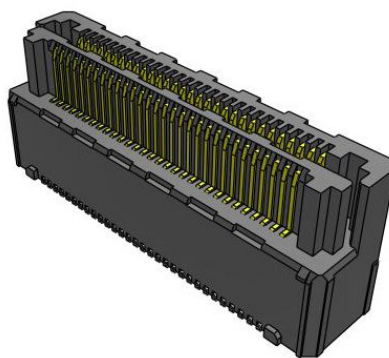




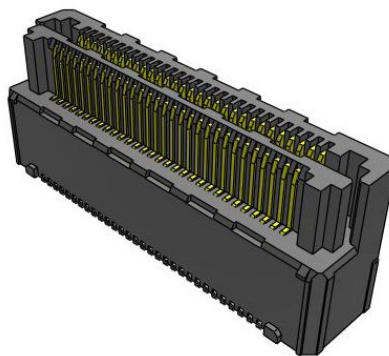
High Speed Characterization Report

LSHM-130-06.0-X-DV-X-N



Mated With

LSHM-130-06.0-X-DV-X-N



Description:

**0.50 mm Razor Beam™ High-Speed Hermaphroditic
Terminal/Socket Strip, 12mm Mated Stack Height**

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

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Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
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Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

Connector Overview

The LSHM is a high-density, rugged connector for use in board-to-board and board-to-cable applications with optional shielding for EMI protection. Using the Razor Beam™ fine pitch contact system, the hermaphroditic design saves PCB real estate in the X, Y, and Z axes.

The LSHM Series are available in 5, 10, 20, 30, 40 and 50 positions per row. LSHM series board-to-board spacing is available in 5mm (0.197"), 5.5mm (0.217"), 6mm (0.236"), 6.5mm (0.256"), 7mm (0.276"), 8mm (0.315"), 8.5mm (0.335"), 9mm (0.354"), 10mm (0.394") and 12mm (0.472"). The data in this report is applicable only to the 12mm (0.472") board-to-board mated connector stack height.

Frequency Domain Data Summary**Bandwidth Chart – Single-Ended Insertion Loss**

LSHM Connector Series

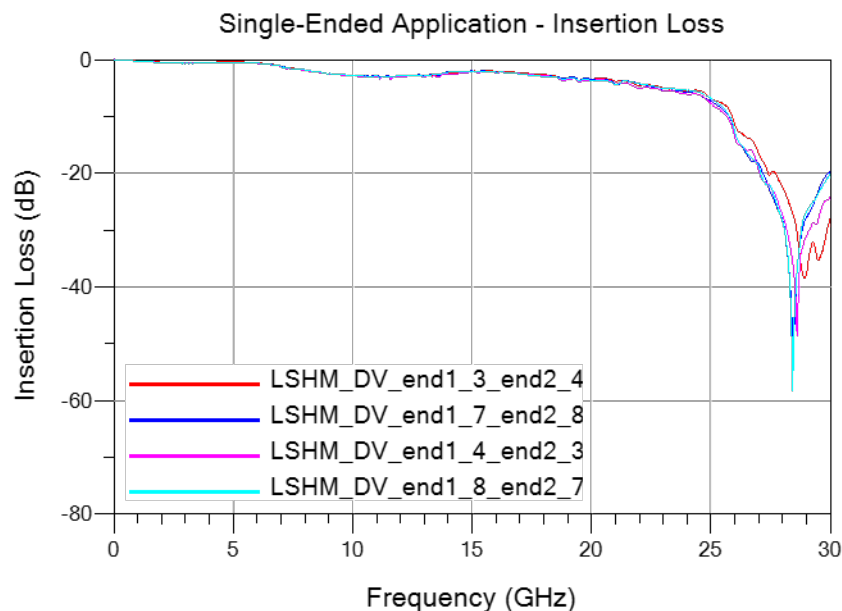


Figure 1

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

Bandwidth Chart – Differential Insertion Loss

LSHM Connector Series

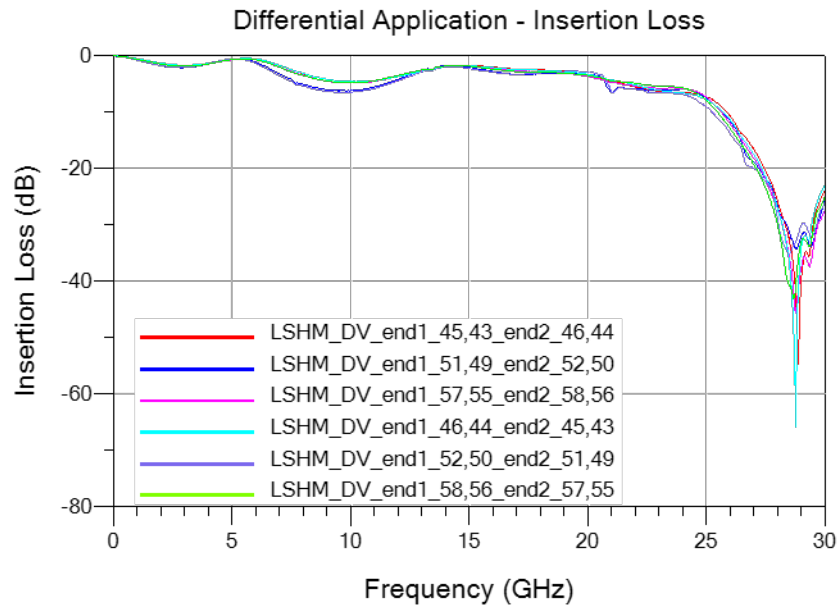


Figure 2

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

Time Domain Data Summary

Table 1 – Single-Ended Impedance (Ω)				
Driver	Signal Rise-time	30ps	50ps	100ps
LSHM_3	Maximum Impedance	51.2	50.8	50.8
	Minimum Impedance	33.7	36.9	40.2
LSHM_7	Maximum Impedance	51.1	50.8	50.8
	Minimum Impedance	33.6	36.5	39.7
LSHM_4	Maximum Impedance	51.0	50.8	50.7
	Minimum Impedance	35.1	37.6	40.1
LSHM_8	Maximum Impedance	51.0	50.7	50.7
	Minimum Impedance	34.9	37.4	39.9

Table 2 - Differential Impedance (Ω)				
Driver	Signal Rise-time	30ps	50ps	100ps
LSHM_45,43	Maximum Impedance	100.9	100.9	100.9
	Minimum Impedance	49.2	54.6	60.8
LSHM_51,49	Maximum Impedance	100.8	100.7	100.7
	Minimum Impedance	43.7	49.7	56.2
LSHM_57,55	Maximum Impedance	100.8	100.8	100.8
	Minimum Impedance	47.8	53.4	60.3
LSHM_46,44	Maximum Impedance	101.0	101.0	100.9
	Minimum Impedance	50.5	56.7	61.5
LSHM_52,50	Maximum Impedance	100.8	100.8	100.7
	Minimum Impedance	44.7	52.3	56.6
LSHM_58,52	Maximum Impedance	100.8	100.8	100.8
	Minimum Impedance	50.0	54.1	59.6

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

Table 3 – Single Ended Crosstalk (%)					
Input(tr)	Driver	Receiver	30ps	50ps	100ps
NEXT	LSHM DV end1_3	LSHM DV end1_7	2.24	1.96	1.51
	LSHM DV end1_3	LSHM DV end1_4	1.20	1.12	0.82
	LSHM DV end1_3	LSHM DV end1_8	0.46	0.43	0.31
	LSHM DV end1_4	LSHM DV end1_8	2.26	1.99	1.52
	LSHM DV end1_7	LSHM DV end1_8	0.97	0.92	0.68
FEXT	LSHM DV end1_3	LSHM DV end2_8	0.68	0.45	0.28
	LSHM DV end1_3	LSHM DV end2_3	0.34	0.29	0.22
	LSHM DV end1_3	LSHM DV end2_7	<0.1	<0.1	<0.1
	LSHM DV end1_4	LSHM DV end2_7	0.66	0.46	0.28
	LSHM DV end1_7	LSHM DV end2_7	0.29	0.25	0.19

