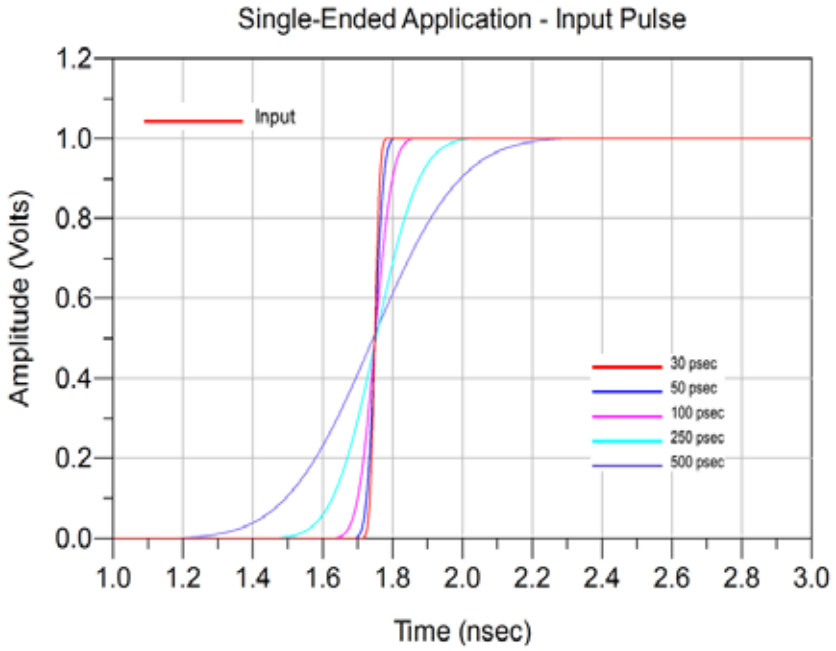
Appendix B – Time Domain Response Graphs

Single-Ended Application – Input Pulse



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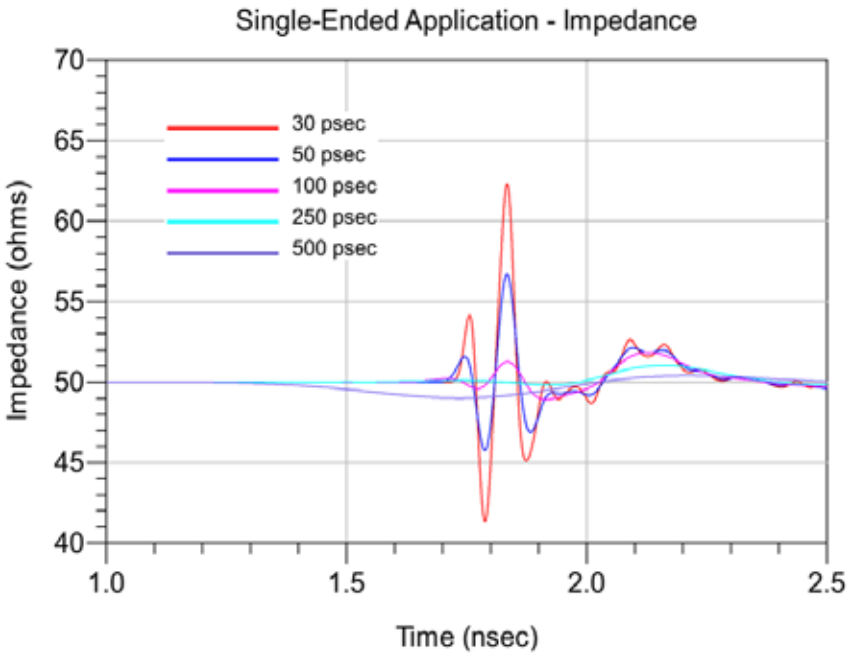
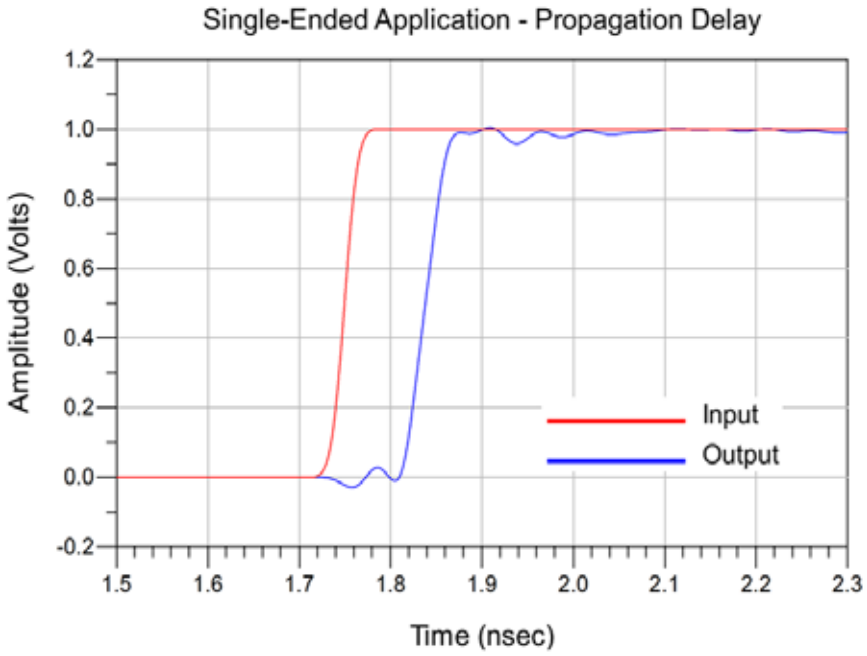
Single-Ended Application – Impedance



Single-Ended Application – Propagation Delay



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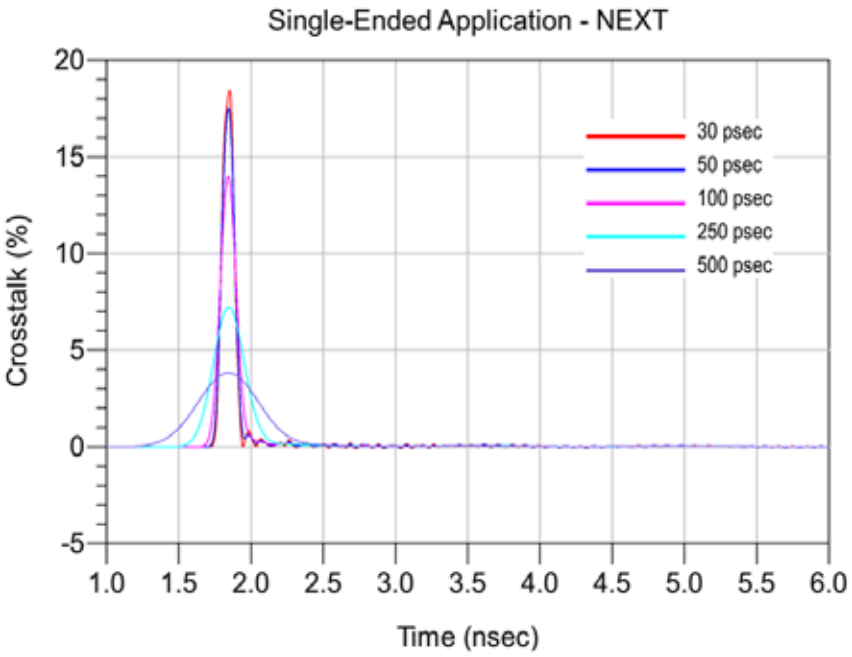
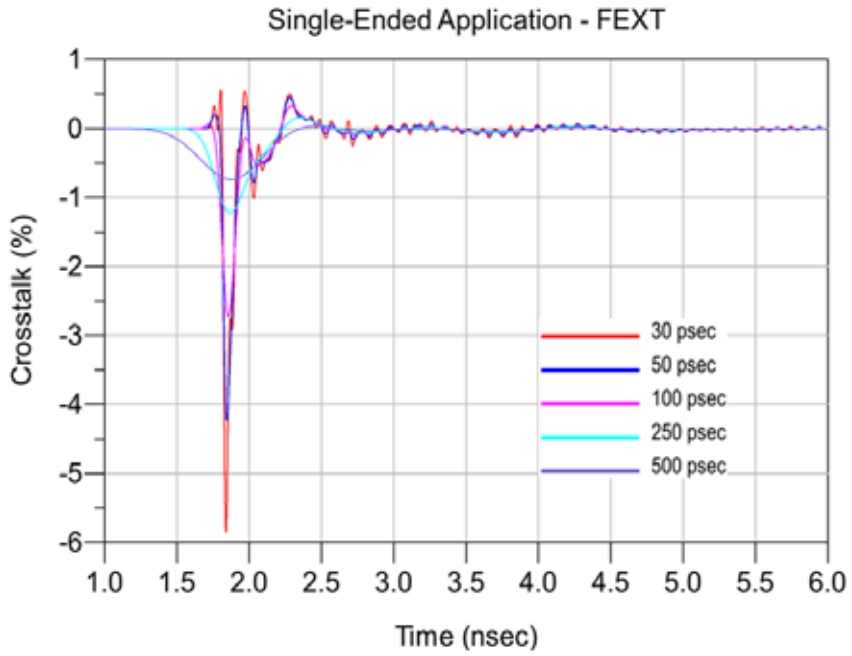
Single-Ended Application – NEXT, Worst Case Configuration

