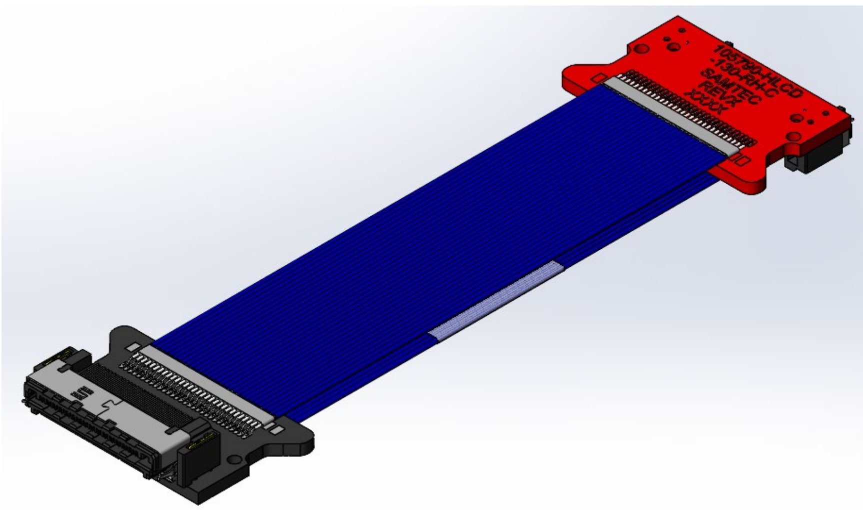
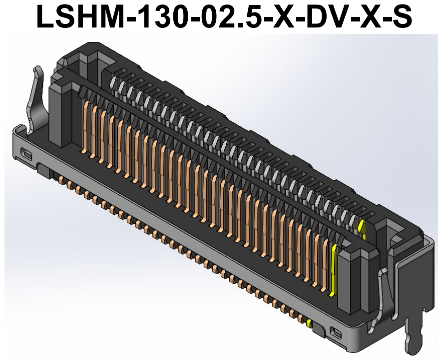
High Speed Characterization Report

HLCD-30-XX. XX-TH-BH-1



Mated with:

LSHM-130-02.5-X-DV-X-S



Description:

0.50 mm (.0197") pitch High Speed Hermaphroditic Cable Assembly

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Report Revision: 2/27/2025

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

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Cable Assembly Overview

The 0.50 mm (.0197") pitch HLCD Cable Assembly is constructed using 38 AWG Coax cable. It is a double row structure with up to 50 contacts per row. The data in this report is applicable to 9.80-, 19.68-, and 39.37-inch cable assemblies with reversed right-angle LSHM-RH connectors on ends 1 and 2.

The test sample consists of two micro-coaxial ribbon cables that contain 30 lines each. At each end of the cable there is a connector that is terminated to a small transition PCB. Each connector is soldered to its respective PCB. The connector terminals are on 0.5 mm centers. The HLCD-30-XX.XX-TH-BH-1 assembly is wired to facilitate a Pin 1 to Pin 1 mapping between the cable ends.

The HLCD assemblies were tested by mating to LSHM-130-02.5-X-DV-A-S at both ends. One sample of each length assembly was tested. The actual part number that was tested is shown in Table 1, which also identifies End 1 and End 2 of the assembly; a relative sample picture is shown in Figure 1. End 1 of the HLCD-30-XX.XX-TH-BH-1 has a black transition PCB, and End 2 has a red transition PCB.

Length	Part Number	End 1	End 2
9.80 inches	HLCD-30-09.80-TH-BH-1	TH	BH
19.68 inches	HLCD-30-19.68-TH-BH-1	TH	BH
39.37 inches	HLCD-30-39.37-TH-BH-1	TH	BH

Table 1: Sample Description

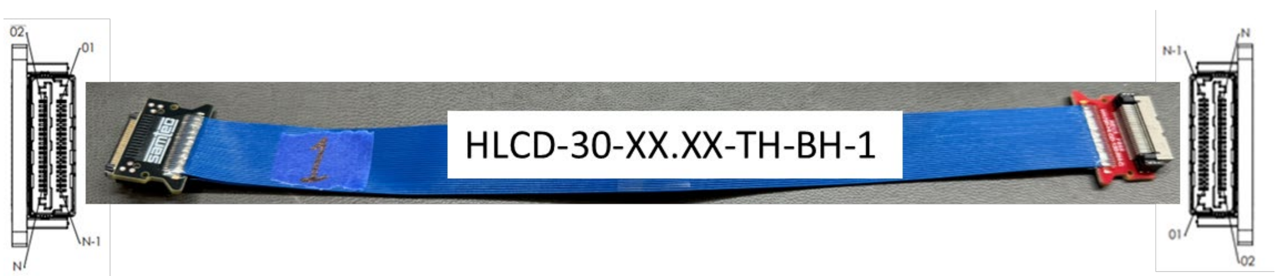

Figure 1: Test Sample

Series: HLCD-TH-BH-1
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Frequency Domain Data Summary