Table 4 - Differential Crosstalk (%)					
Input(tr)	Driver	Receiver	30ps	50ps	100ps
NEXT	LSHM DV end1_45,43	LSHM DV end1_51,49	0.33	0.28	0.22
	LSHM DV end1_45,43	LSHM DV end1_57,55	<0.1	<0.1	<0.1
	LSHM DV end1_45,43	LSHM DV end1_46,44	0.16	0.14	0.11
	LSHM DV end1_46,44	LSHM DV end1_52,50	0.35	0.29	0.23
	LSHM DV end1_46,44	LSHM DV end1_58,56	<0.1	<0.1	<0.1
	LSHM DV end1_46,44	LSHM DV end1_51,49	<0.1	<0.1	<0.1
	LSHM DV end1_46,44	LSHM DV end1_57,55	<0.1	<0.1	<0.1
	LSHM DV end1_57,55	LSHM DV end1_51,49	0.34	0.28	0.23
	LSHM DV end1_57,55	LSHM DV end1_58,56	0.17	0.16	0.12
	LSHM DV end1_57,55	LSHM DV end1_52,50	<0.1	<0.1	<0.1
FEXT	LSHM DV end1_45,43	LSHM DV end2_52,50	0.20	0.17	0.11
	LSHM DV end1_45,43	LSHM DV end2_58,56	<0.1	<0.1	<0.1
	LSHM DV end1_45,43	LSHM DV end2_45,43	<0.1	<0.1	<0.1
	LSHM DV end1_46,44	LSHM DV end2_51,49	0.18	0.16	0.11
	LSHM DV end1_46,44	LSHM DV end2_57,55	<0.1	<0.1	<0.1
	LSHM DV end1_46,44	LSHM DV end2_52,50	<0.1	<0.1	<0.1
	LSHM DV end1_46,44	LSHM DV end2_58,56	<0.1	<0.1	<0.1
	LSHM DV end1_57,55	LSHM DV end2_52,50	0.20	0.17	0.12
	LSHM DV end1_57,55	LSHM DV end2_57,55	<0.1	<0.1	<0.1
	LSHM DV end1_57,55	LSHM DV end2_51,49	<0.1	<0.1	<0.1

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

Table 5 - Propagation Delay (Mated Connector)	
LSHM DV end1 3 end2 4	105 ps
LSHM DV end1 7 end2 8	106 ps
LSHM DV end1 4 end2 3	107 ps
LSHM DV end1 8 end2 7	106 ps
LSHM DV end1 45,43 end2 46,44	97 ps
LSHM DV end1 51,49 end2 52,50	101 ps
LSHM DV end1 57,55 end2 58,56	97 ps
LSHM DV end1 46,44 end2 45,43	98 ps
LSHM DV end1 52,50 end2 51,49	103 ps
LSHM DV end1 58,56 end2 57,55	100 ps

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

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 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: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

For this connector, the following configurations were evaluated:

G	T	G	8	G	4	G
G	T	G	7	G	3	G

G	58	56	G	52	50	G	46	44	G	T	T	G
G	57	55	G	51	49	G	45	43	G	T	T	G

Single-Ended and Differential Impedance (denoted by blue circles):

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

Single-Ended and 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.

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 30 ps and 100 ps.

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

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

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. 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 2.04 mm for Single-Ended and 2.1 mm for Differential of PCB trace on both LSHM sides each. Delay is measured at 100 picoseconds signal risetime. 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. The crosstalk ratio is tabulated in this report as a percentage. Measurements are made at both the near-end and far-end of the SUT.

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 located in the appendices of this report. Further information may be obtained by contacting our Signal Integrity Group at sig@samtec.com.

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

Appendix A – Frequency Domain Responses

Single-Ended Application – Insertion Loss

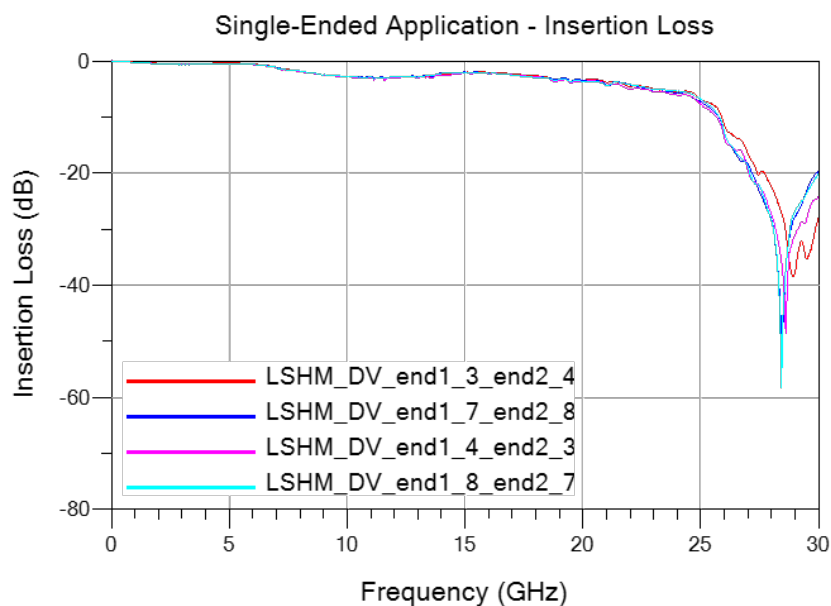


Figure 3

Single-Ended Application – Return Loss

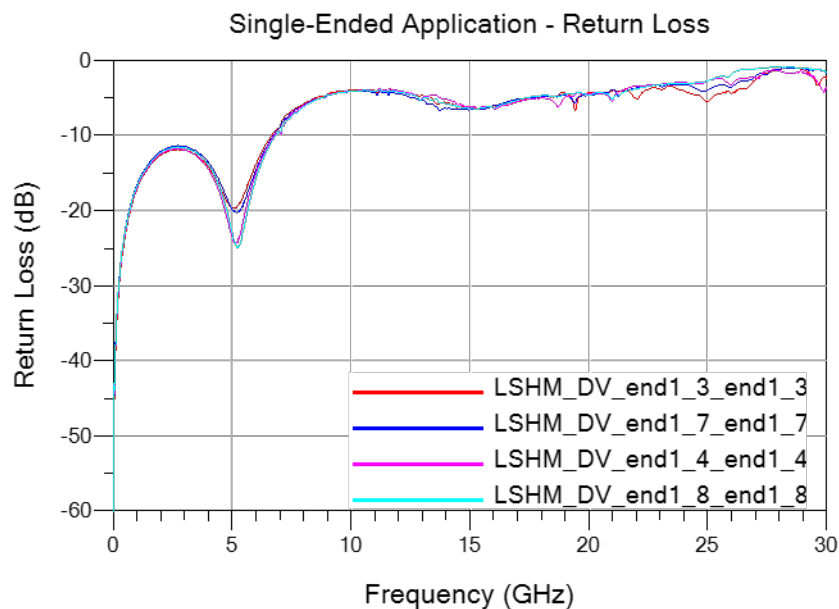


Figure 4

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197") Pitch, 12mm (0.472") Stack Height