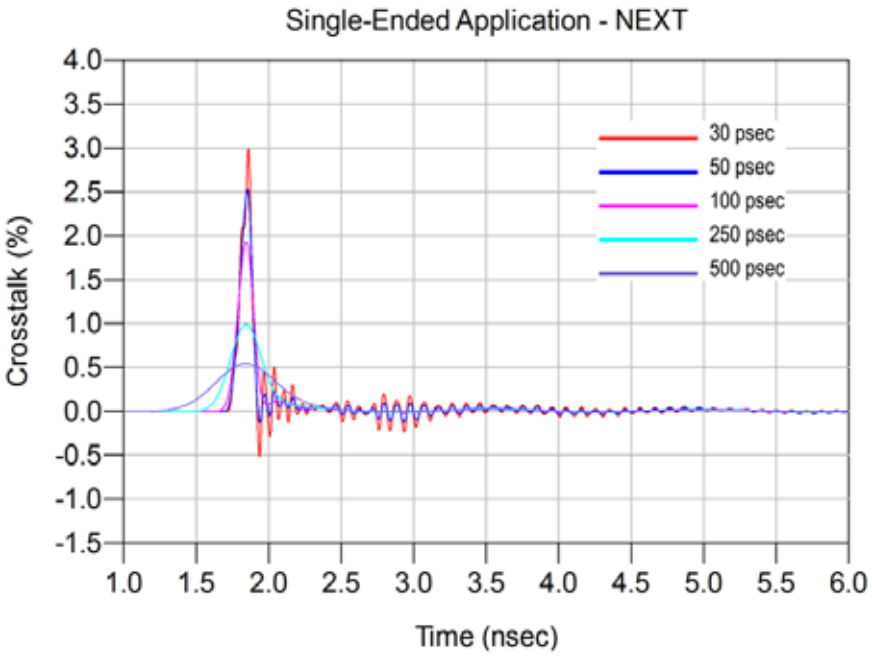


Single-Ended Application – FEXT, Worst Case Configuration

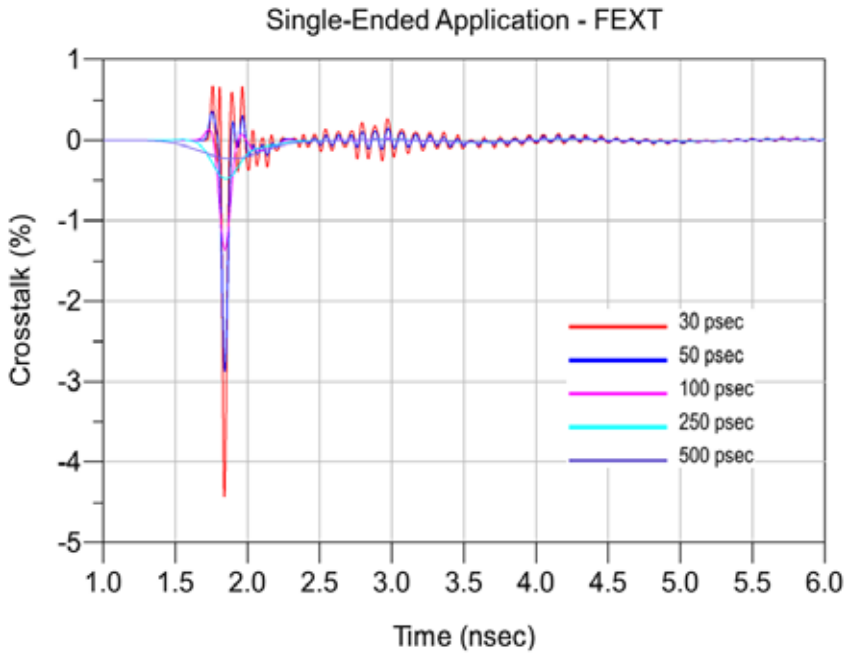


Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

Single-Ended Application – NEXT, Best Case Configuration

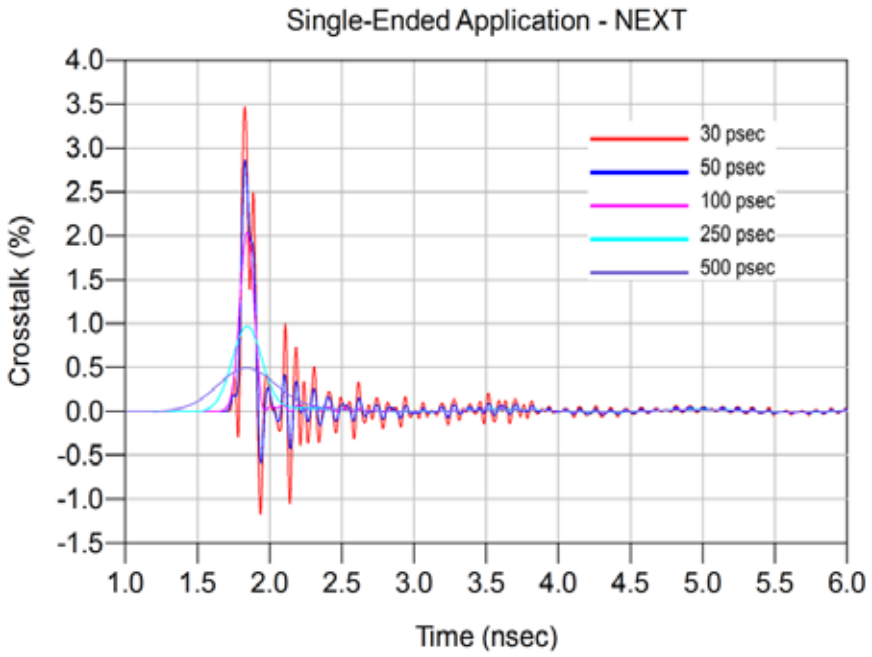


Single-Ended Application – FEXT, Best Case Configuration

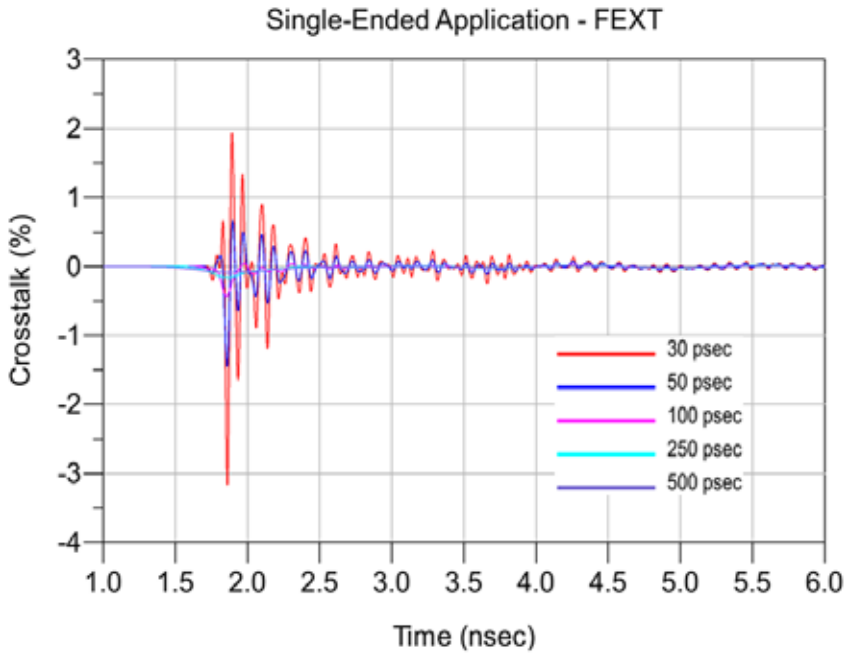


Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