Bandwidth Figures – Single-Ended Insertion Loss

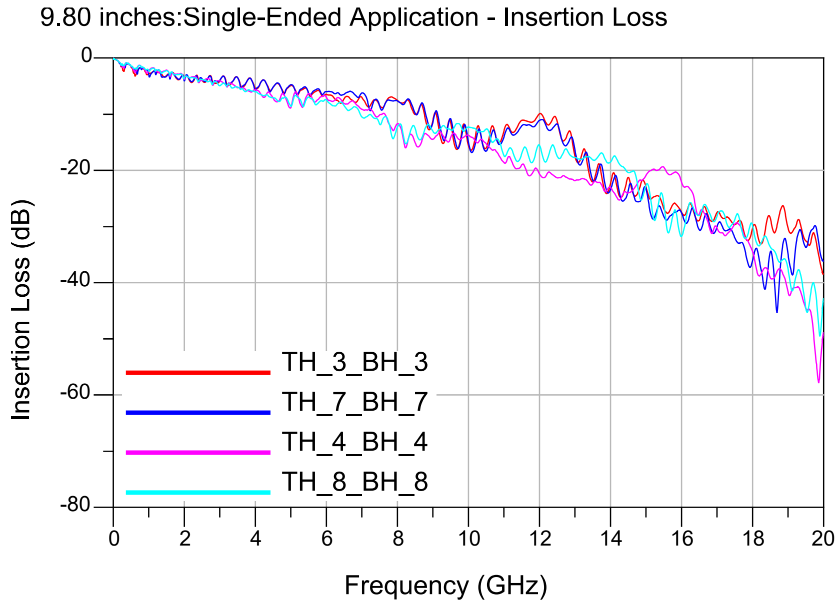

Figure 2

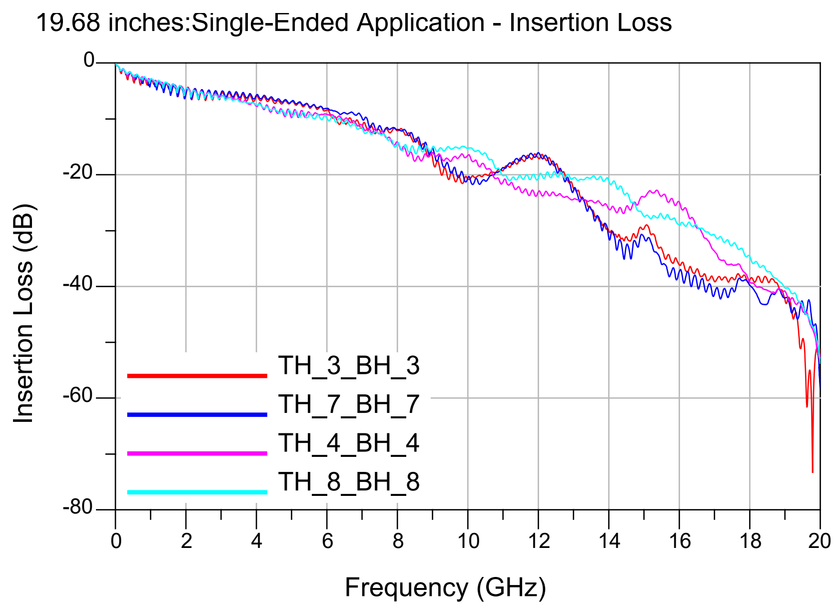

Figure 3

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

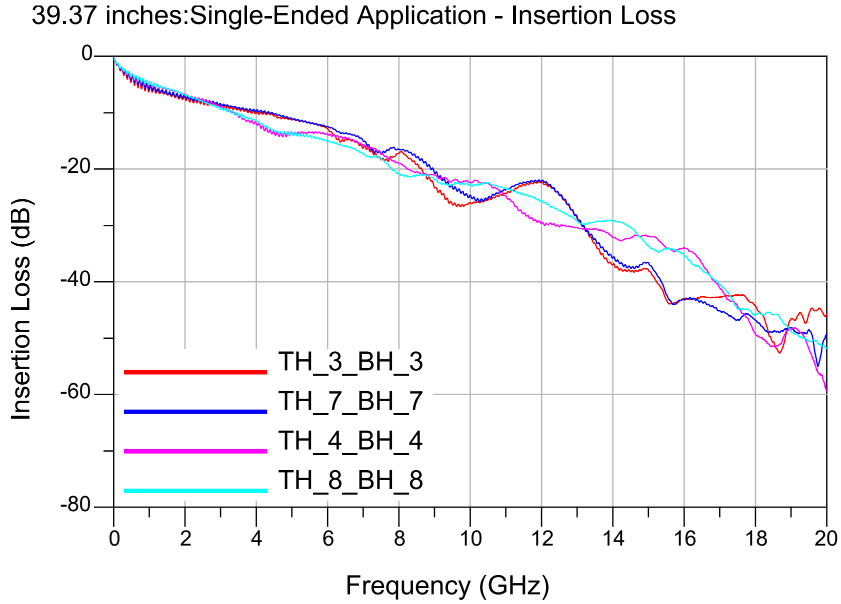

Figure 4

Bandwidth Figures – Differential Insertion Loss

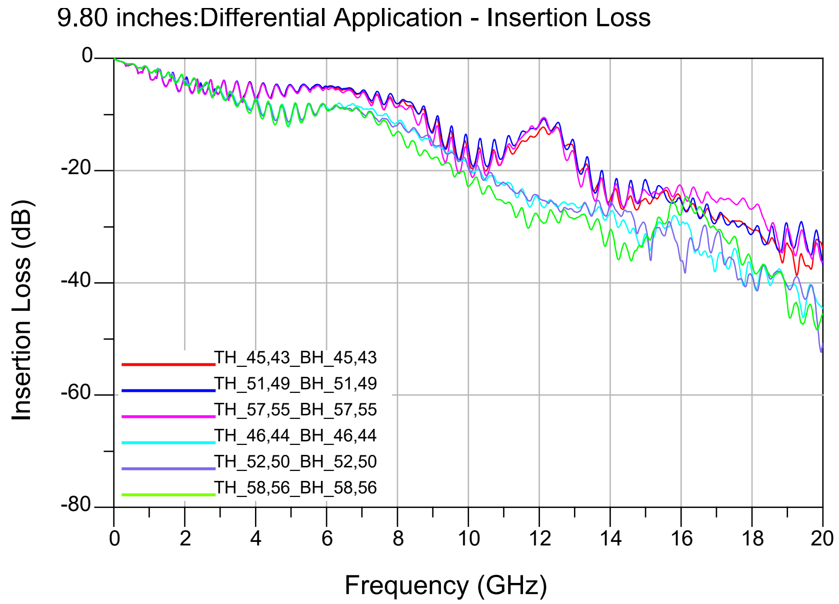

Figure 5

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

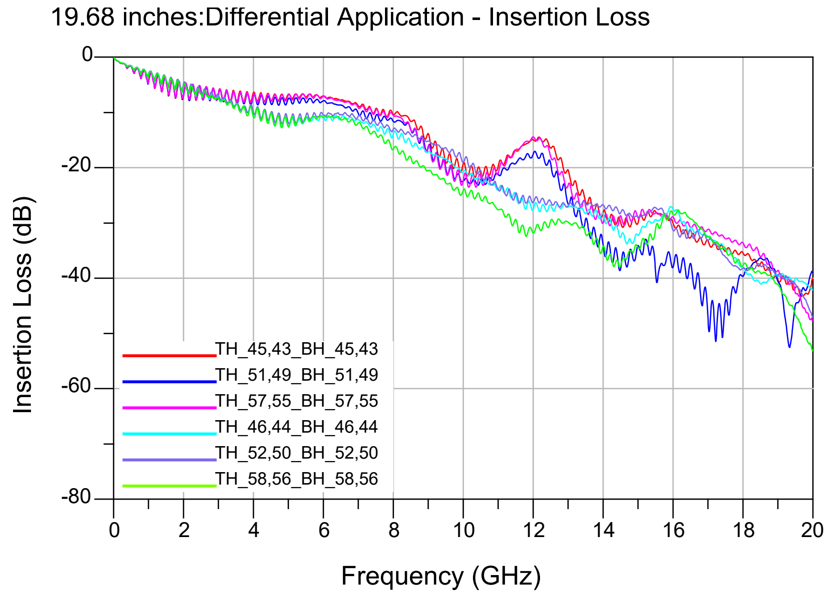

Figure 6

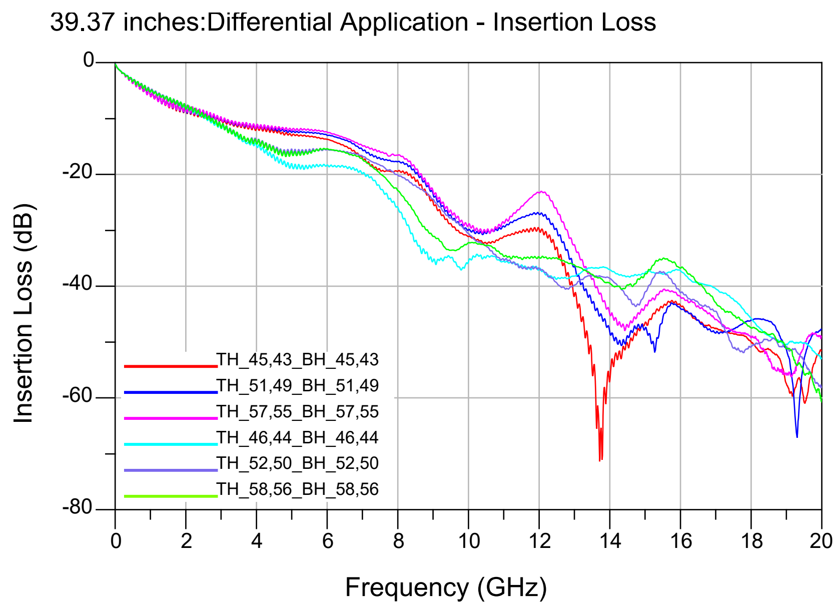

Figure 7

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Time Domain Data Summary

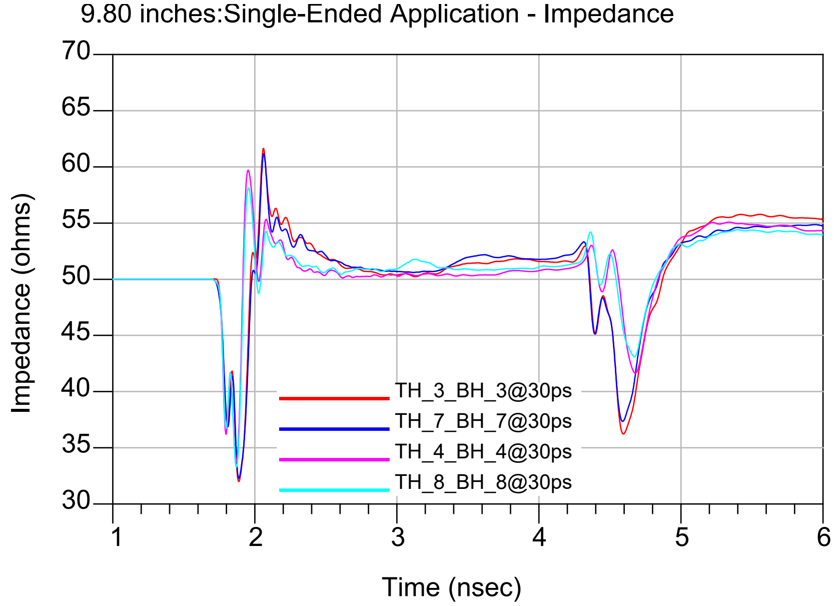

Figure 8

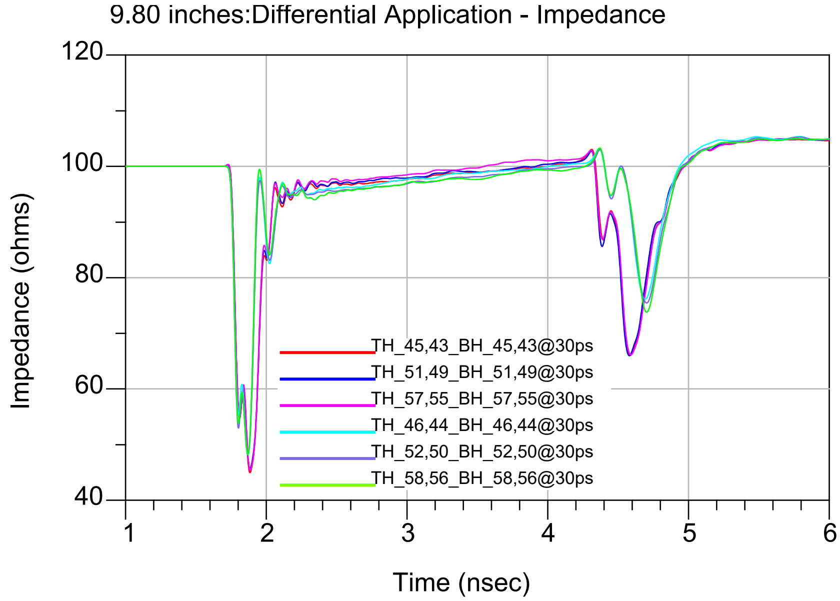

Figure 9

Because the same type of cable is used in cable assemblies with different lengths, only the impedance profile of 9.80 inches cable assembly is reported.

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Table 2 - Propagation Delay (Cable Assembly)				
Driver	**Receiver**	**9.80 inches**	**19.68 inches**	**39.37 inches**
TH_3	BH_3	1.517 ns	2.732 ns	5.140 ns
TH_7	BH_7	1.512 ns	2.723 ns	5.126 ns
TH_4	BH_4	1.523 ns	2.735 ns	5.108 ns
TH_8	BH_8	1.516 ns	2.728 ns	5.113 ns
TH_45,43	BH_45,43	1.506 ns	2.708 ns	5.114 ns
TH_51,49	BH_51,49	1.503 ns	2.700 ns	5.118 ns
TH_57,55	BH_57,55	1.509 ns	2.707 ns	5.121 ns
TH_46,44	BH_46,44	1.527 ns	2.729 ns	5.127 ns
TH_52,50	BH_52,50	1.530 ns	2.722 ns	5.139 ns
TH_58,56	BH_58,56	1.533 ns	2.726 ns	5.141 ns

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Characterization Details

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

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

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

Differential and Single-Ended Data

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

Cable assembly Signal to Ground Ratio

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

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

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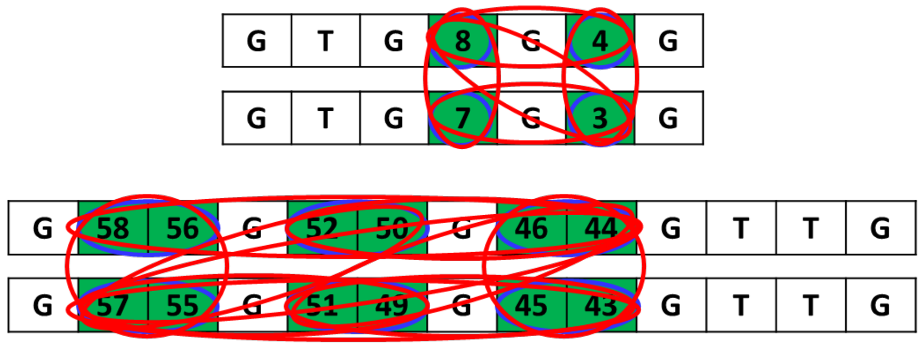
For this cable assembly, the following configurations are evaluated:



<u>Single-Ended and Differential Impedance (denoted by blue circles)</u>**:**

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

<u>Single-Ended and Differential Crosstalk (denoted by red circles)</u>**:**

- 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.

See Appendix C – Product and Test System Descriptions for details

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.

<u>Signal Edge Speed (Rise Time)</u>

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 cable assembly 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.

Unless otherwise stated, measured rise times were at 20%-80% signal levels.

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Frequency Domain Data

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

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

Time Domain Data

Time Domain parameters indicate Impedance mismatch versus length and signal propagation time in a pulsed signal environment. The measured S-Parameters from the network analyzer are post-processed using Keysight ADS to obtain the time domain response for signal propagation time. The Time Domain procedure is provided in Appendix D of this report. Parameters or formats not included in this report may be available upon request. Please contact our Signal Integrity Group at sig@samtec.com for more information.

In this report, propagation delay is defined as the signal propagation time through the cable assembly, mating connectors, and connector footprint. It 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 rise-time. Delay is calculated as the difference in time measured between the 50% amplitude levels of the input and output pulses.

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: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Appendix A – Frequency Domain Responses