Single-Ended Application – NEXT Configurations

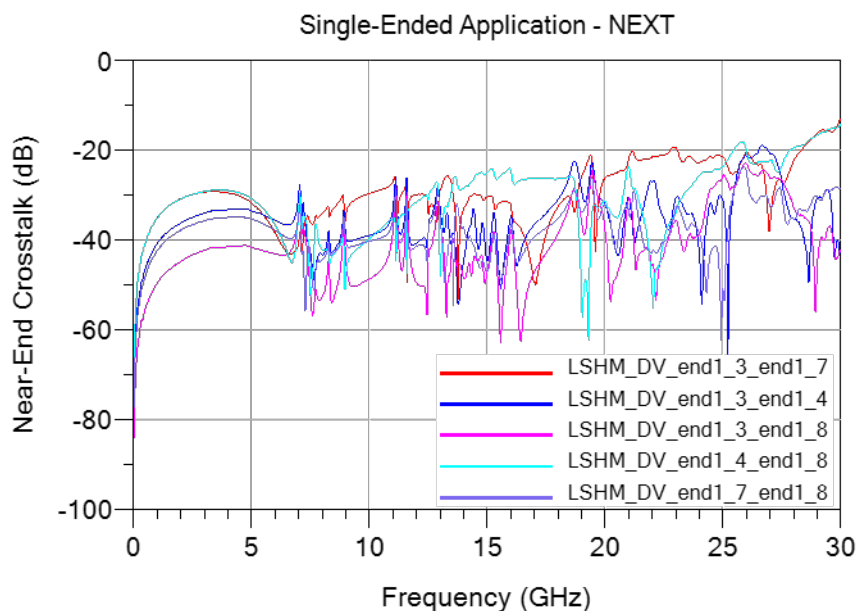


Figure 5

Single-Ended Application – FEXT Configurations

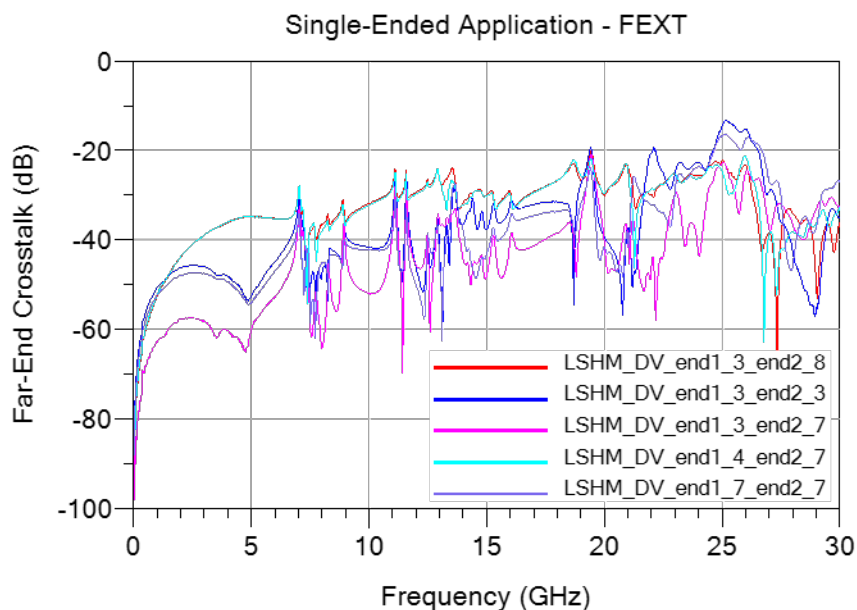


Figure 6

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

Differential Application – Insertion Loss

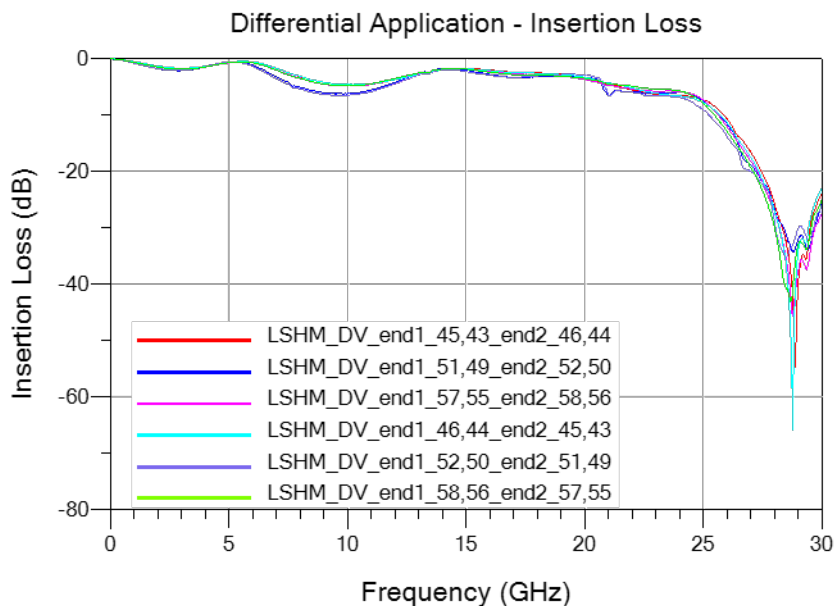


Figure 7

Differential Application – Return Loss

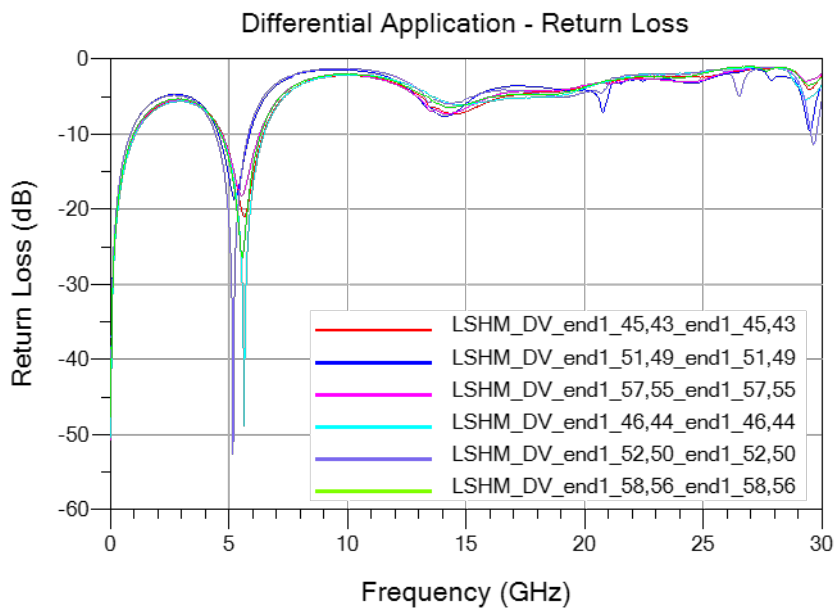
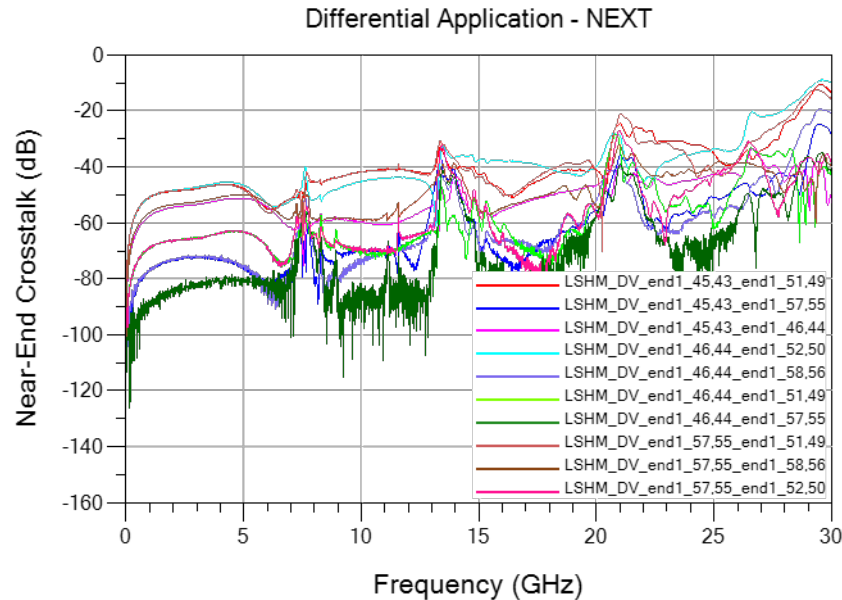


Figure 8

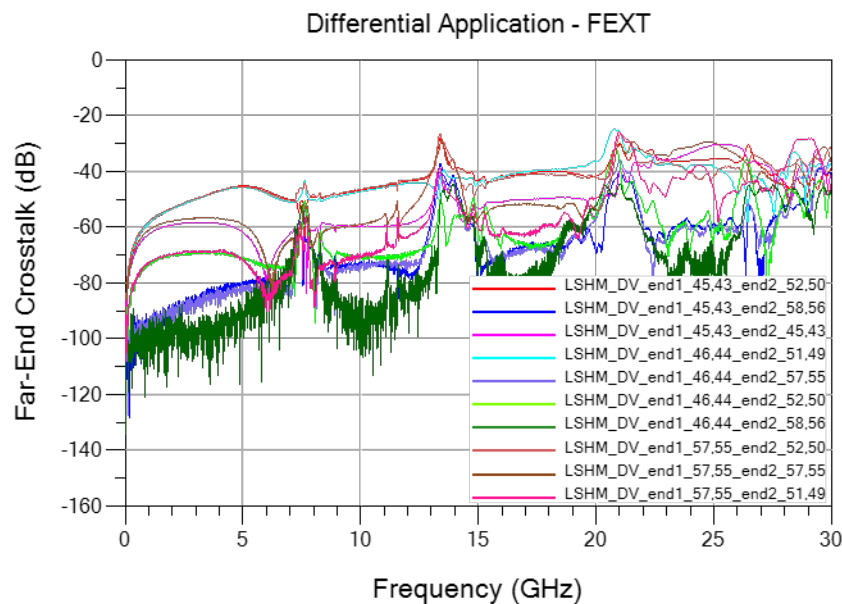
Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