Single-Ended Application – NEXT, Across Row Configuration



Single-Ended Application – FEXT, Across Row Configuration



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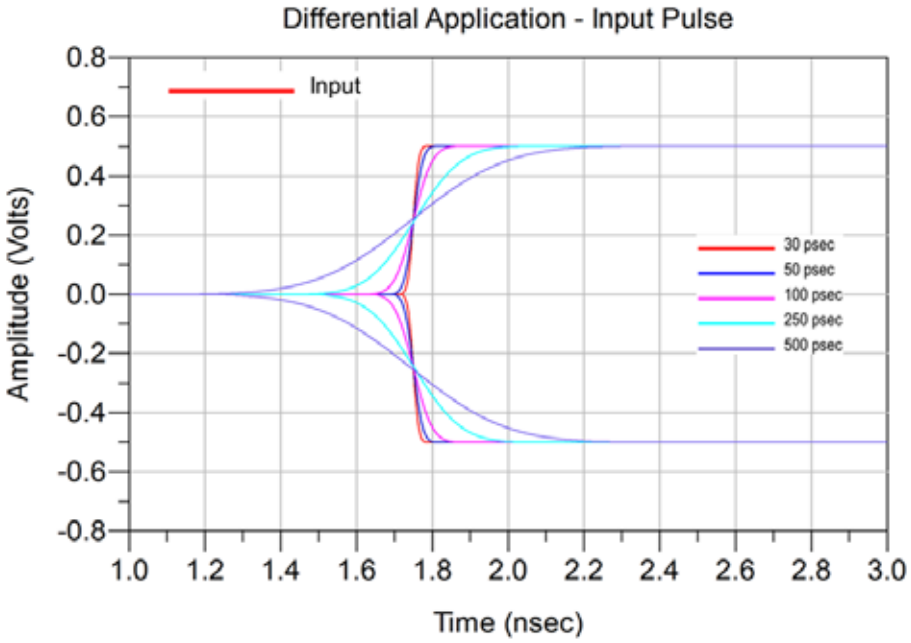
Differential Application – Input Pulse



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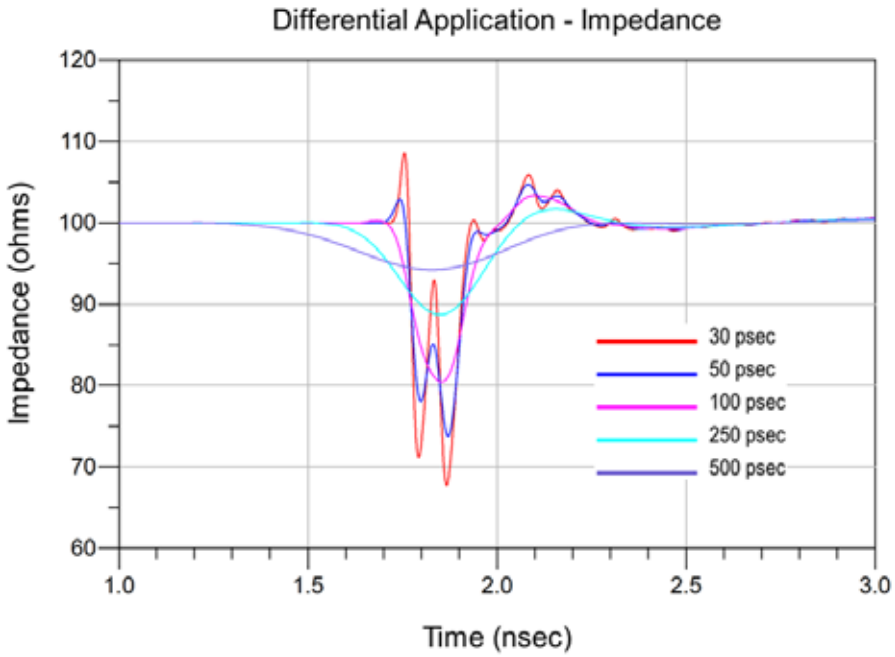
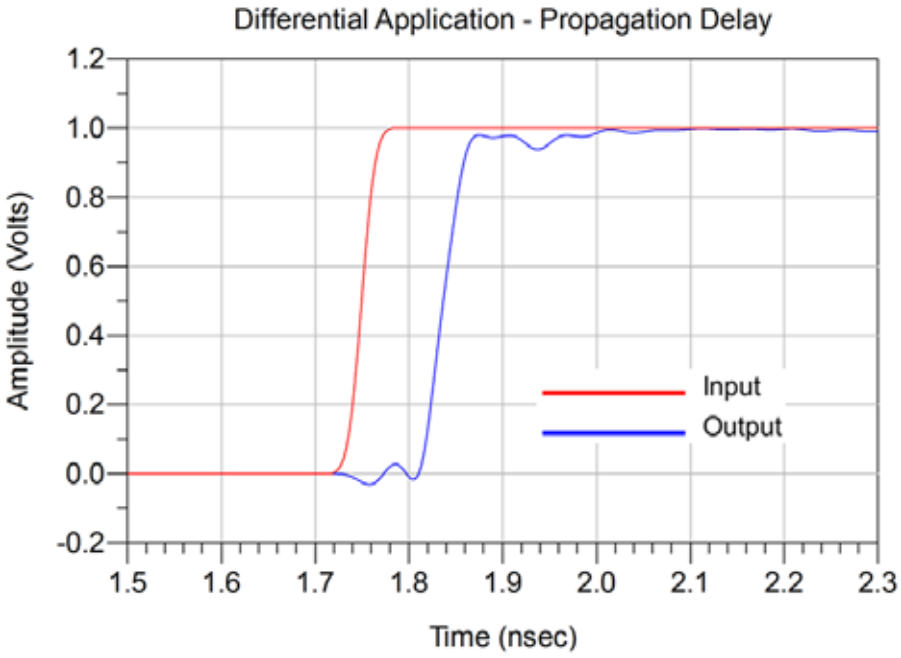
Differential Application – Impedance