Single-Ended Application – Insertion Loss

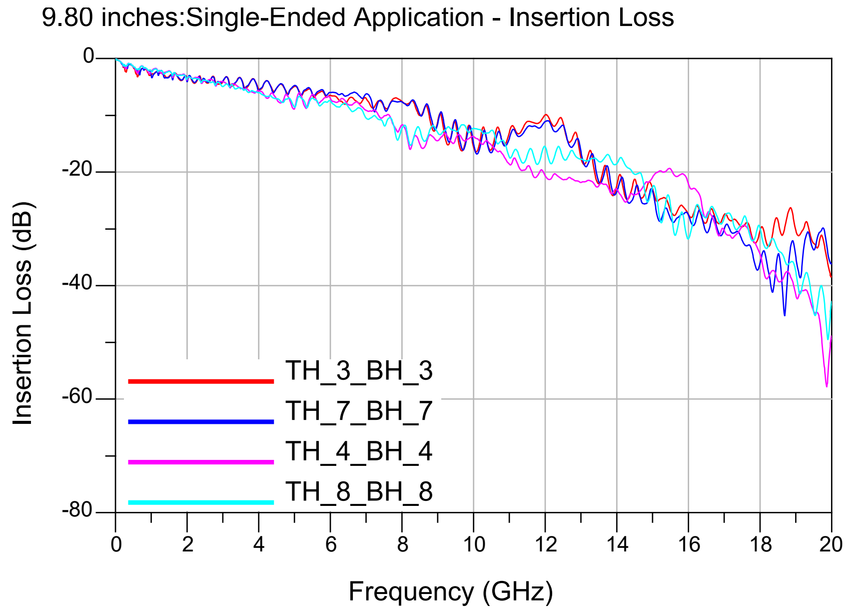

Figure 10

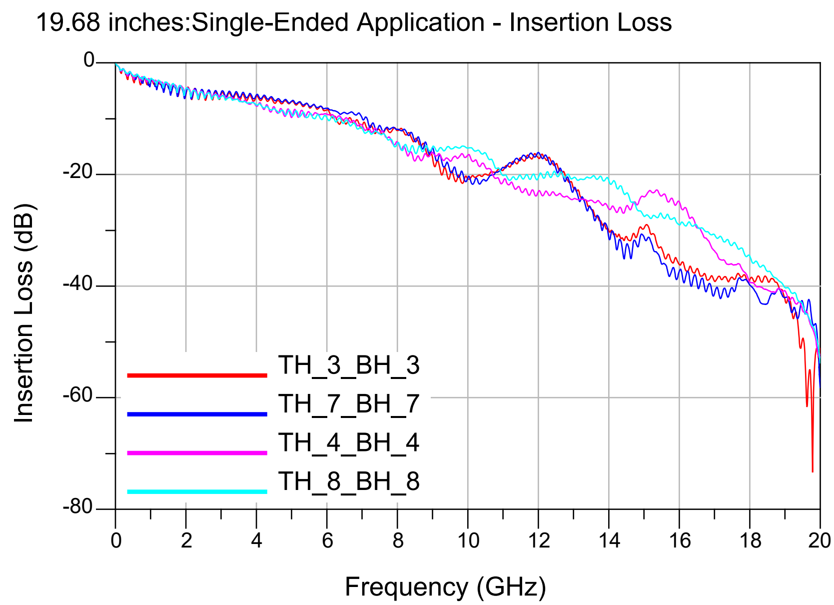

Figure 11

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

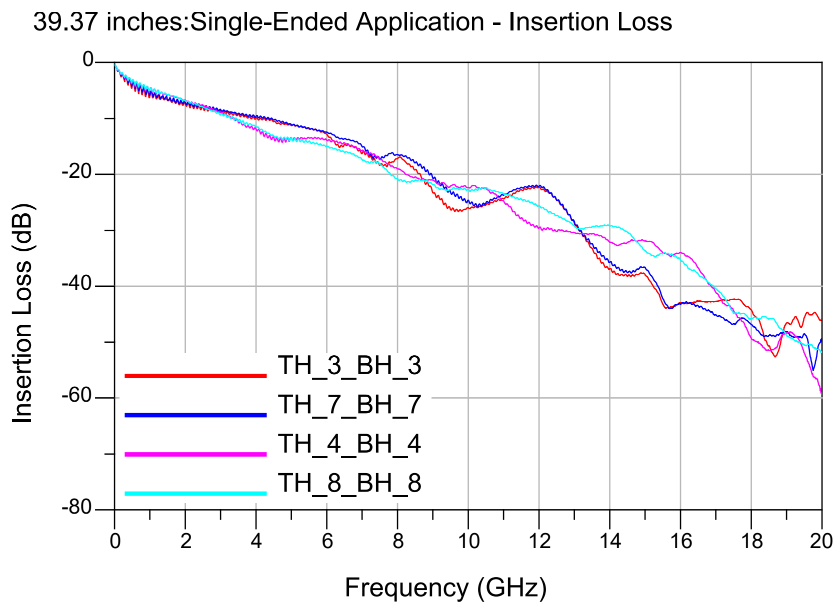

Figure 12

Single-Ended Application – Return Loss

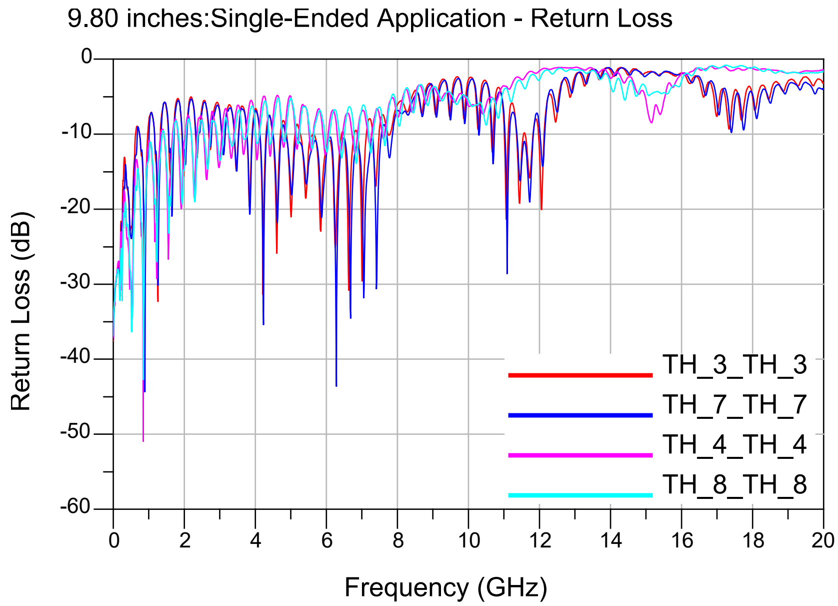

Figure 13

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

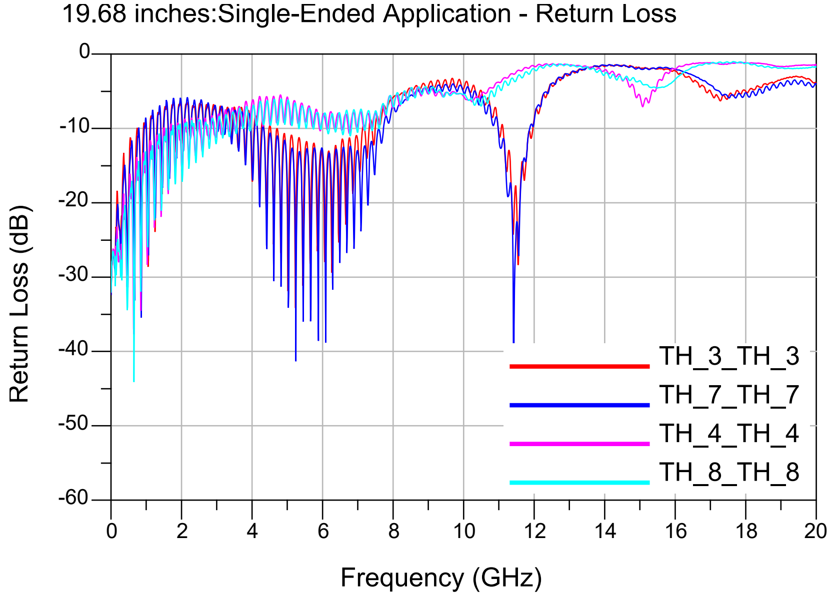

Figure 14

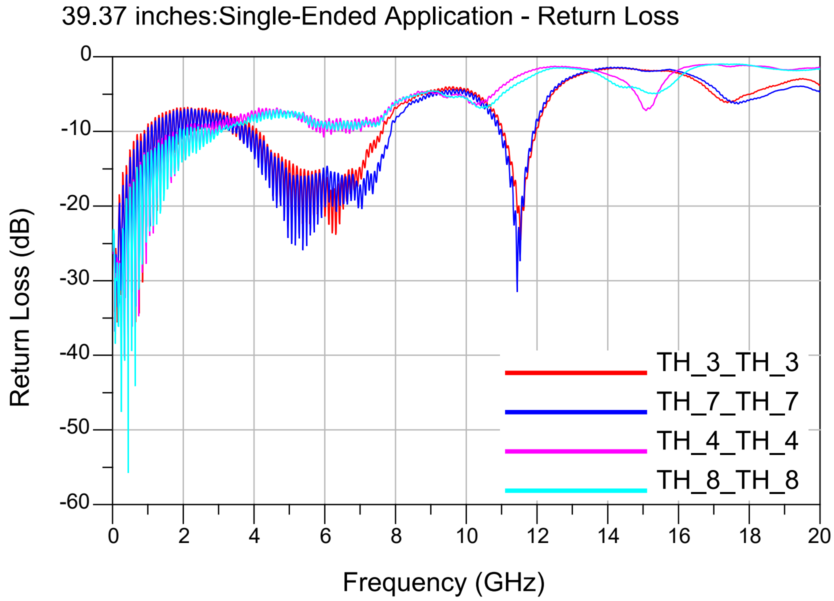

Figure 15

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Single-Ended Application – NEXT Configurations