Differential Application – NEXT Configurations



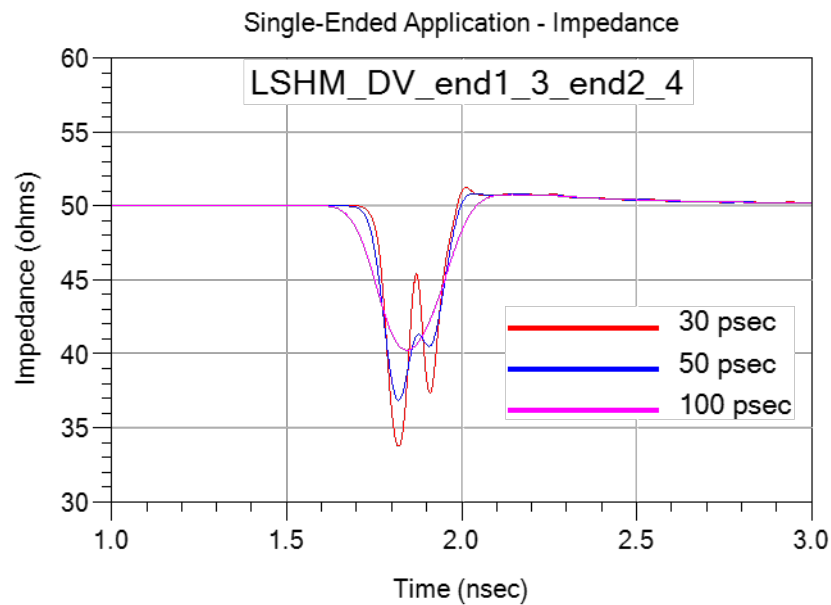
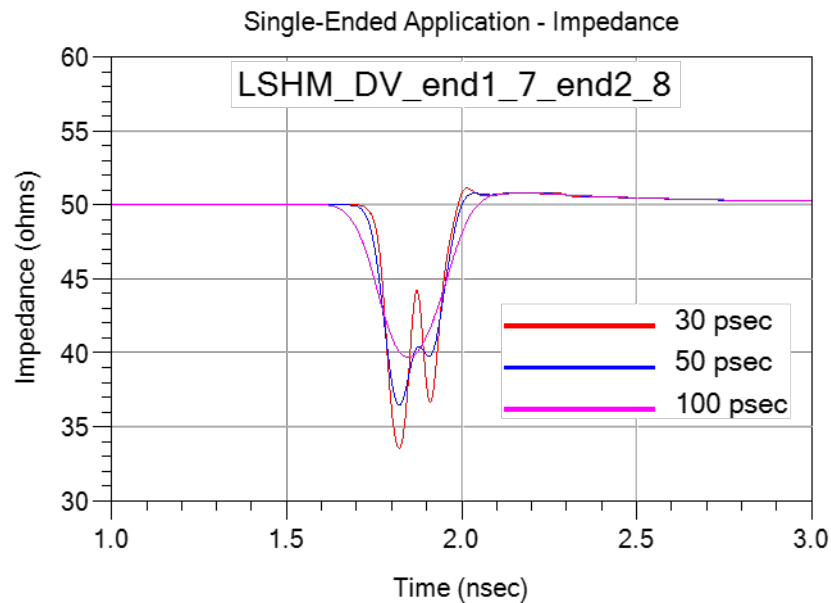
Differential Application – FEXT Configurations



Series: LSHM**Description:** High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

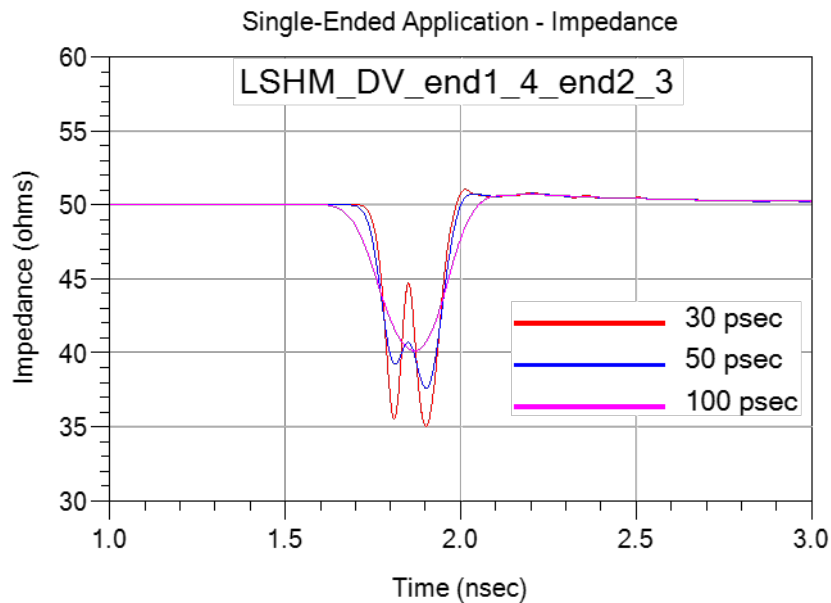
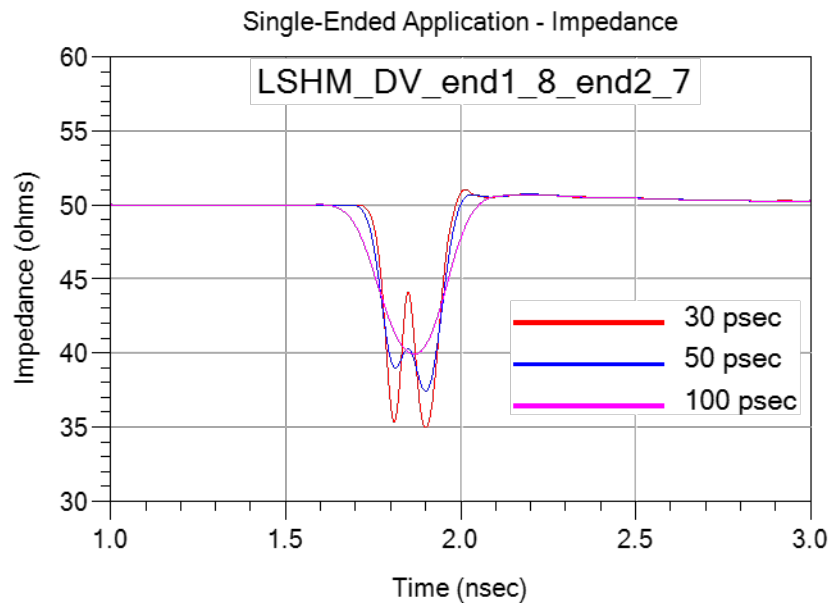
Appendix B – Time Domain Responses

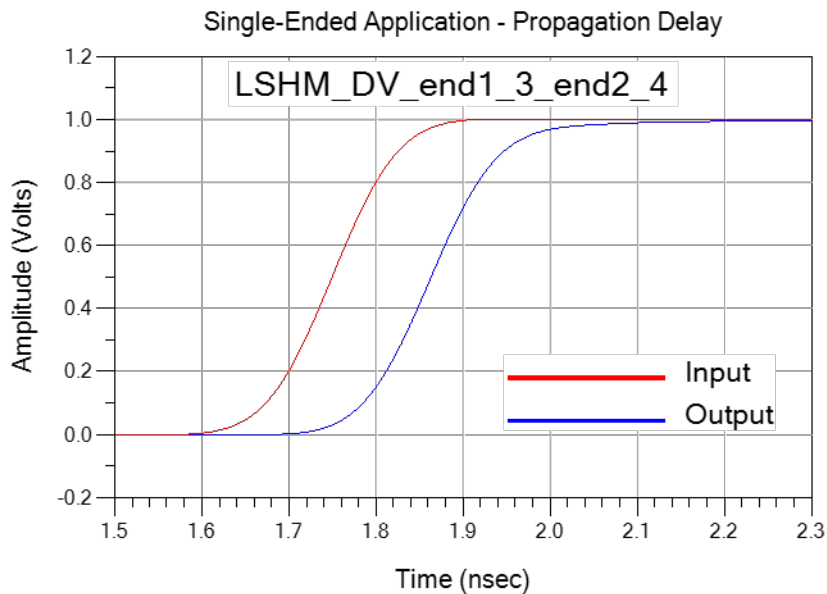
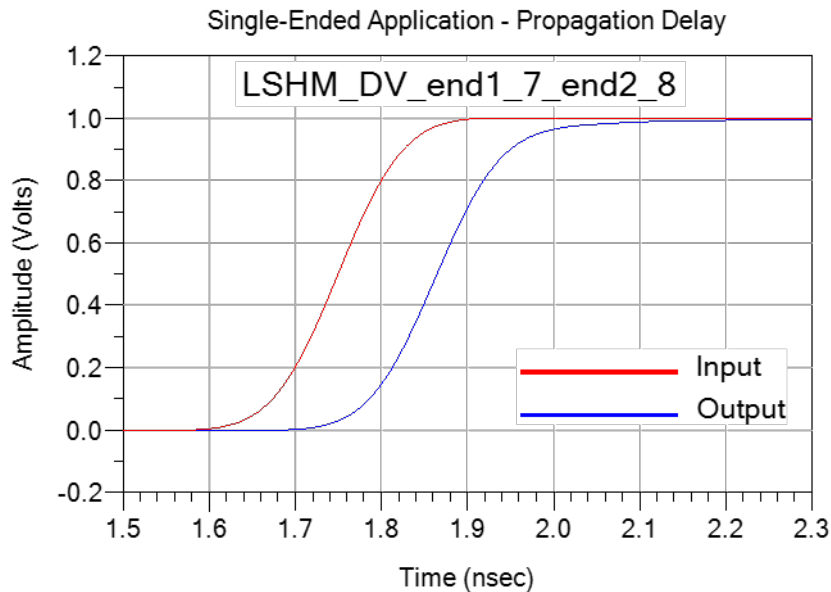
Single-Ended Application – Impedance