Differential Application – Propagation Delay



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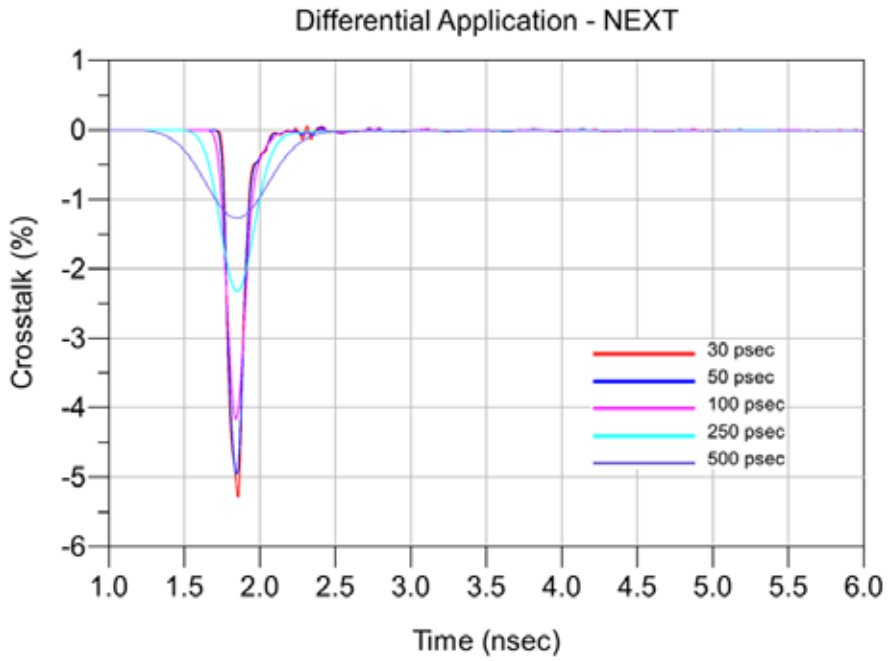
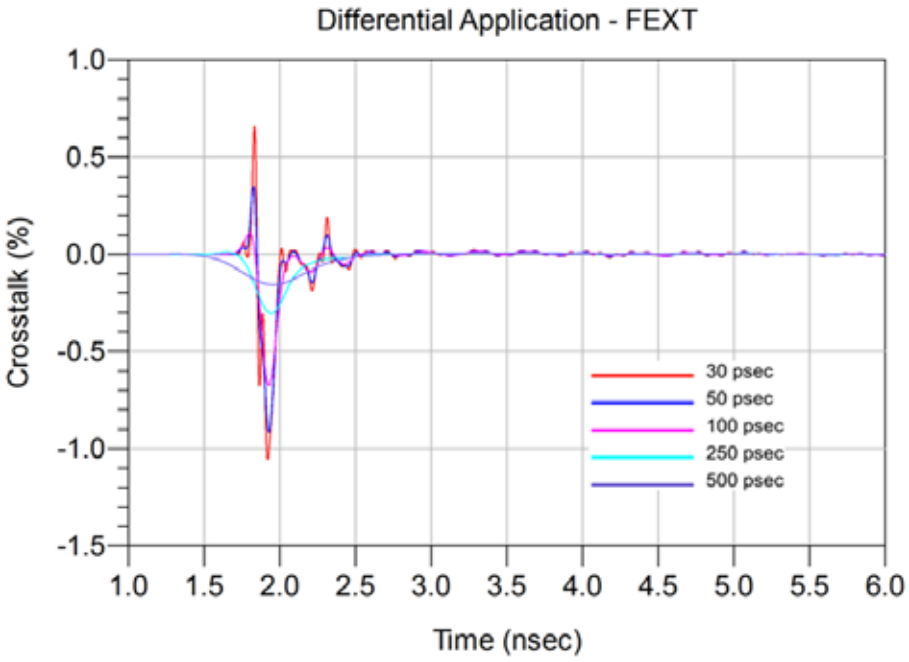
Differential Application – NEXT, Worst Case Configuration



Differential Application – FEXT, Worst Case Configuration



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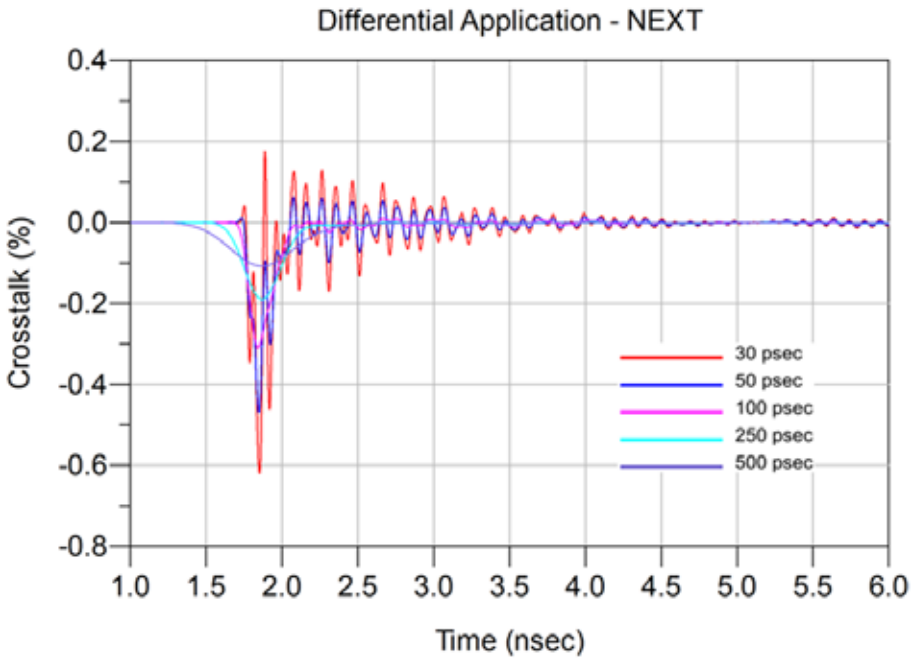
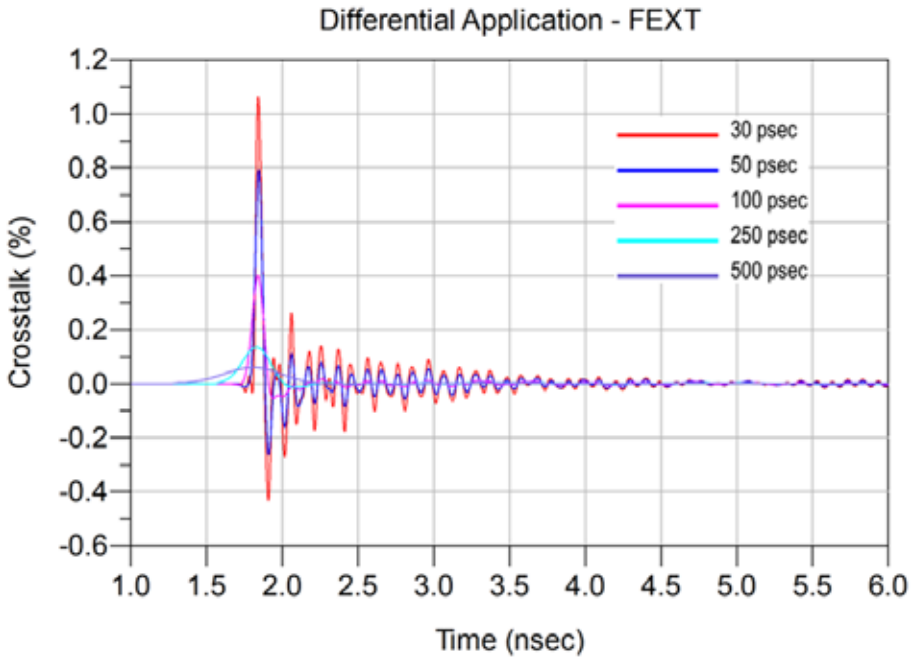
Differential Application – NEXT, Best Case Configuration