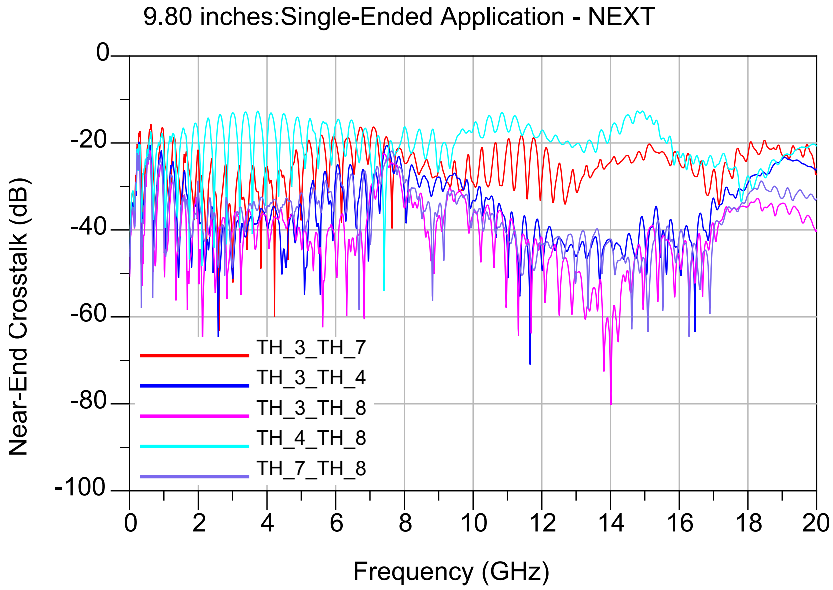

Figure 16

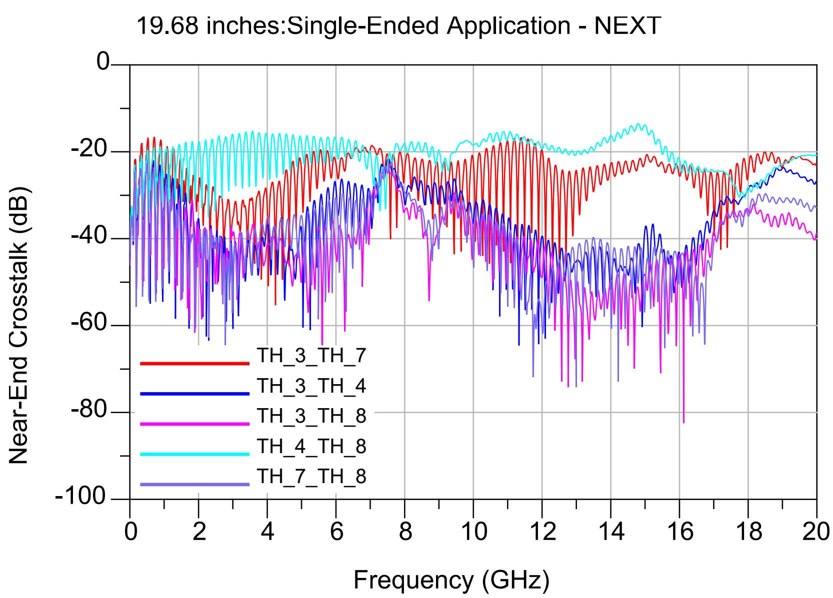

Figure 17

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

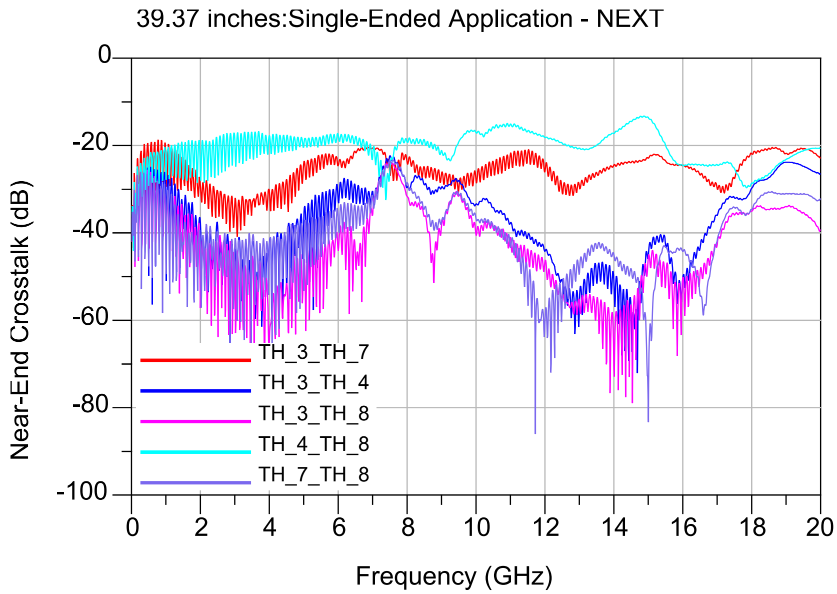

Figure 18

Single-Ended Application – FEXT Configurations

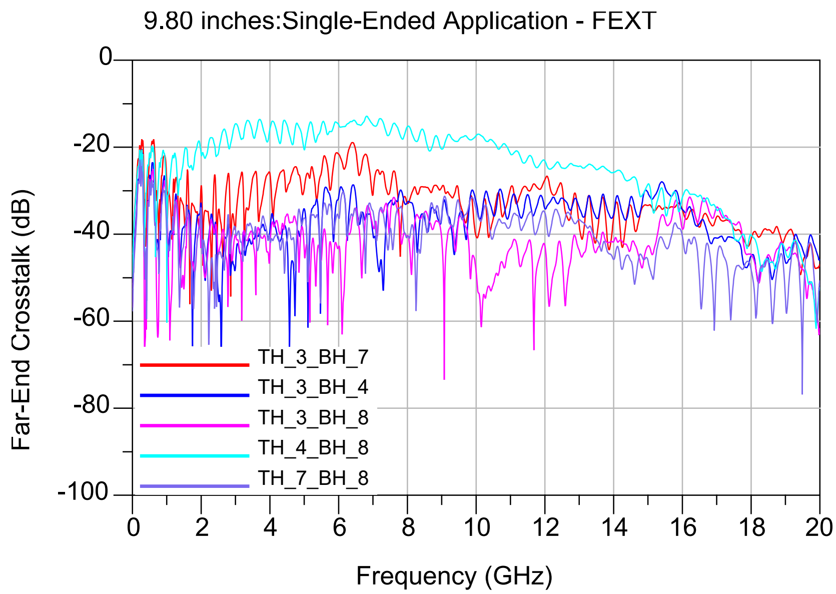

Figure 19

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

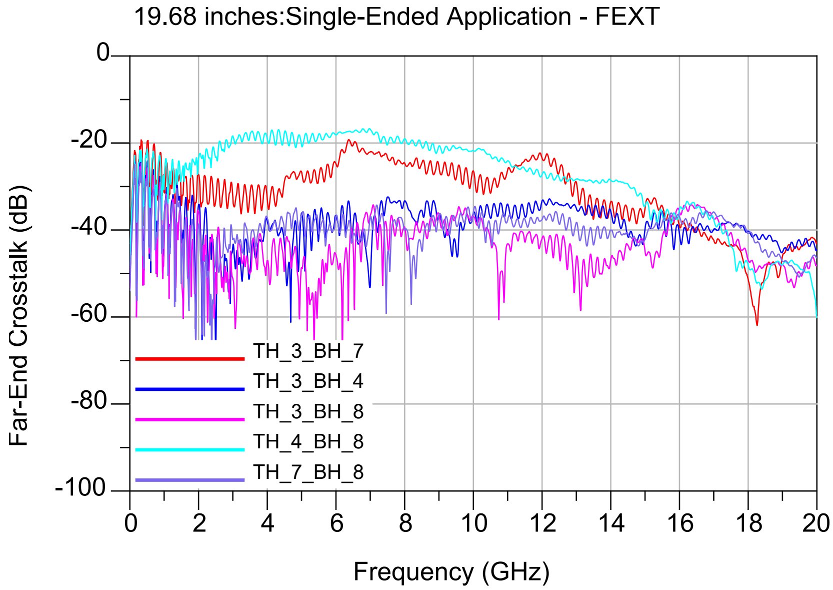

Figure 20

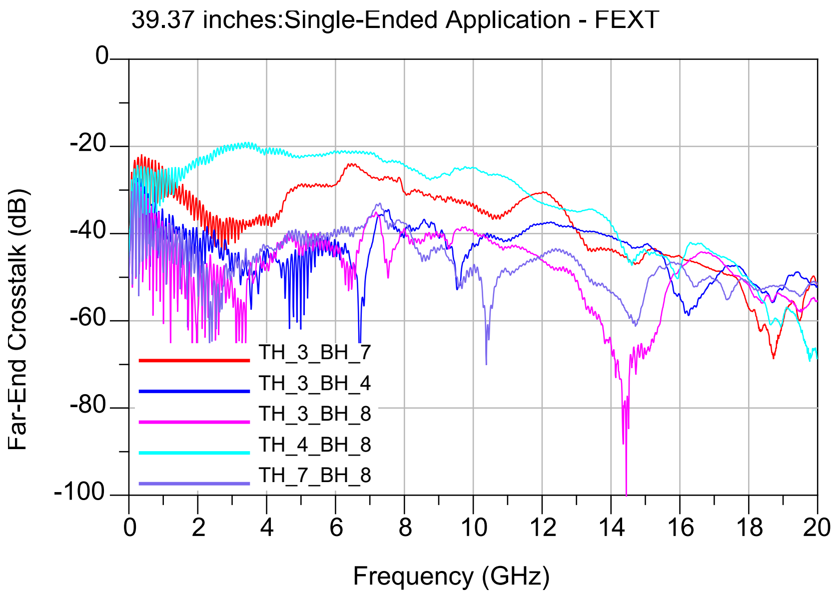

Figure 21

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Differential Application – Insertion Loss