**Figure 11****Figure 12**

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

**Figure 13****Figure 14**

Series: LSHM**Description:** High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height**Single-Ended Application – Propagation Delay****Figure 15****Figure 16**

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

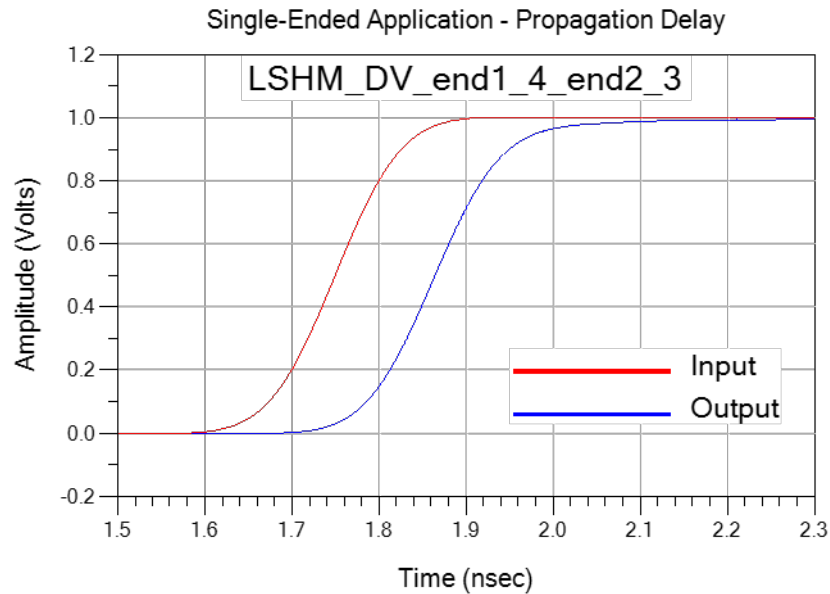


Figure 17

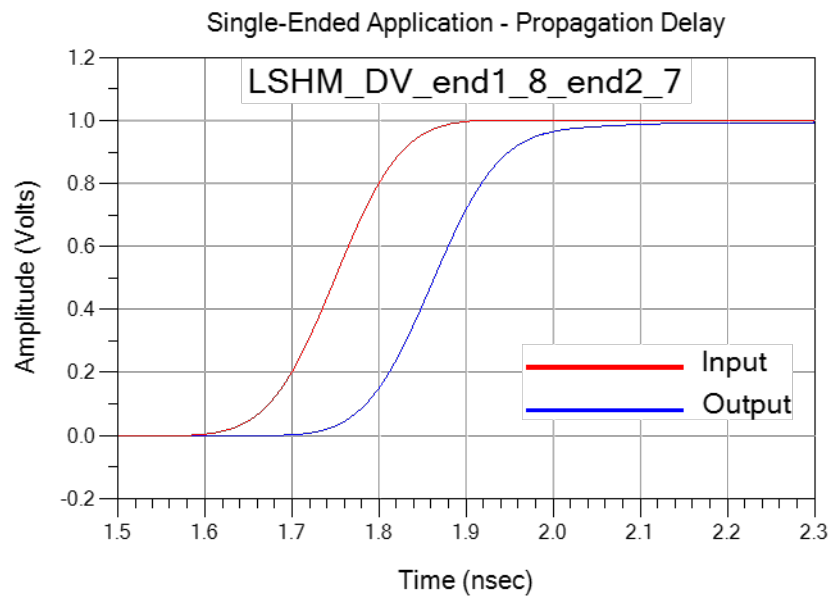
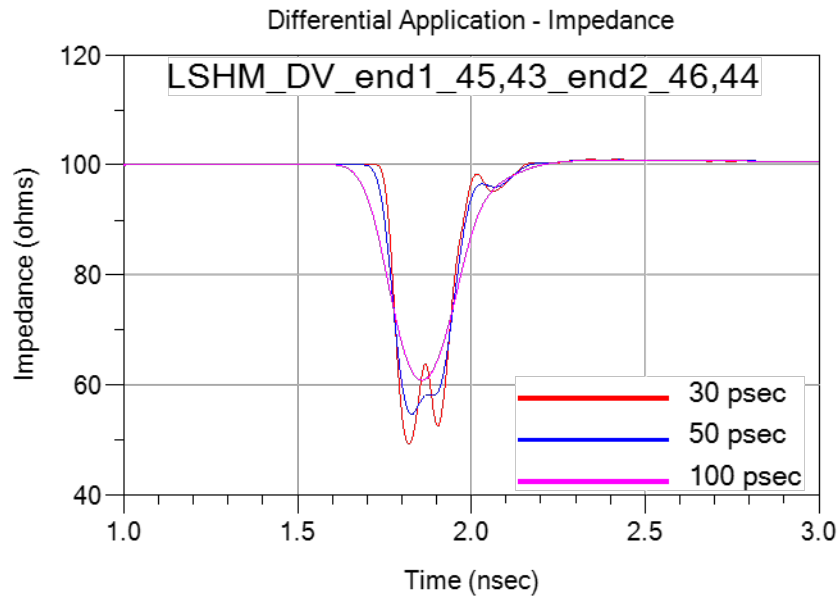
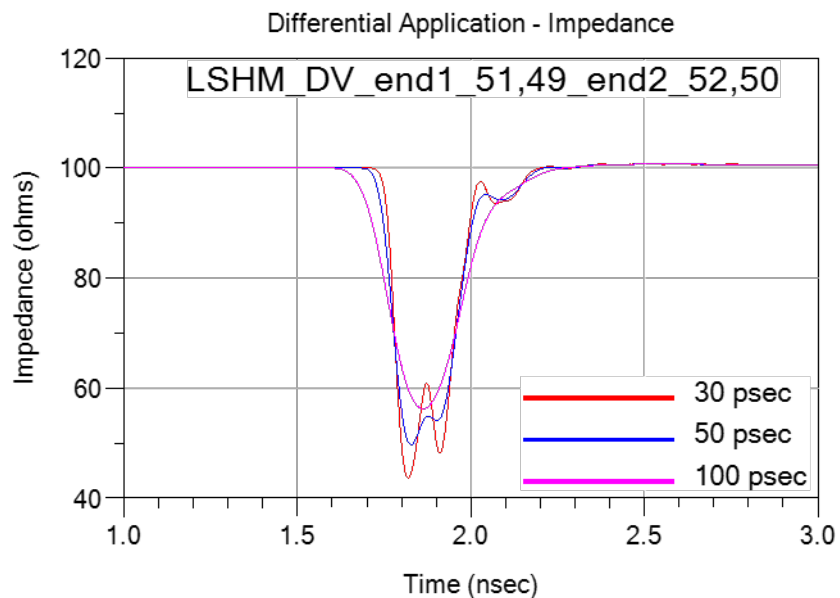