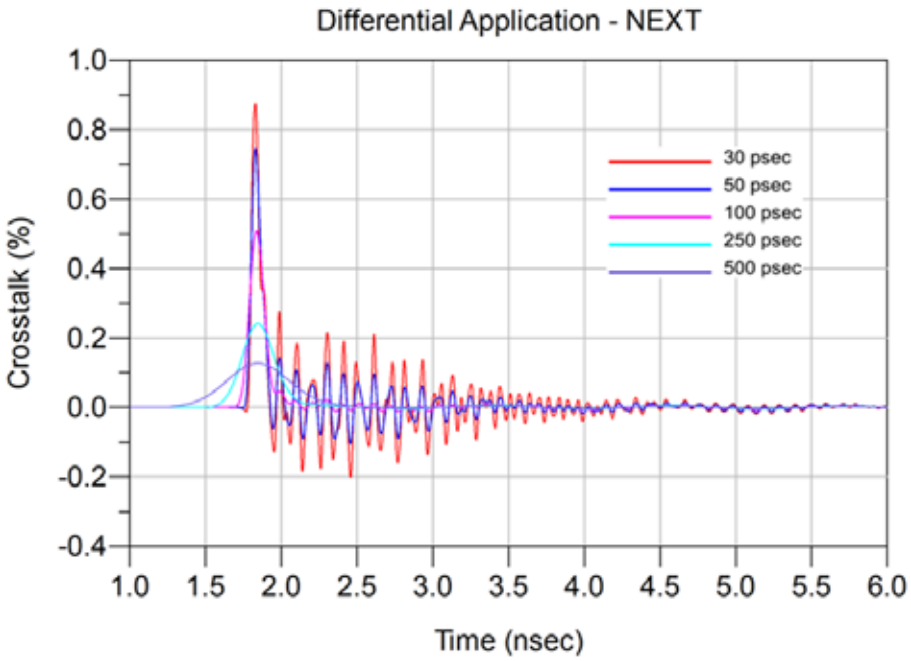


Differential Application – FEXT, Best Case Configuration

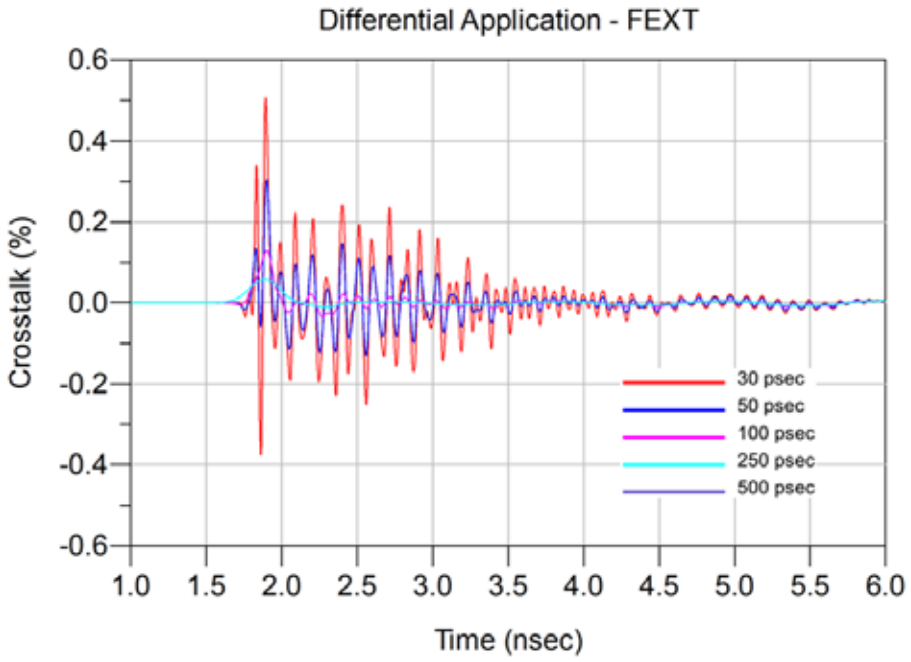


Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

Differential Application – NEXT, Across Row Case Configuration



Differential Application – FEXT, Across Row Case Configuration



Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

Appendix C – Product and Test System Descriptions

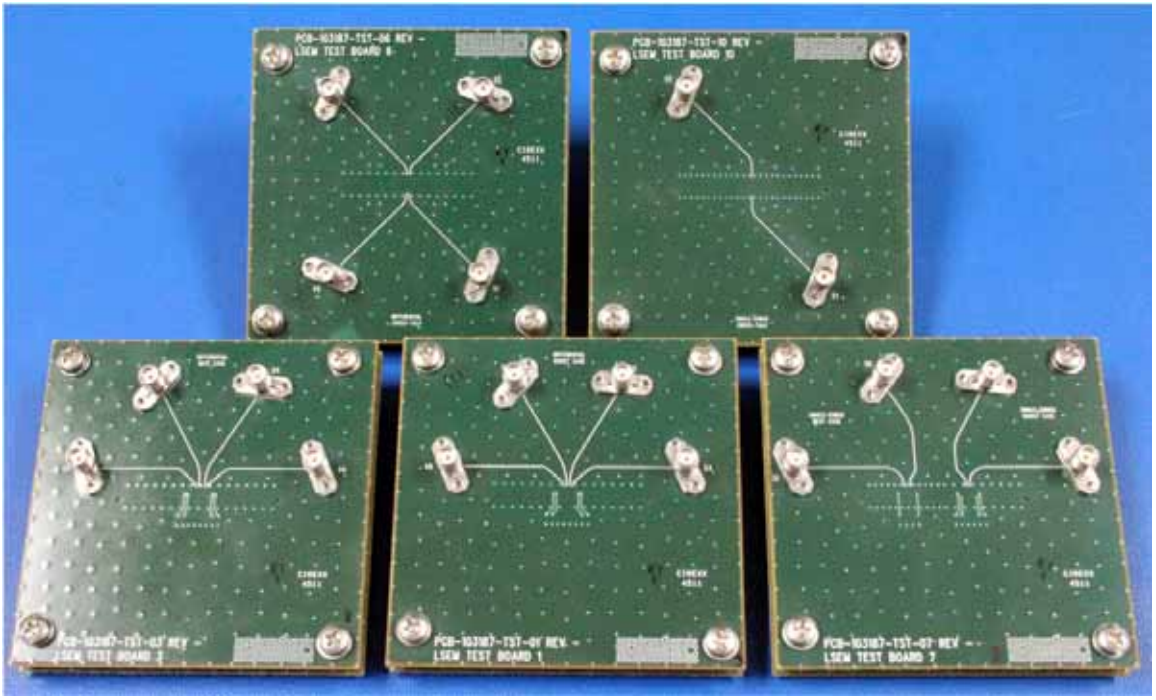
Product Description

Product test samples are High Speed Hermaphroditic LSEM Strip. The part number is LSEM-150-03.0-L-DV-A-N-TR and it mates to itself. The connector has two rows of 50 contacts evenly spaced on a 0.8 mm (0.0315”) pitch. A photo of the mated test article mounted to SI test boards is shown at right.

Test System Description

The test fixtures are composed of four-layer FR-406 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. SMA launch optimization is attained using full wave simulation tools to minimize reflections. There are 11 test fixtures specific to the LSEM series connector set. Ten of the 11 fixtures mate to comprise a full hi-speed characterization test The remaining board contains the SMA/LRM calibration structures designed specifically for the LSEM series. Displayed on the following pages is information for the SMA/LRM calibration structure and directives for mating LSEM fixtures.