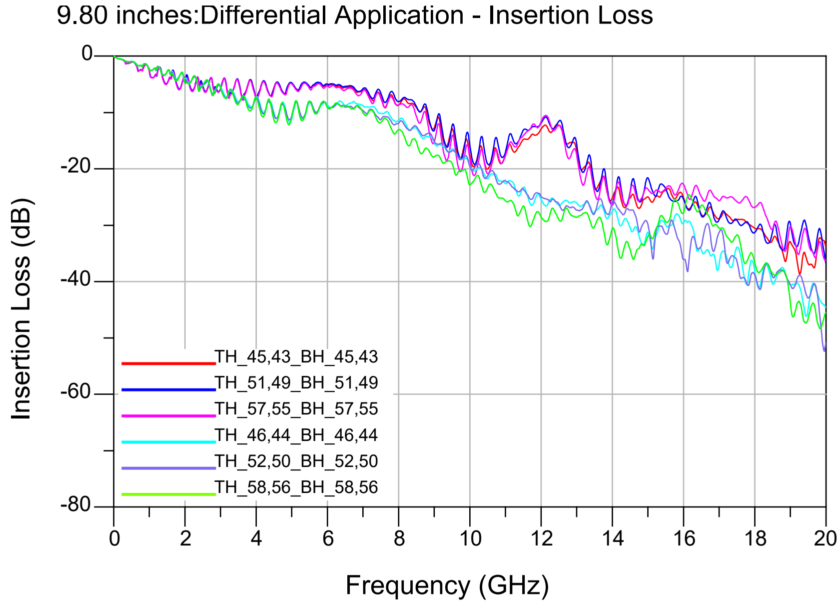

Figure 22

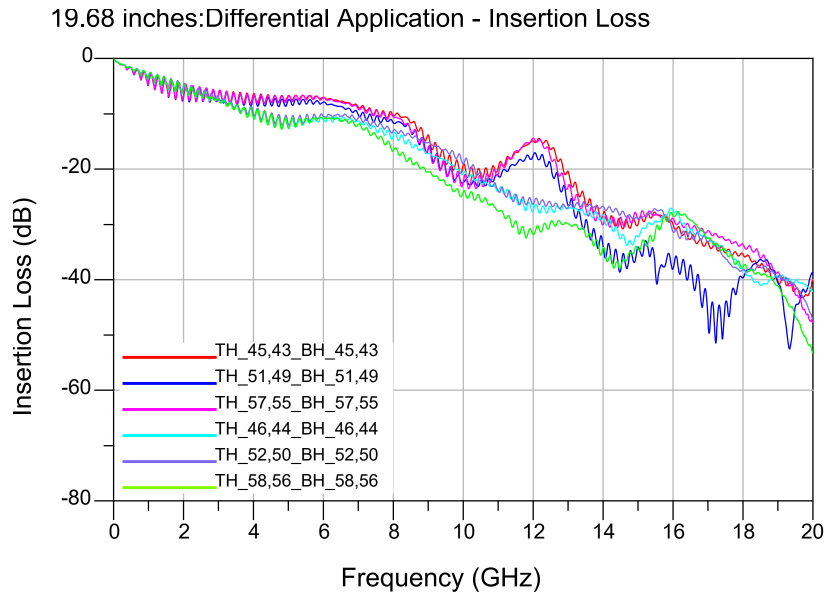

Figure 23

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

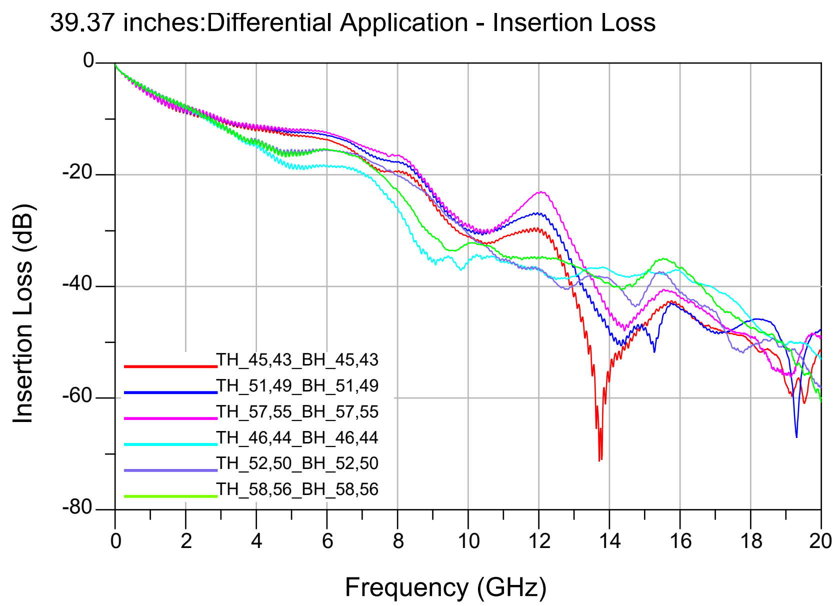

Figure 24

Differential Application – Return Loss

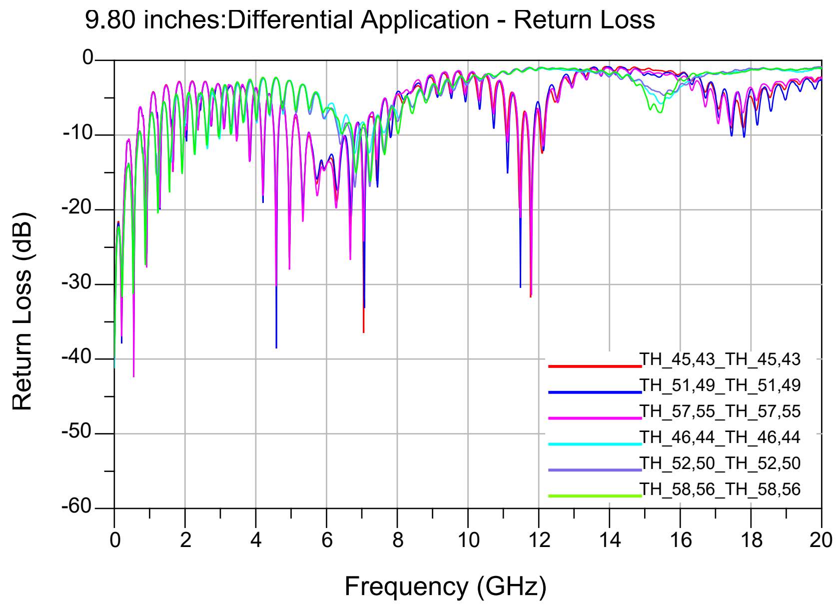

Figure 25

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

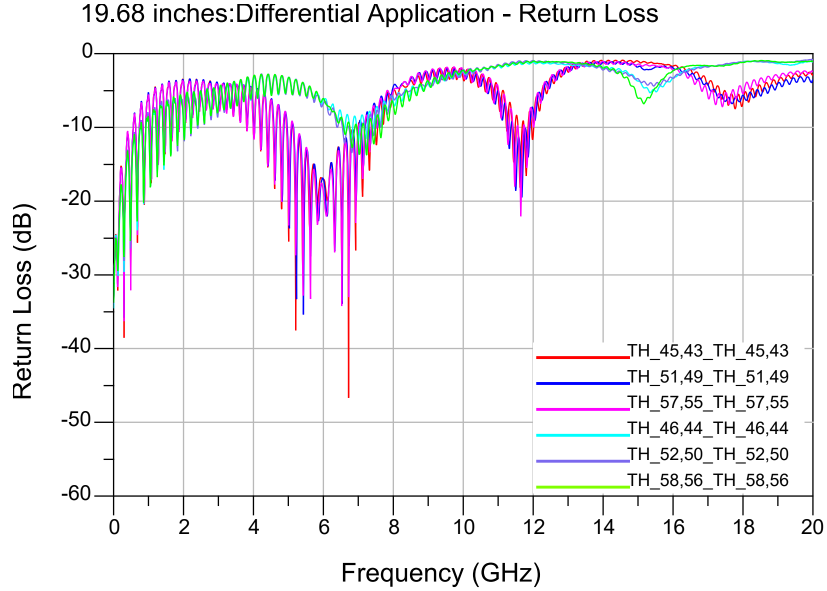

Figure 26

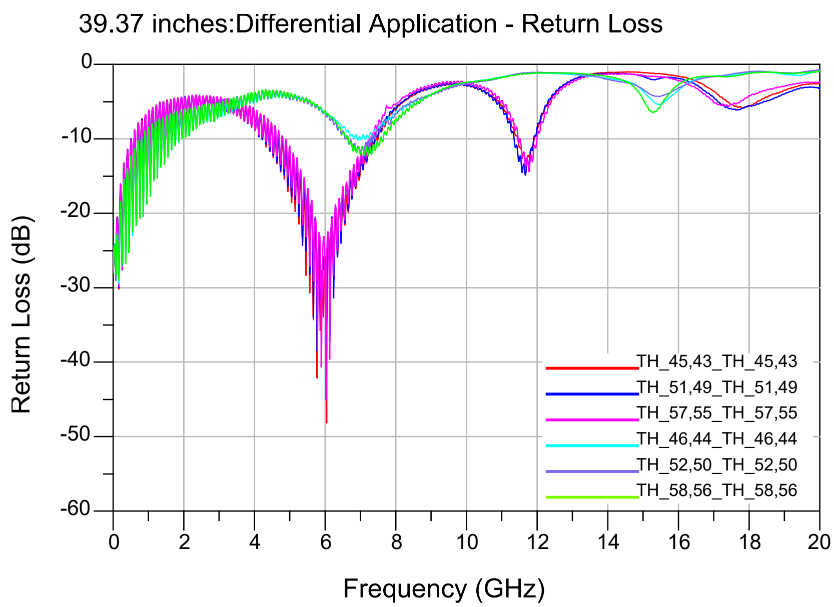

Figure 27

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Differential Application – NEXT Configurations

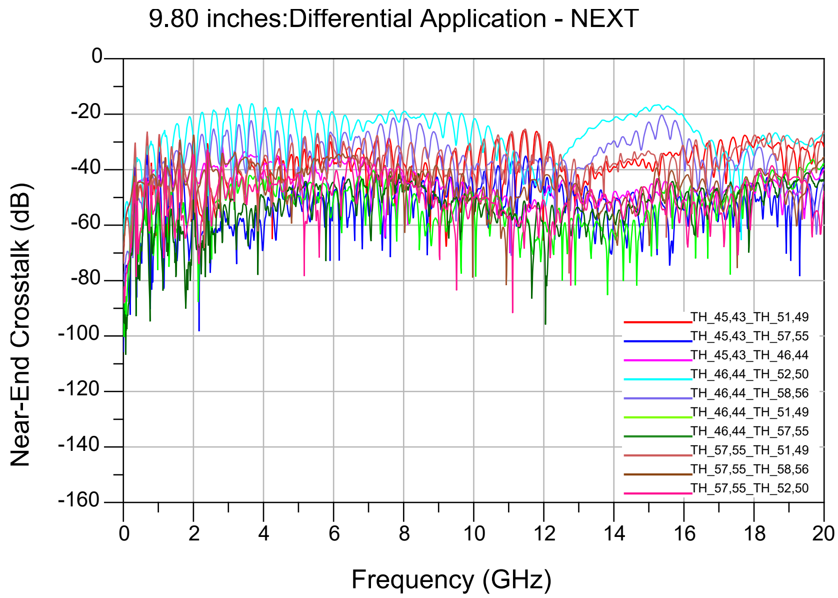

Figure 28

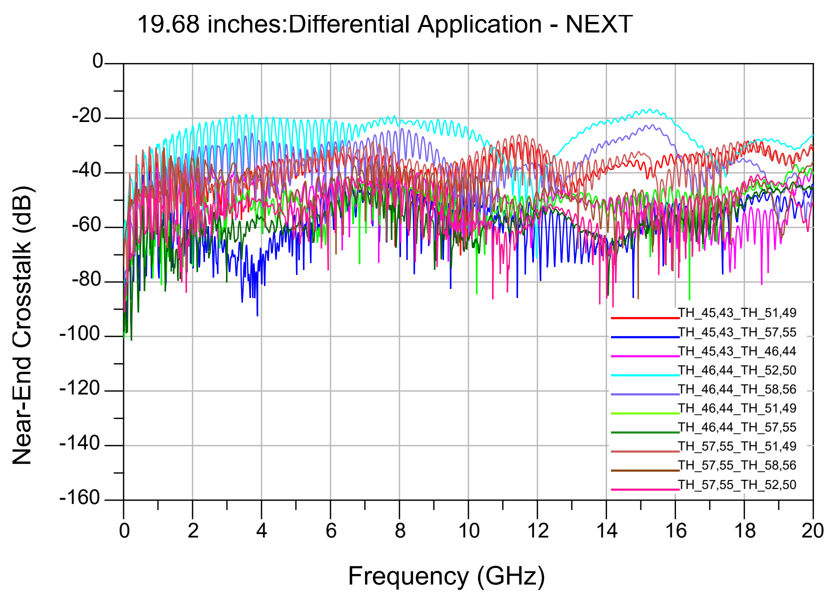

Figure 29

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

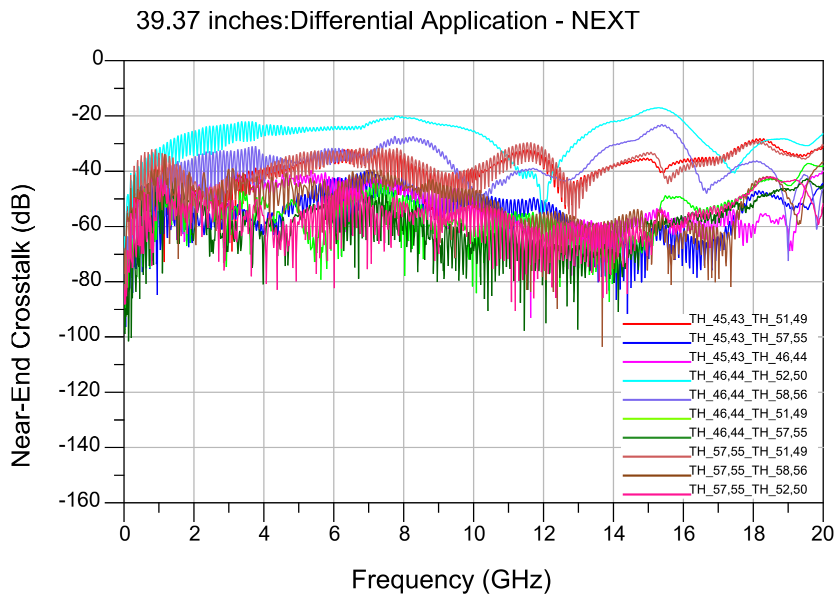

Figure 30

Differential Application – FEXT Configurations

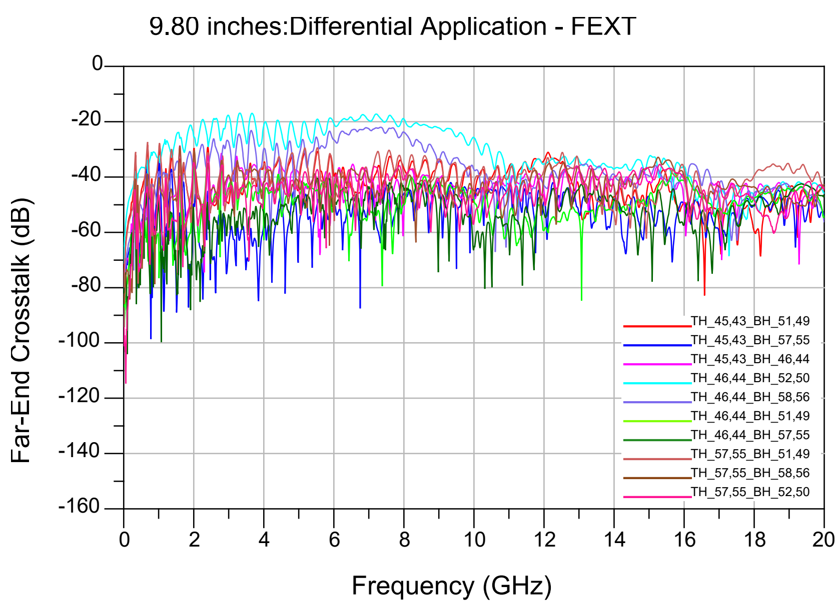

Figure 31

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

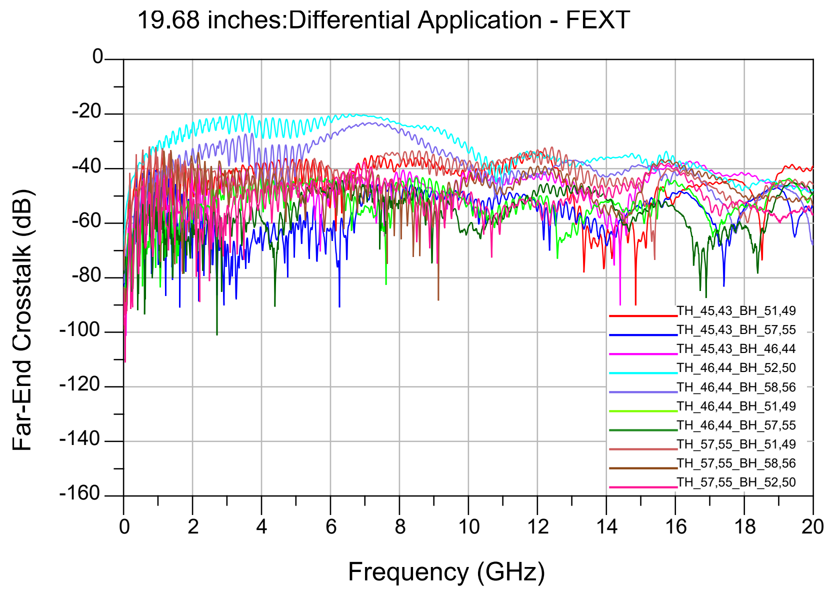

Figure 32

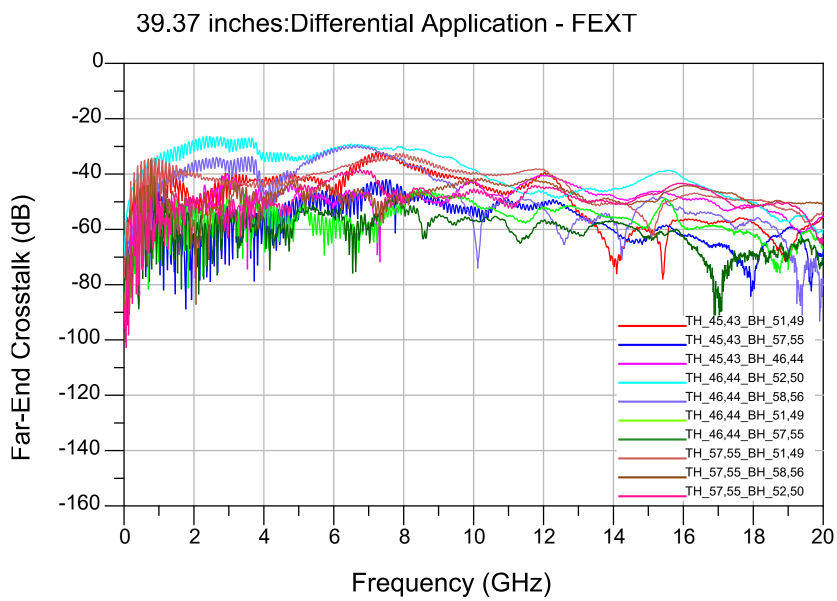

Figure 33

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Differential Application – Differential to Common Mode Conversion