Figure 18

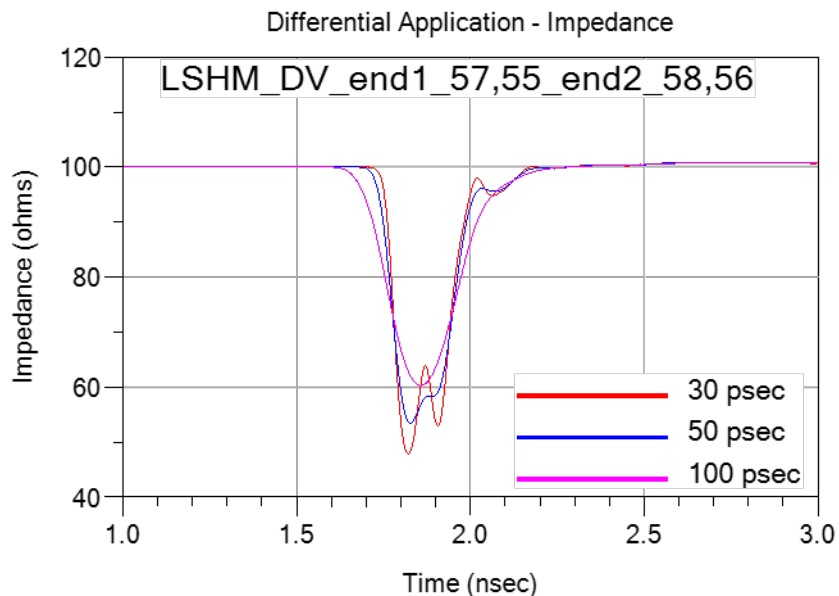
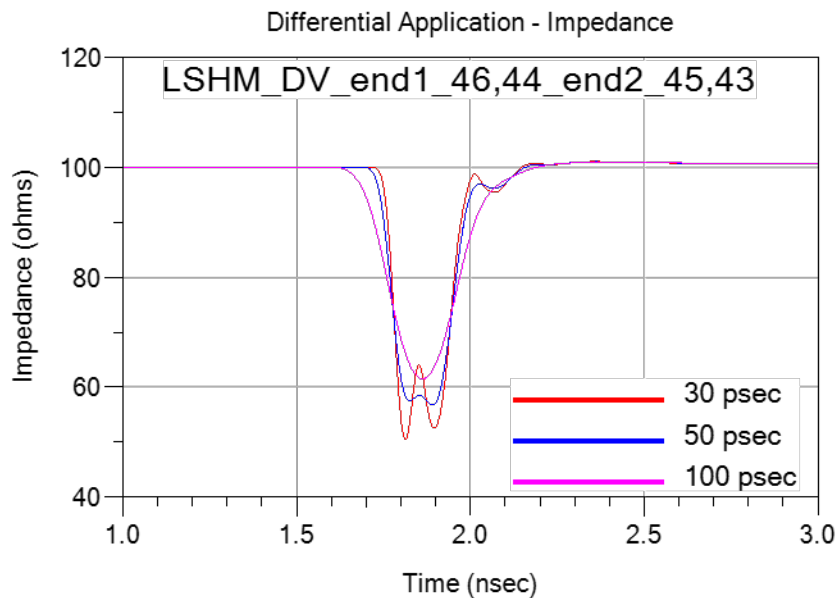
Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

Differential Application – Impedance**Figure 19****Figure 20**

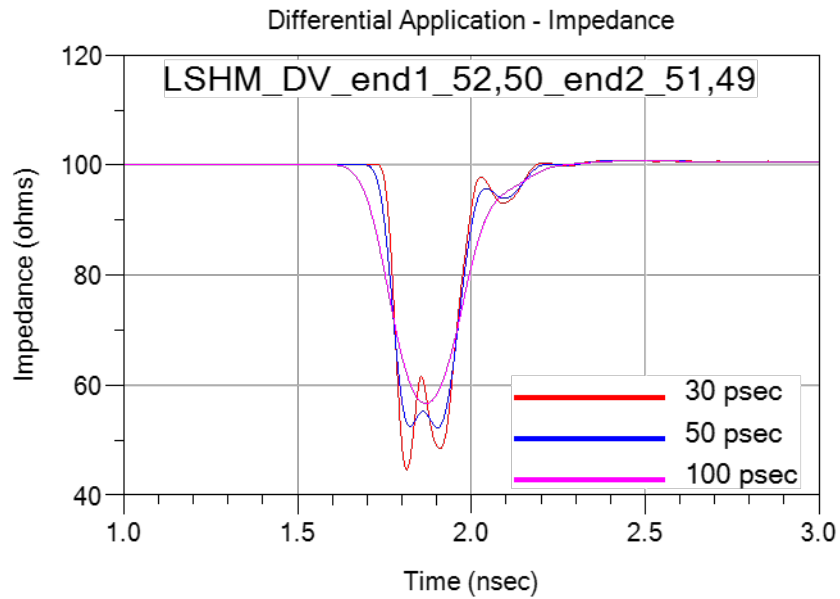
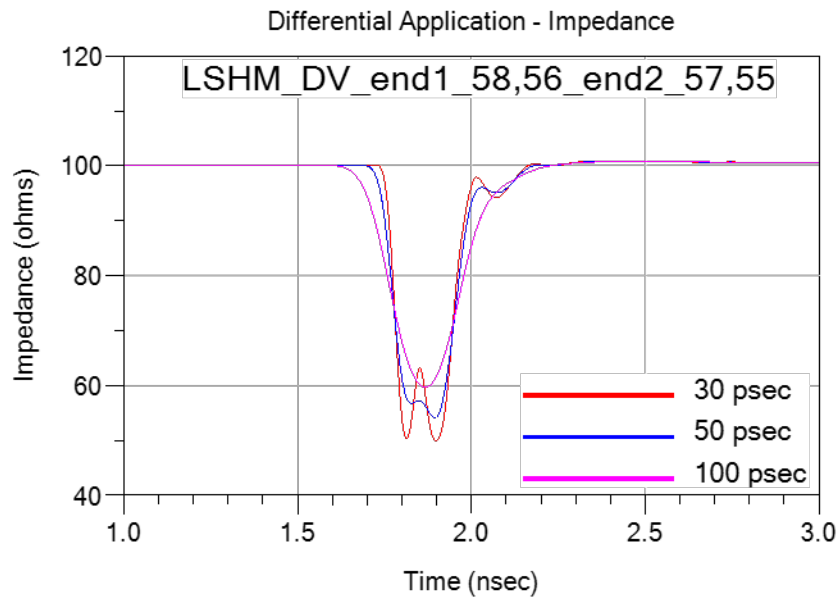
Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

**Figure 21****Figure 22**

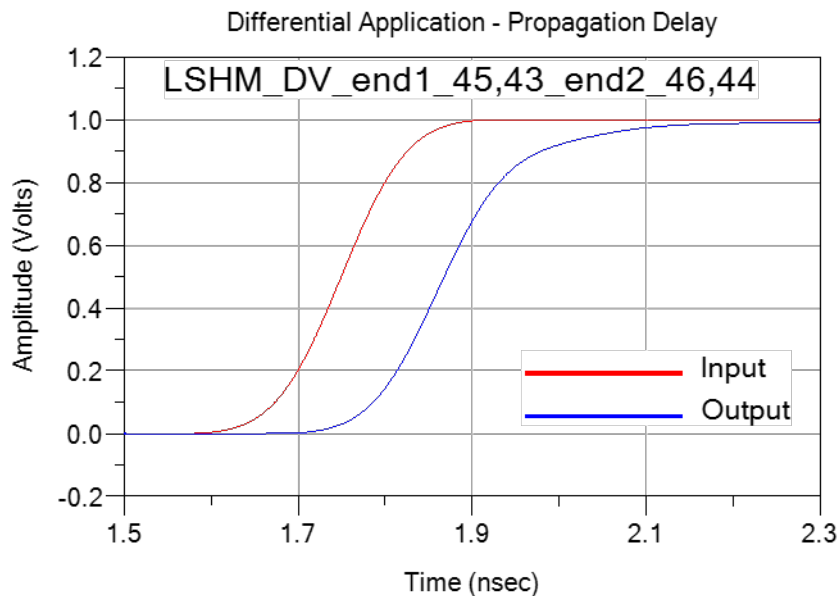
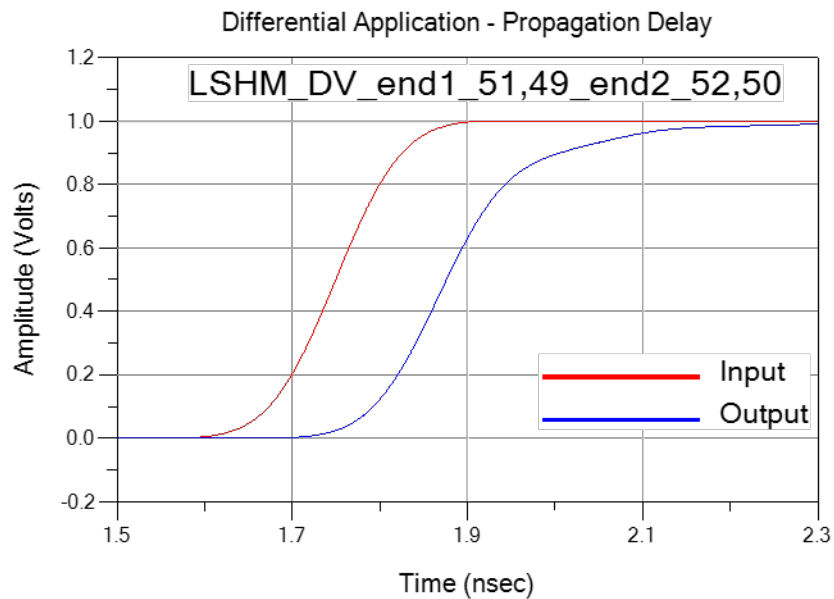
Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