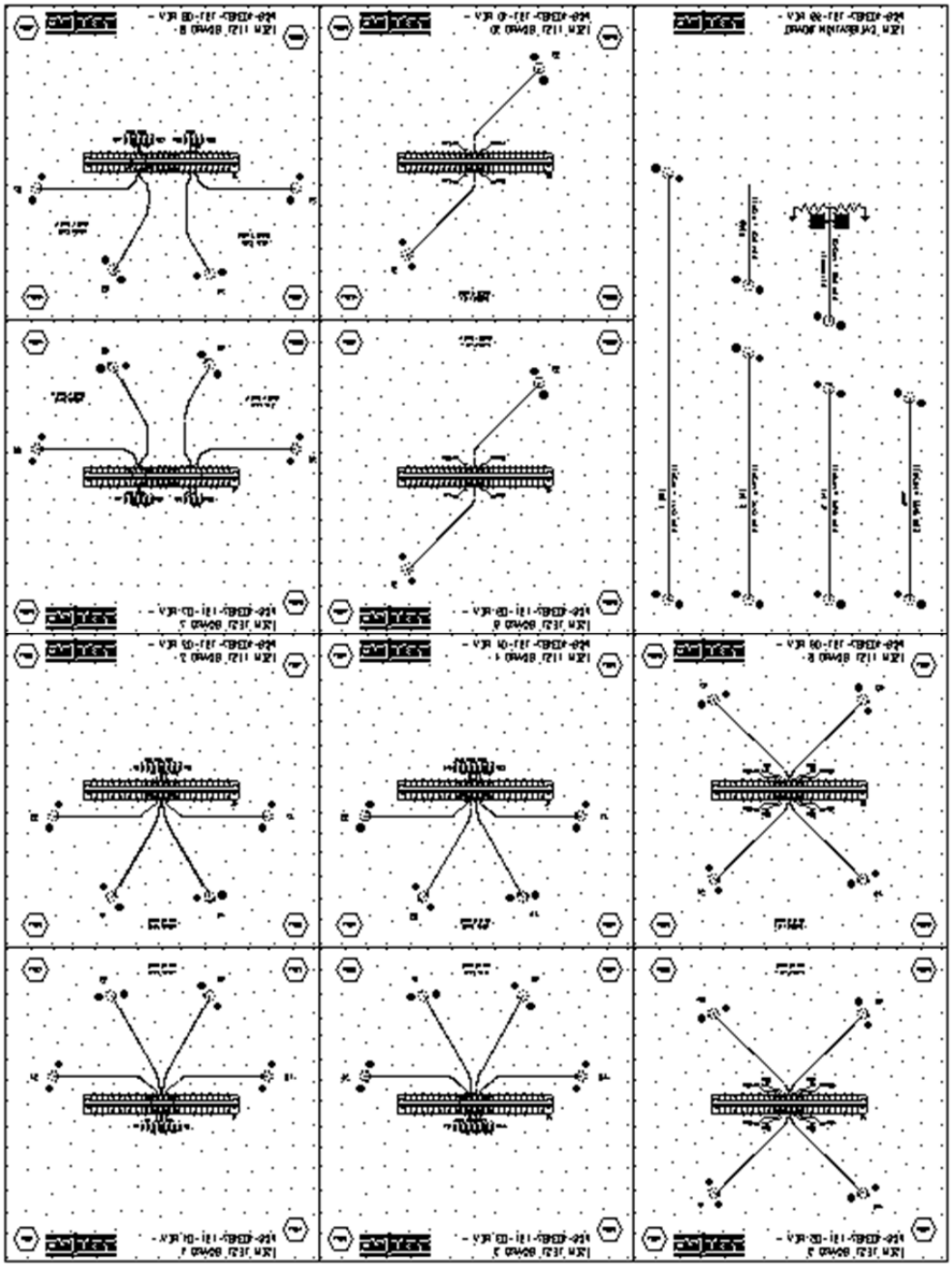
PCB-103187-TST-XX Test Fixtures



Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

PCB-103187-TST-XX PCB Layout Panel

PCB design artwork shown below.

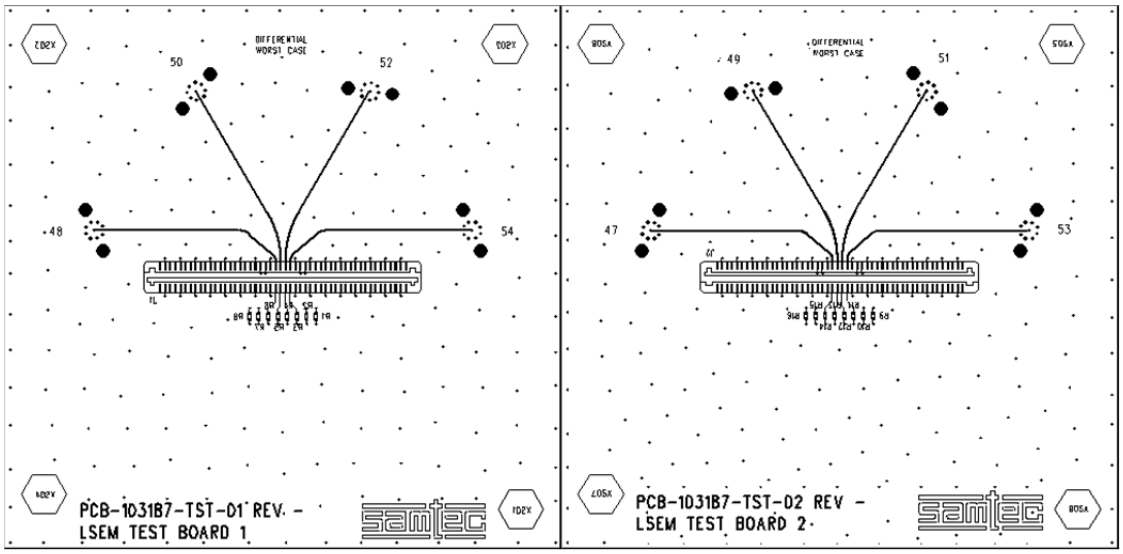


Series: LSEM
Description: Board-to-Board, 0.8mm (.0315") Pitch, , 6mm (0.2362") Stack Height

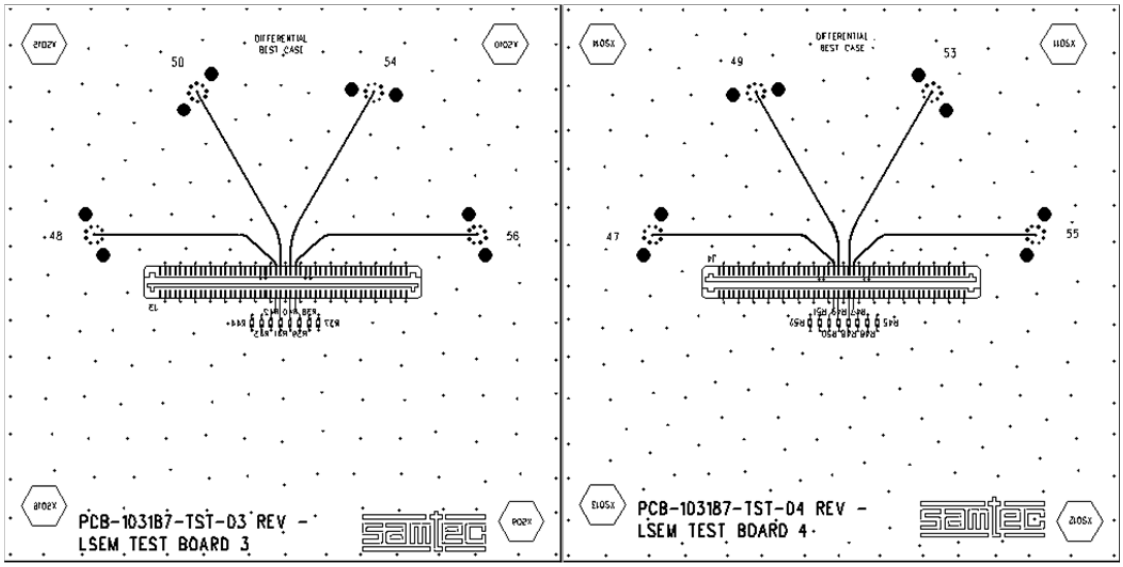
PCB Fixtures

The test fixtures used are as follows:

PCB-103187 -TST-01 Rev, LSEM Hermaphroditic *mates with* PCB-103187 -TST-02, Rev, LSEM Hermaphroditic, Differential Worst Case Configuration, Crosstalk Parameters