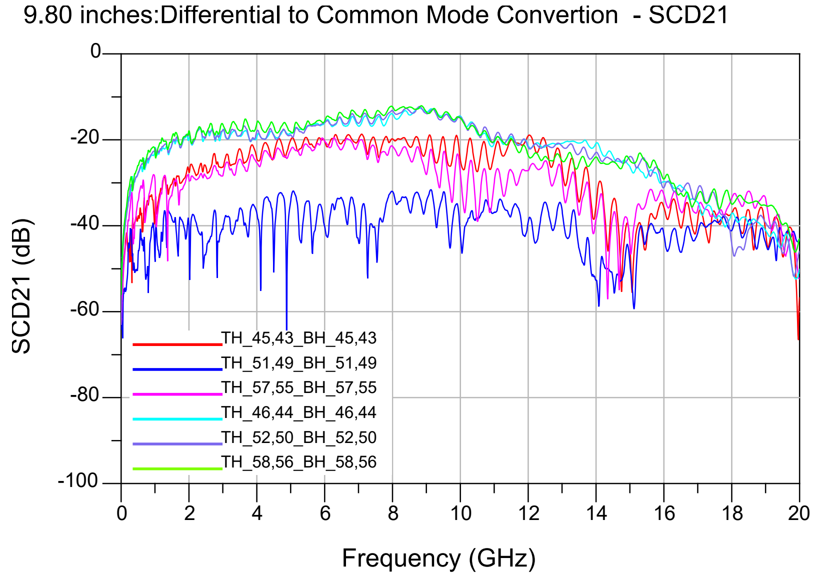

Figure 34

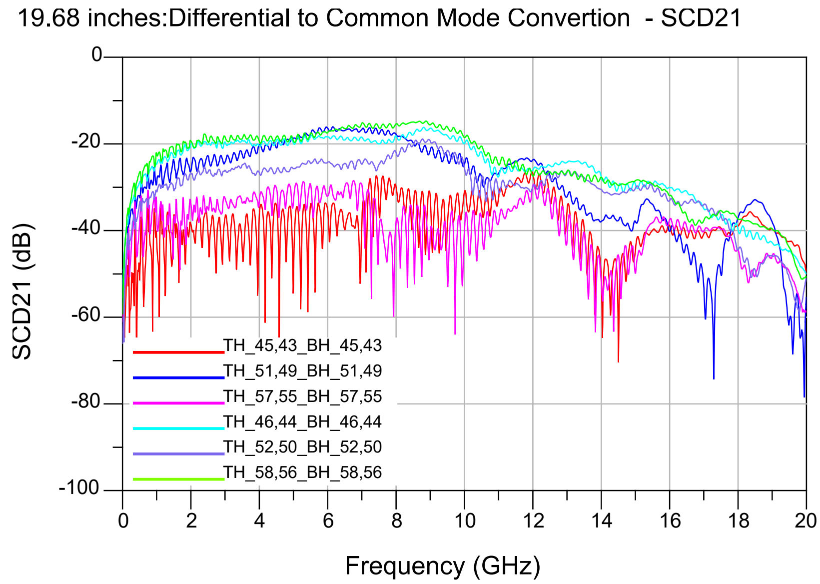

Figure 35

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

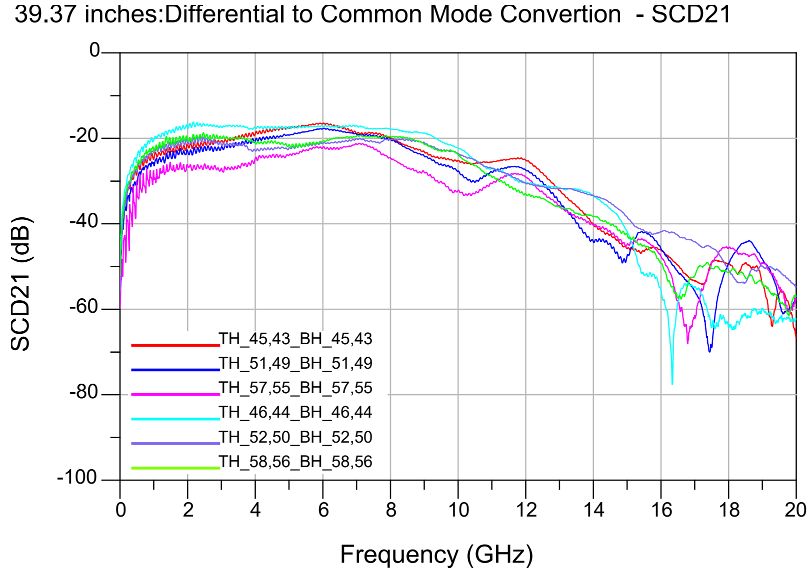

Figure 36

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Appendix B – Time Domain Responses

Single-Ended Application – Input Pulse

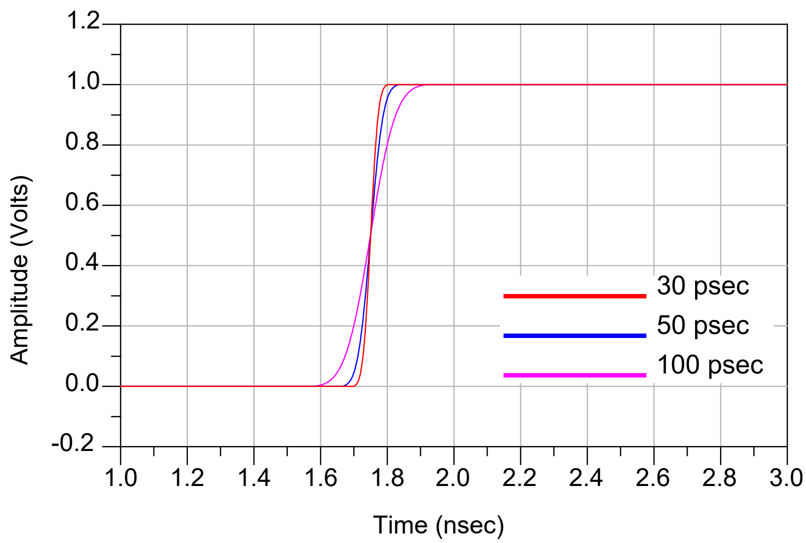

Figure 37

Single-Ended Application – Cable Assembly Impedance Summary

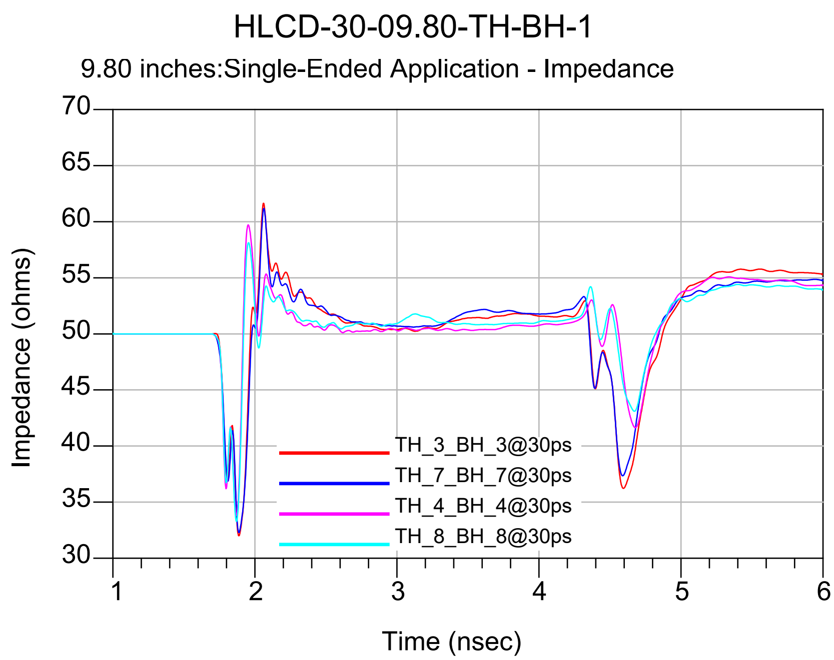

Figure 38

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Single-Ended Application – Cable Assembly Impedance