**Figure 23****Figure 24**

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

Differential Application – Propagation Delay**Figure 25****Figure 26**

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

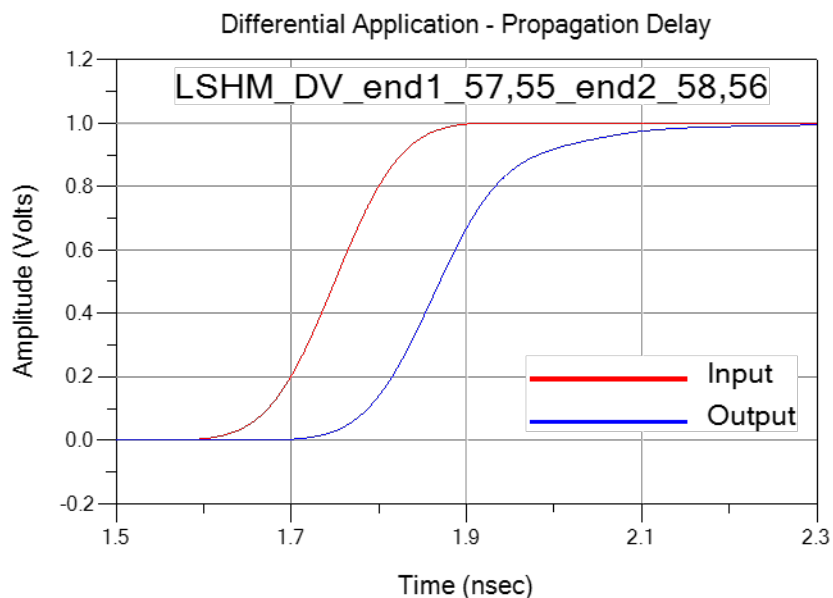


Figure 27

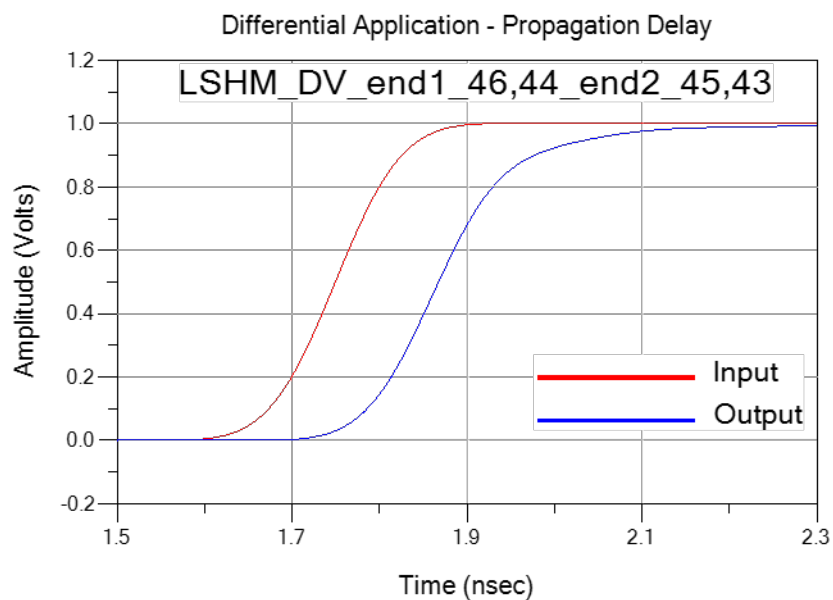


Figure 28

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

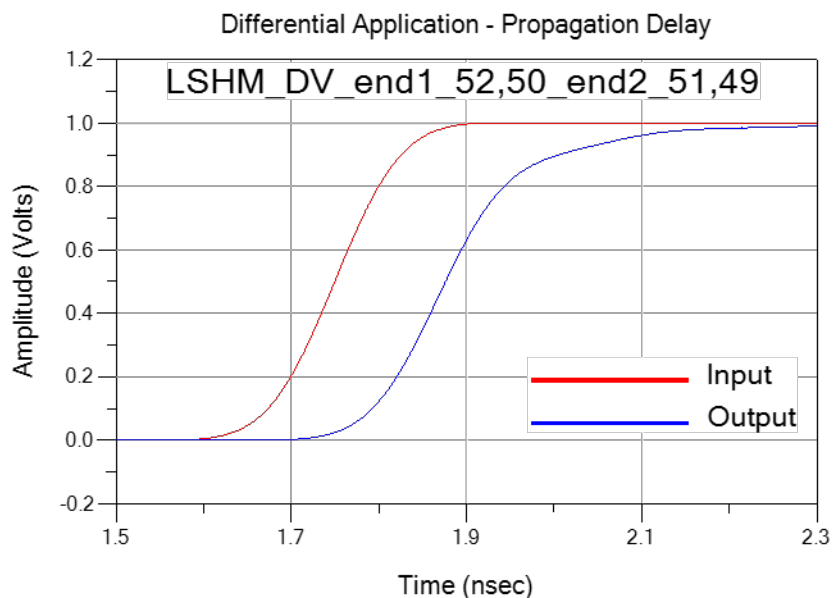


Figure 29

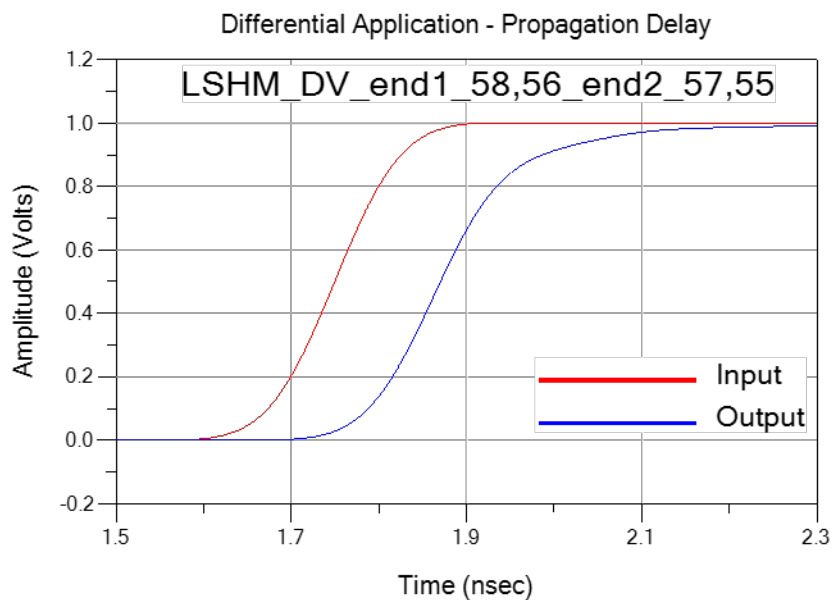


Figure 30

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

Appendix C – Product and Test System Descriptions**Product Description**

Product test samples are LSHM Series connectors. The part number is LSHM-130-06.0-X-DV-X-N. A photo of the test articles mounted to SI test boards is shown below.