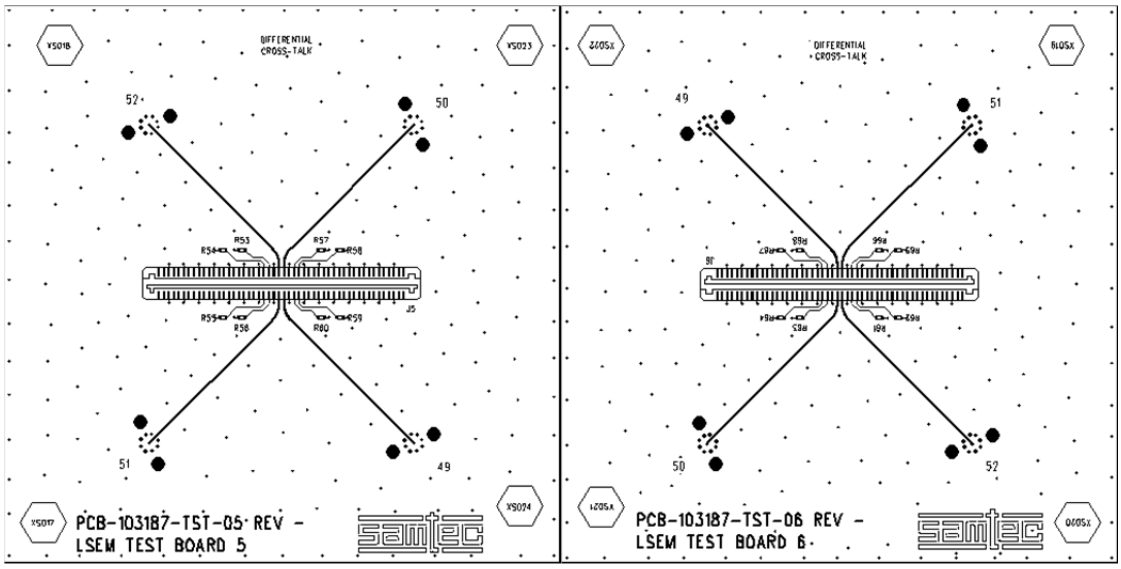
PCB-103187 -TST-03 Rev, LSEM Hermaphroditic *mates with* PCB-103187 -TST-04 Rev, LSEM Hermaphroditic, Differential Best Case Configuration, Transmission/Reflection Parameters, Crosstalk Parameters



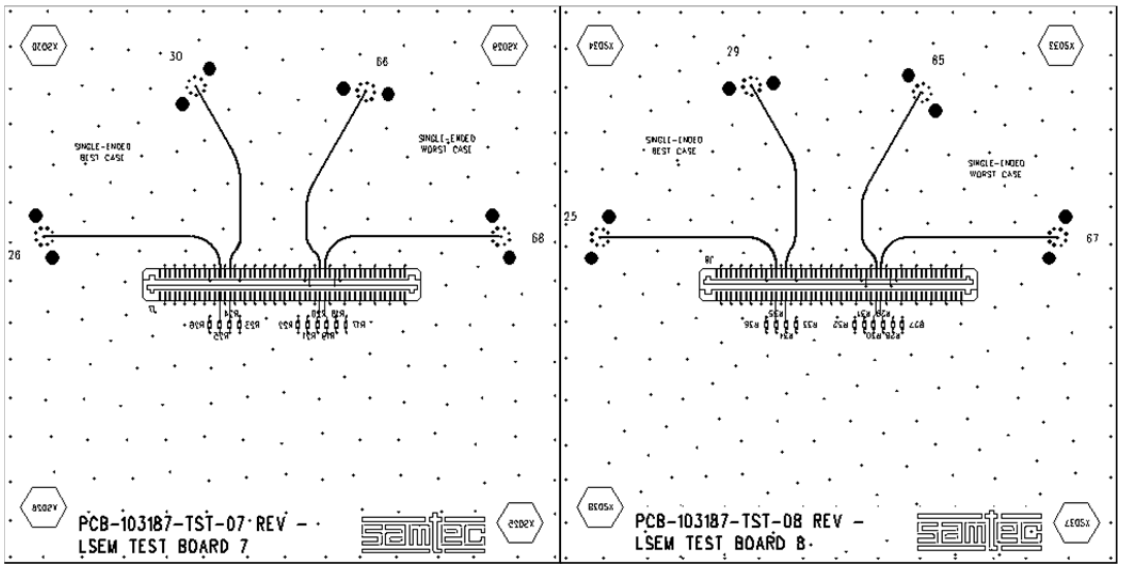
Series: LSEM
Description: Board-to-Board, 0.8mm (.0315") Pitch, , 6mm (0.2362") Stack Height

PCB Fixtures (Cont.)

PCB-103187 -TST-05 Rev, LSEM Hermaphroditic *mates with* PCB-103187 -TST-06 Rev, LSEM Hermaphroditic, Differential Across Row Configuration, Crosstalk Parameters



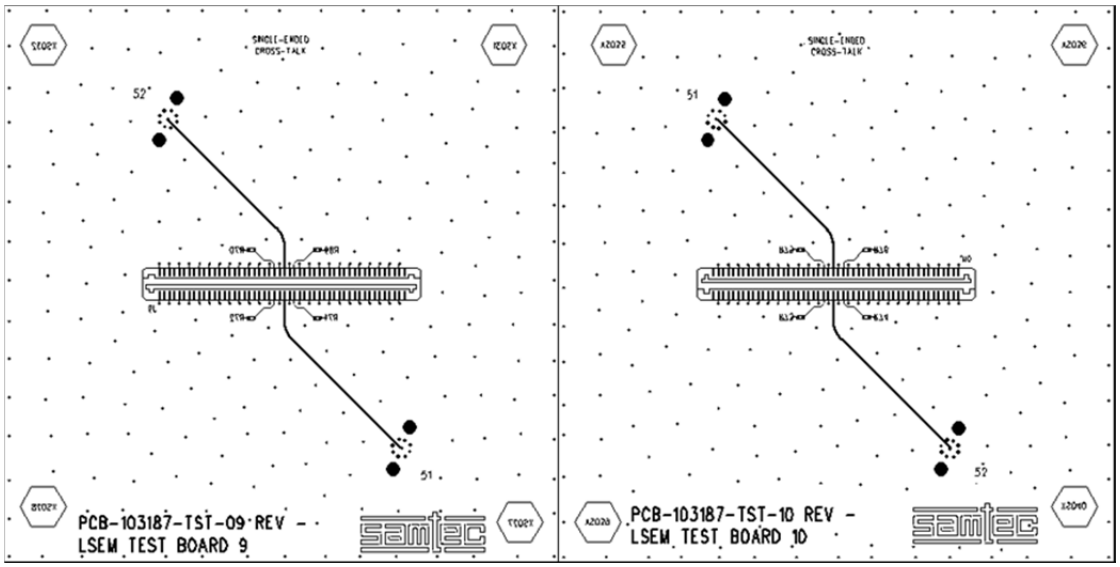
PCB-103187 -TST-07 Rev, LSEM Hermaphroditic *mates with* PCB-103187 -TST-08 Rev, LSEM Hermaphroditic, Single-Ended Best & Worst Case Configurations, Transmission/ Reflection Parameters, Crosstalk Parameters



Series: LSEM
Description: Board-to-Board, 0.8mm (.0315") Pitch, , 6mm (0.2362") Stack Height

PCB Fixtures (Cont.)