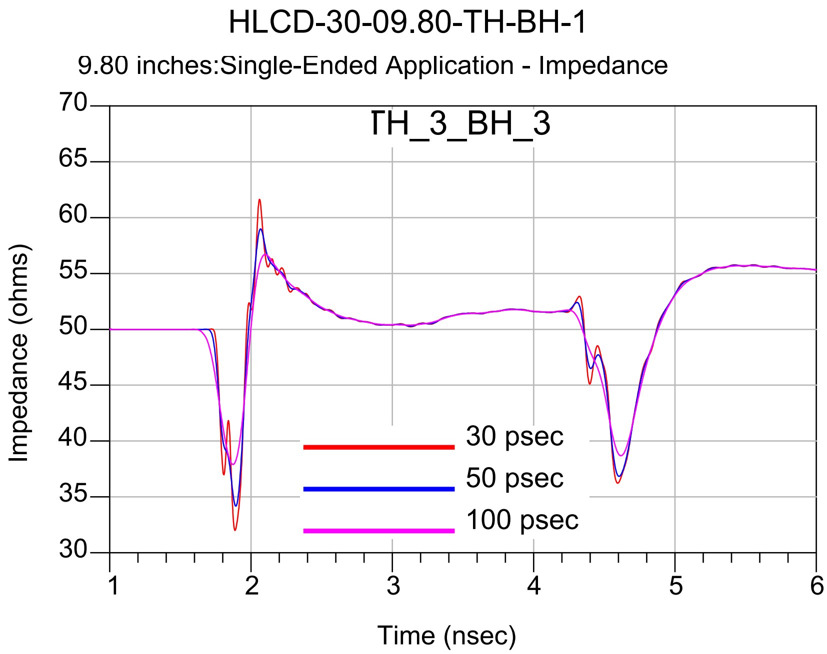

Figure 39

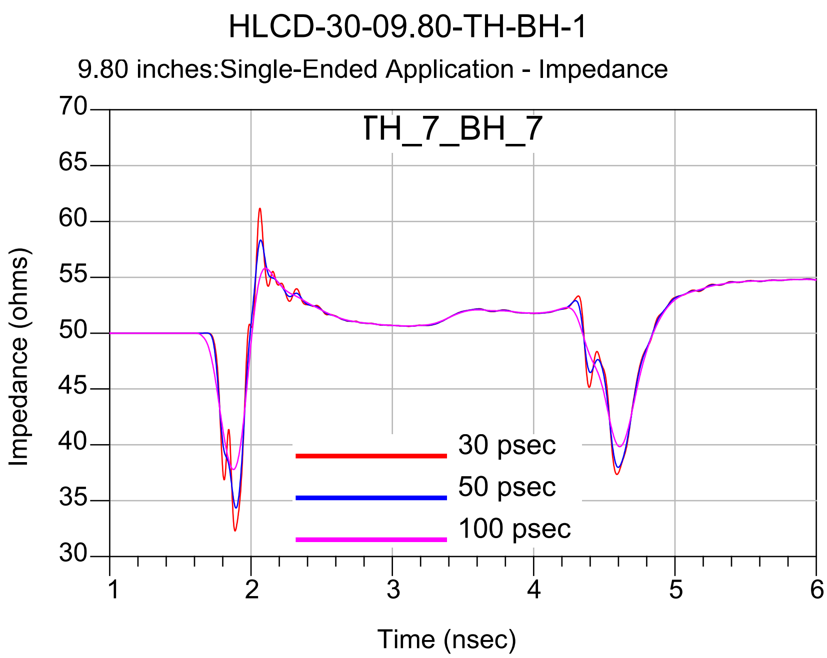

Figure 40

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

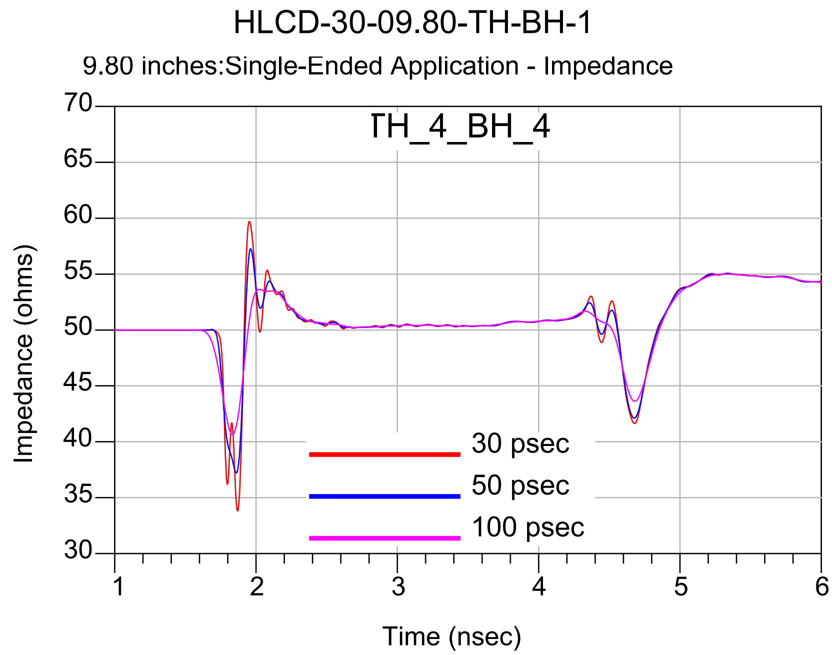

Figure 41

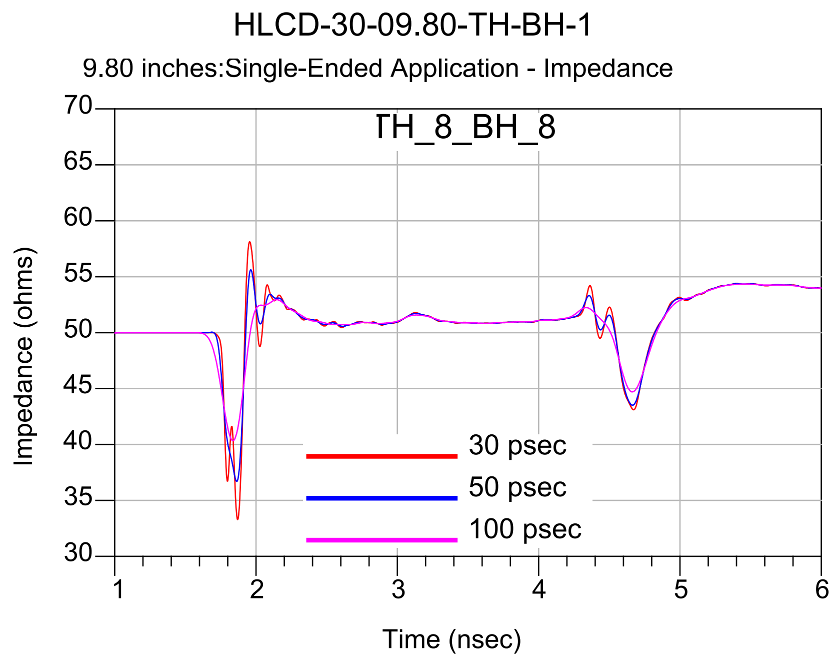

Figure 42

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Single-Ended Application – Propagation Delay

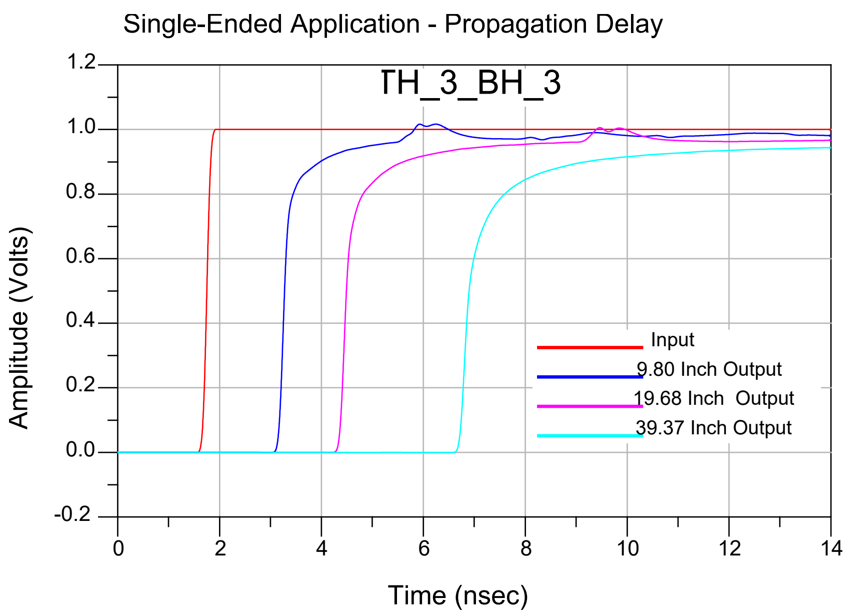

Figure 43

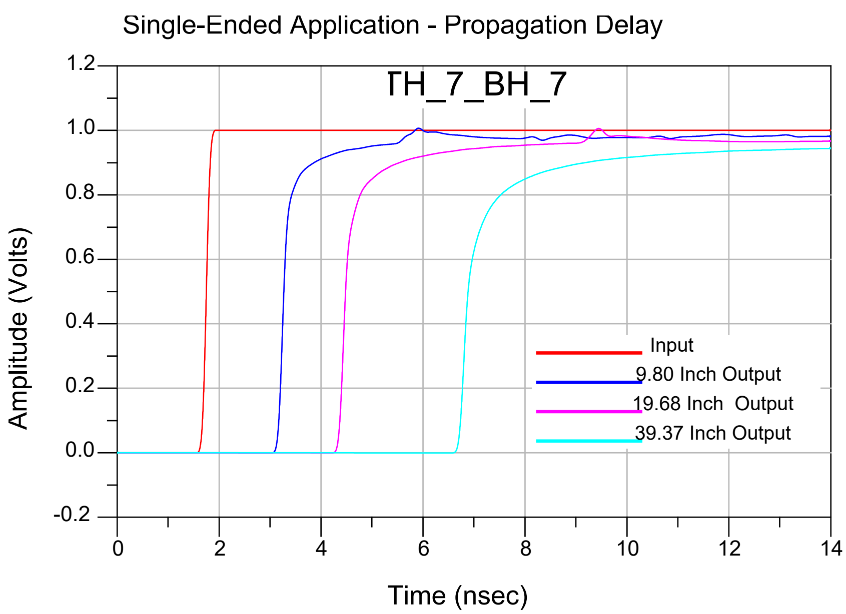

Figure 44

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

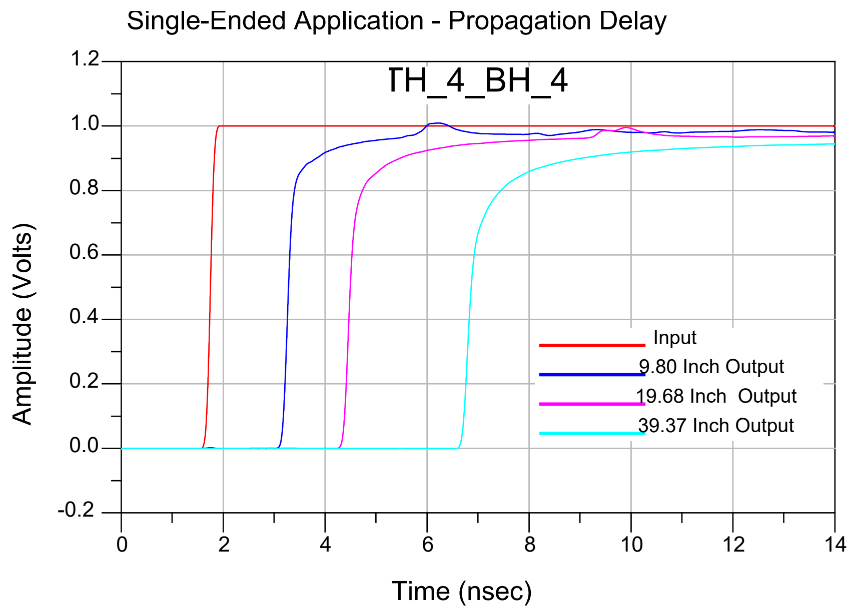

Figure 45

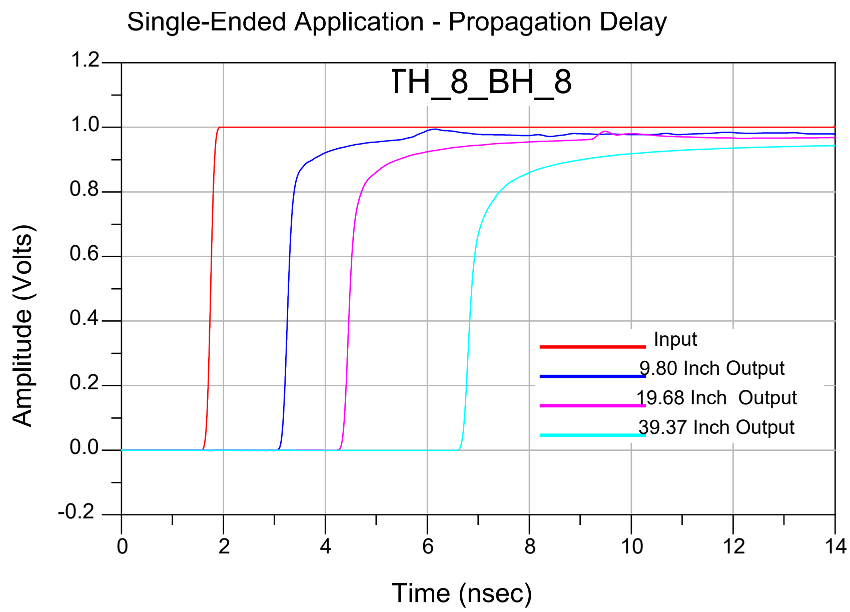

Figure 46

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Differential Application – Input Pulse

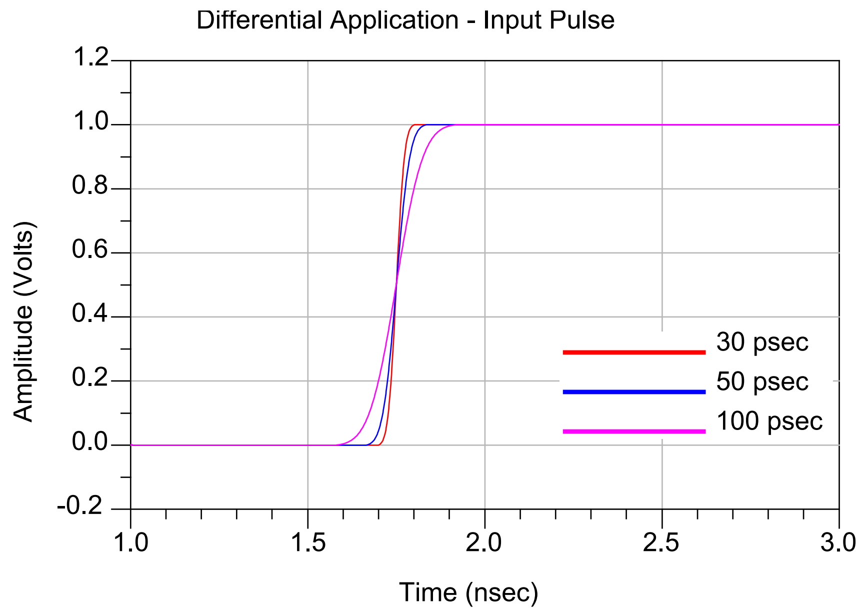

Figure 47

Differential Application – Cable Assembly Impedance Summary

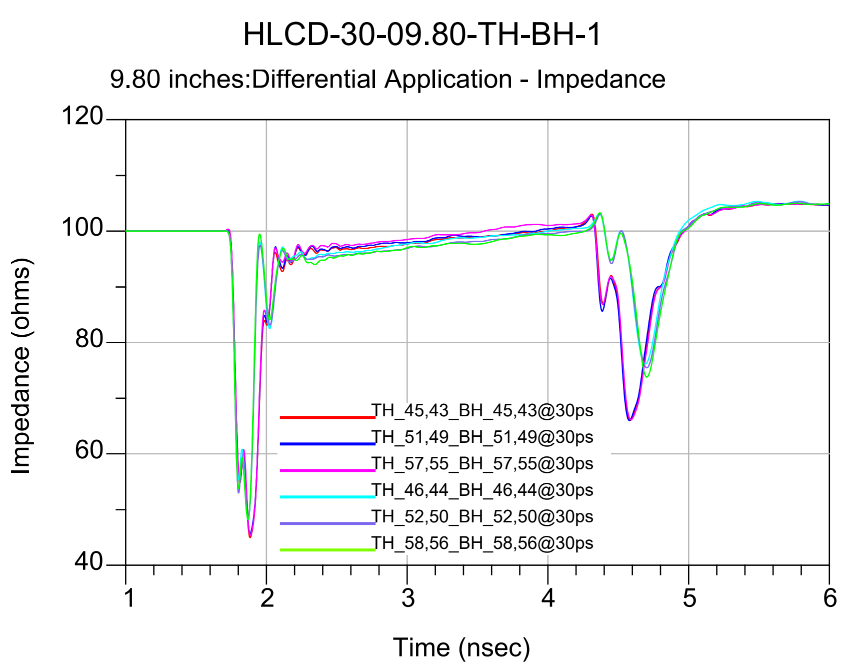

Figure 48

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Differential Application – Cable Assembly Impedance