Test System Description

The test fixtures are composed of six-layer MT40 material with 50Ω signal trace and pad configurations designed for the electrical characterization of Samtec high speed connector products. A PCB mount 2.4mm connector is used to interface the PNA test cables to the test fixtures. Optimization of the 2.4mm launch was performed using full wave simulation tools to minimize reflections. The test fixtures and calibration kit are specific to the LSHM series connector set and identified by part number PCB-LSHMDV-112313-SIG-0.

PCB-LSHMDV-112313-SIG-0 Test Fixtures

Shown below is a photograph of the test board set.

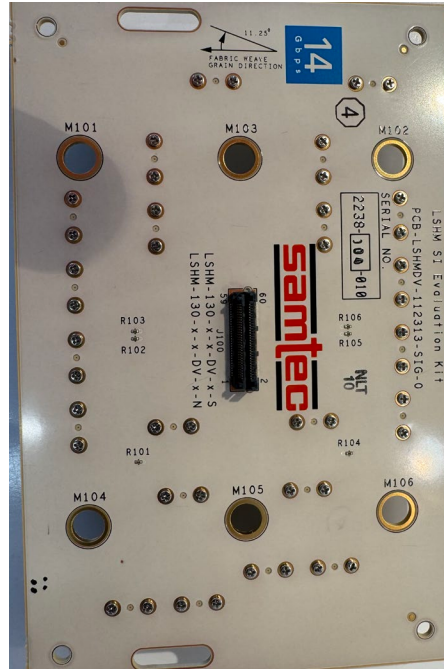


Figure 31

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197")
Pitch, 12mm (0.472") Stack Height

PCB Fixtures

The test fixtures used are as follows:

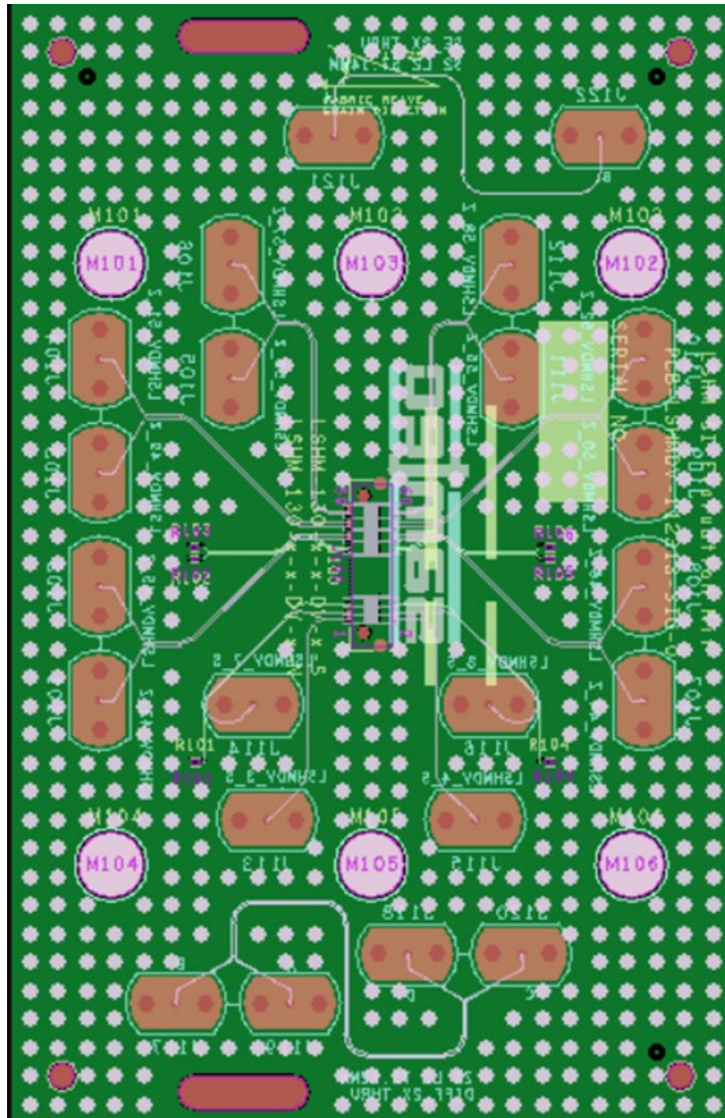


Figure 32

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197") Pitch, 12mm (0.472") Stack Height

All traces on the test boards are length matched to 30.61 mm for Single- Ended and 39.86 mm for Differential measured from the edge of the pad to the 2.4mm connector. The AFR calibration effectively removes 28.57 mm of Single- Ended and 37.76mm of Differential test board trace effects. This means that 2.04 mm of Single- Ended and 2.1 mm of Differential test board trace length effects are included in both sides of test boards in the measurement. The S-Parameter measurement includes:

- A- The LSHM Series connector set
- B- Test board vias, pads (footprint effects) for the LSHM connector.
- C- 2.04 mm Single- Ended of 0.151 mm wide microstrip trace.
- D- 2.1 mm Differential of 0.142 mm wide microstrip trace

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

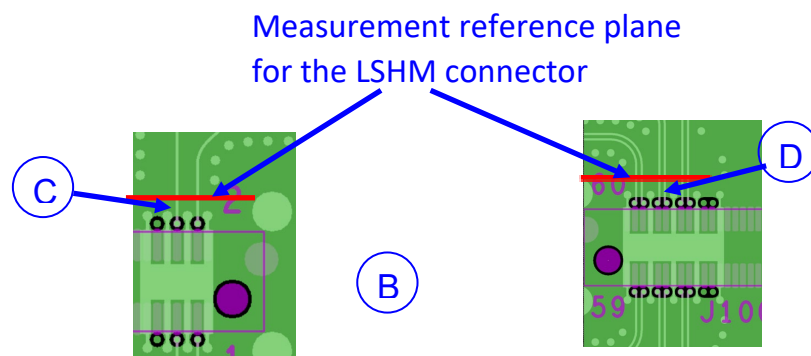


Figure 33

Series: LSHM

Description: High-Speed Hermaphroditic Terminal/Socket Strip, 0.50 mm (0.0197") Pitch, 12mm (0.472") Stack Height

Appendix D – Test and Measurement Setup

For frequency domain measurements, the test instrument is the Keysight N5225B PNA-L network analyzer. Frequency domain data are obtained directly from the instrument and figures are generated by Keysight ADS. The network analyzer is configured as follows:

Start Frequency – 10 MHz
Stop Frequency – 40 GHz
Number of points – 4000
IFBW – 1 KHz

N5225B Measurement Setup

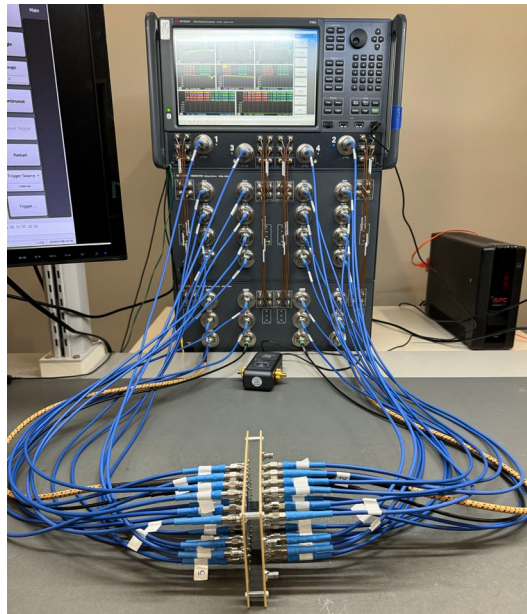


Figure 34

Test Instruments

<u>QTY</u>	<u>Description</u>
1	Keysight N5225B PNA Network Analyzer
1	1.85mm e-cal N4694-60003

Test Cables & Adapters

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

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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 N4694-60003 E-Cal module. Then DUT measurements are performed under SOLT calibration. The measurements include the effect of test fixture. The measurements of the 2X THRU line standards are required to remove the test fixture effect.

Time Domain Procedures

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

The Time Domain responses were generated using Keysight ADS 2023. 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.

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.

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Appendix F – Glossary of Terms

ADS – Advanced Design Systems

FD – Frequency domain

FEXT – Far-End Crosstalk

GSG – Ground–Signal–Ground; geometric configuration

GSSG - Ground–Signal–Signal–Ground; geometric configuration

NEXT – Near-End Crosstalk

PCB – Printed Circuit Board

SE – Single-Ended

SI – Signal Integrity

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

Z – Impedance (expressed in ohms)