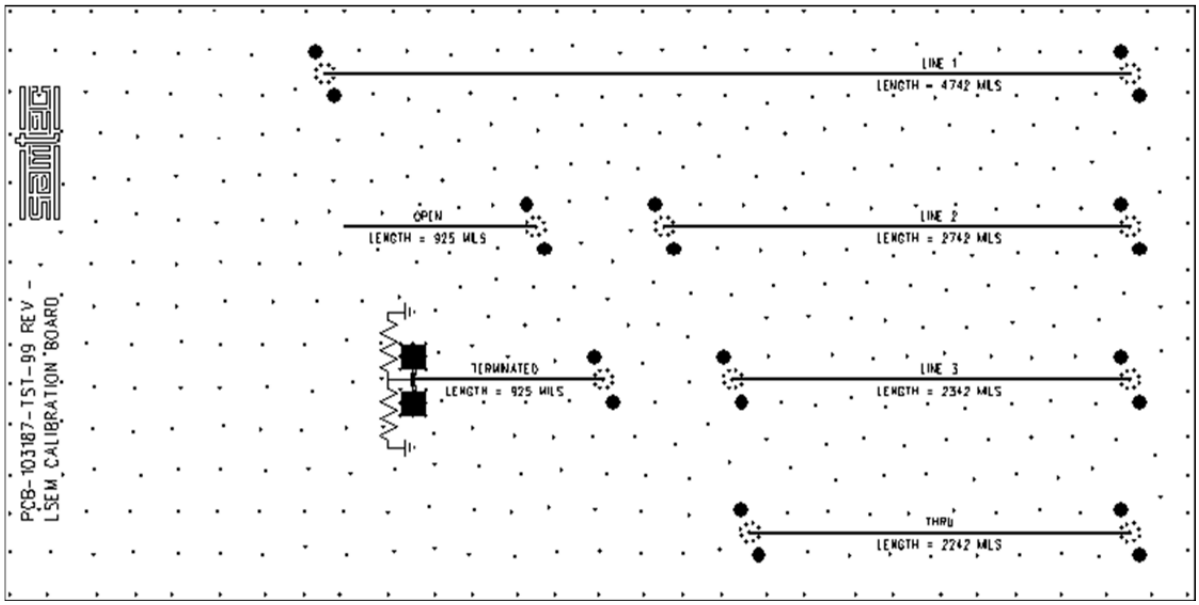
PCB-103187 -TST-09 Rev, LSEM Hermaphroditic *mates with* PCB-103187 -TST-10 Rev, LSEM Hermaphroditic, Across Row Configuration, Crosstalk Parameters



Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

Calibration Board

Test fixture losses and test point reflections were removed from the data by use of LRM calibration. The calibration boards are 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.



Line - Reflect - Match (LRM) Calibration Standards

PCB-103187-TST-99

Line 1 - Length = 4742 mils
Line 2 - Length = 2742 mils
Line 3 - Length = 2342 mils
Thru Line (2X) = 2242 mils
Reflect Standard - Length = 925 mils
Match Standard - Length = 925 mils

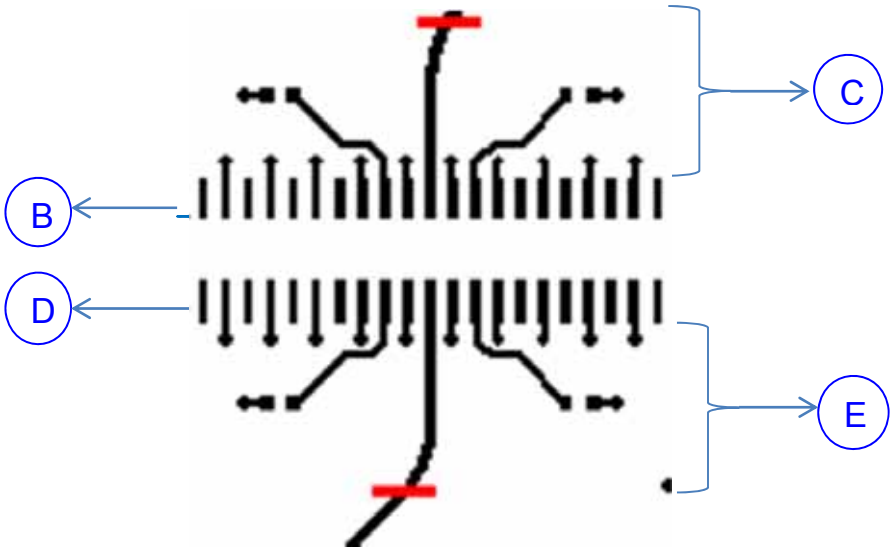
Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

All traces on the test boards are length matched to 1121 mils measured from the bottom edge of the signal pad to the SMA center contact footprint pad. The LRM calibration effectively removes 925 mils of PCB signal trace effects. Since the footprint geometry is equal on both sides of the Hermaphroditic LSEM connector, the reference plane location is also equal distance from the bottom edge of the connectors signal pad. This means the calibrated reference plane is located 196 mils from the connector pad on each side. The S-Parameter measurements include:

A. The LSEM Hermaphroditic Series connector set
B. Test board vias, pads (footprint effects) for the LSEM connector side.
C. 196 mils of 16 mil wide microstrip signal trace
D. Test board vias, pads (footprint effects) for the LSEM connector side.
E. 196 mils of 16 mil wide microstrip signal trace

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

Measurement reference plane
for the LSEM Hermaphroditic



Measurement reference plane
for the LSEM Hermaphroditic

Series: LSEM
Description: Board-to-Board, 0.8mm (.0315") Pitch, , 6mm (0.2362") Stack Height

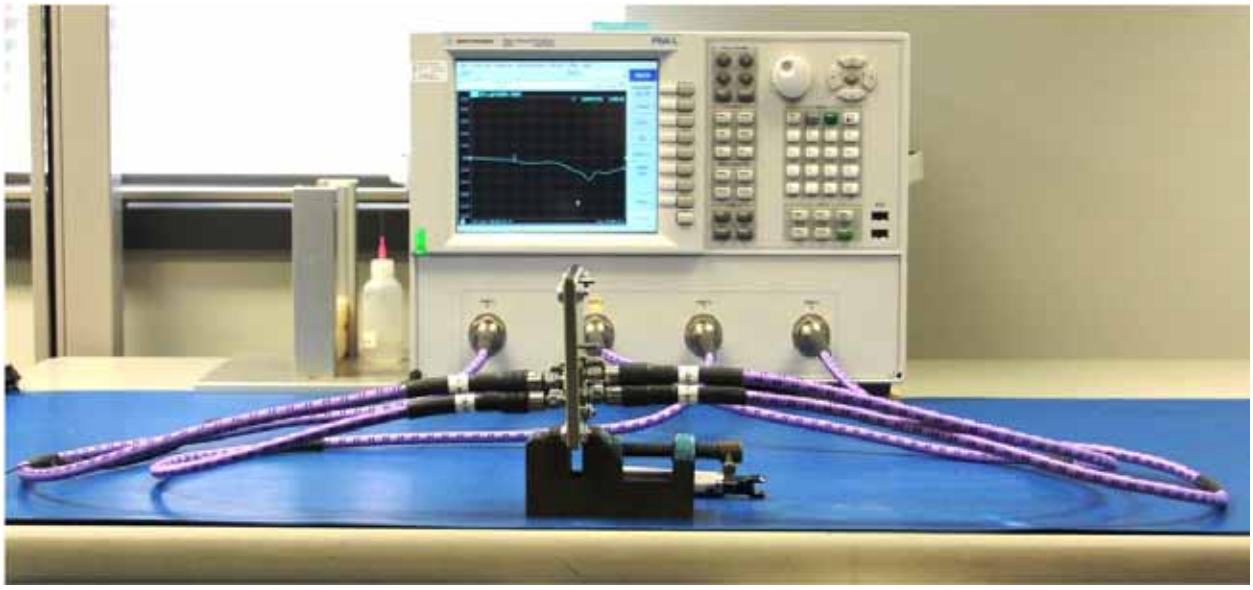
Appendix D – Test and Measurement Setup

The test instrument is the Agilent N5230C 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	Number of points -1601
Stop Frequency – 20 GHz	IFBW – 1 KHz

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

N5230C Measurement Setup



Test Instruments

QTY	Description
1	Agilent N5230C PNA-L 4-Port Network Analyzer (300 KHz to 20 GHz)
1	Agilent N4433A Ecal module (300 KHz to 20 GHz)

Test Cables & Adapters

QTY	Description
4	WL Gore –Z0CJ0CK0360 3.5 mm(f) to 3.5mm(m) Test Port Cables

Series: LSEM
Description: Board-to-Board, 0.8mm (.0315") Pitch, , 6mm (0.2362") Stack Height

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 E-cal 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 LSEM 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 N5230C. 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, 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

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.

Series: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

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: LSEM
Description: Board-to-Board, 0.8mm (.0315”) Pitch, , 6mm (0.2362”) Stack Height

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)