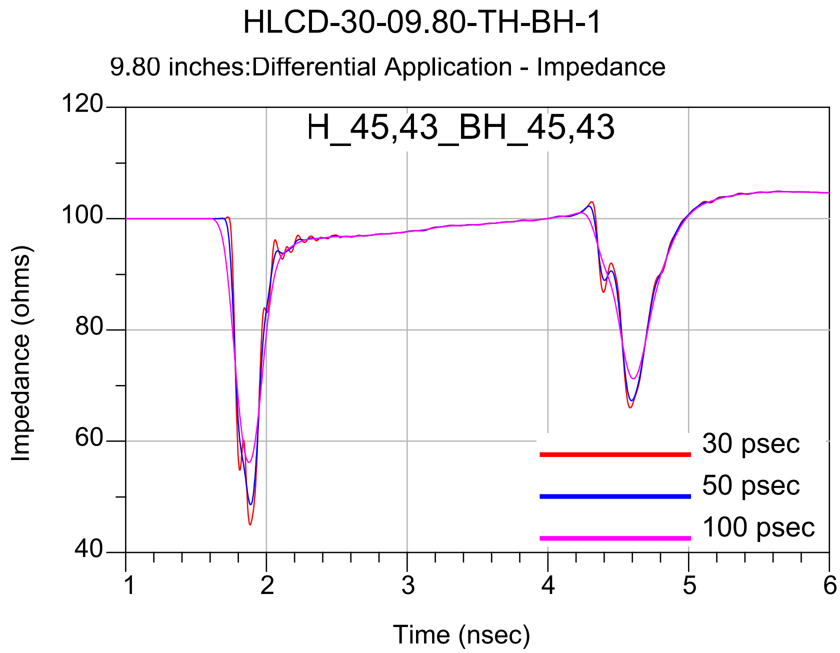

Figure 49

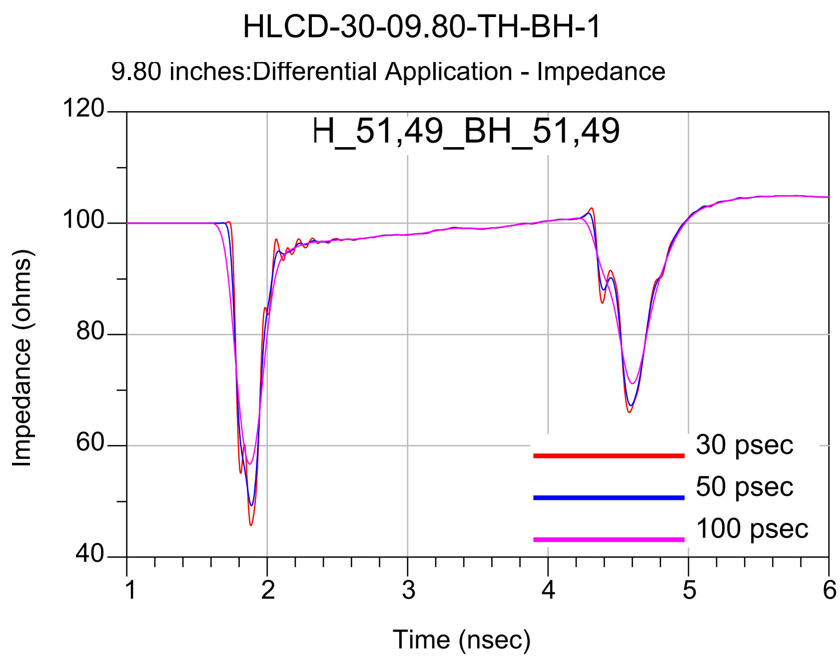

Figure 50

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

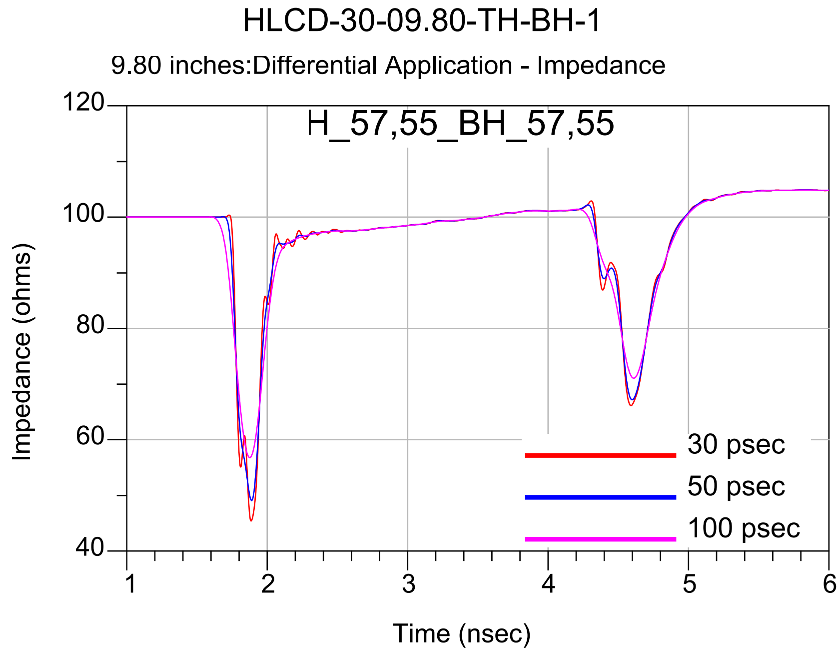

Figure 51

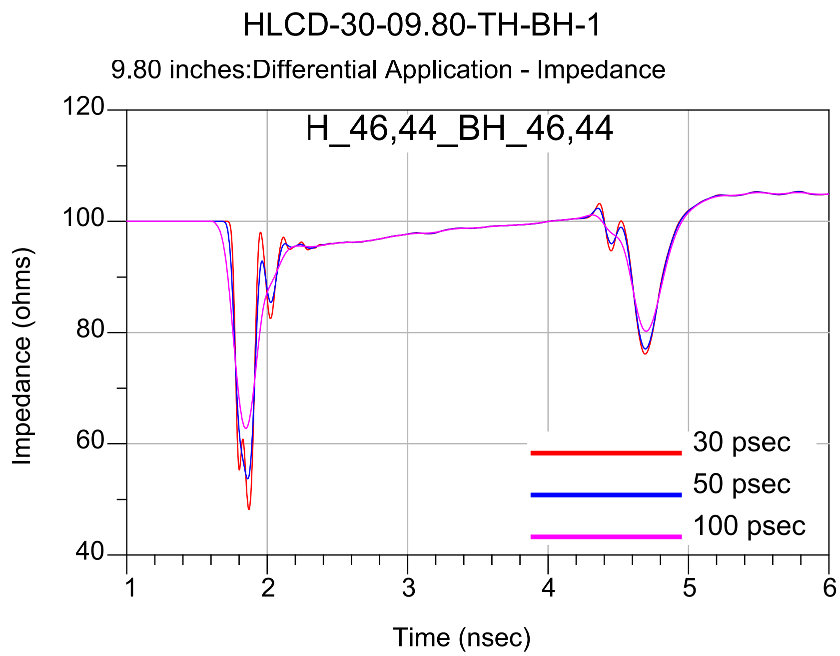

Figure 52

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

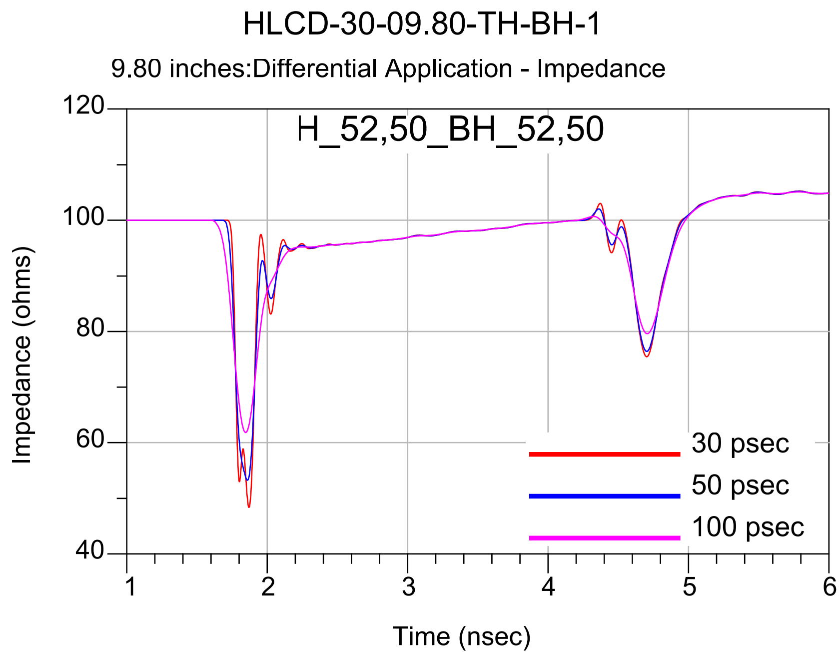

Figure 53

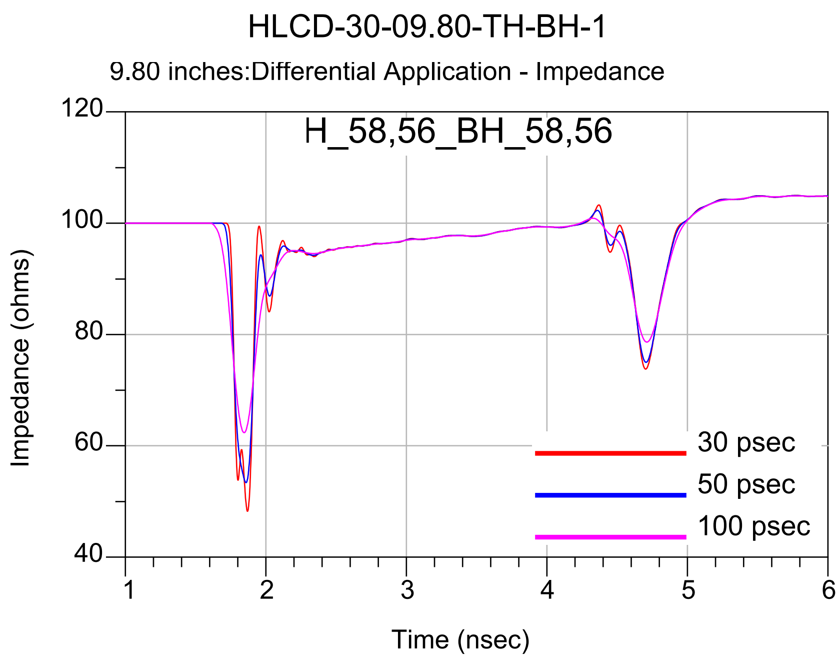

Figure 54

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Differential Application – Propagation Delay

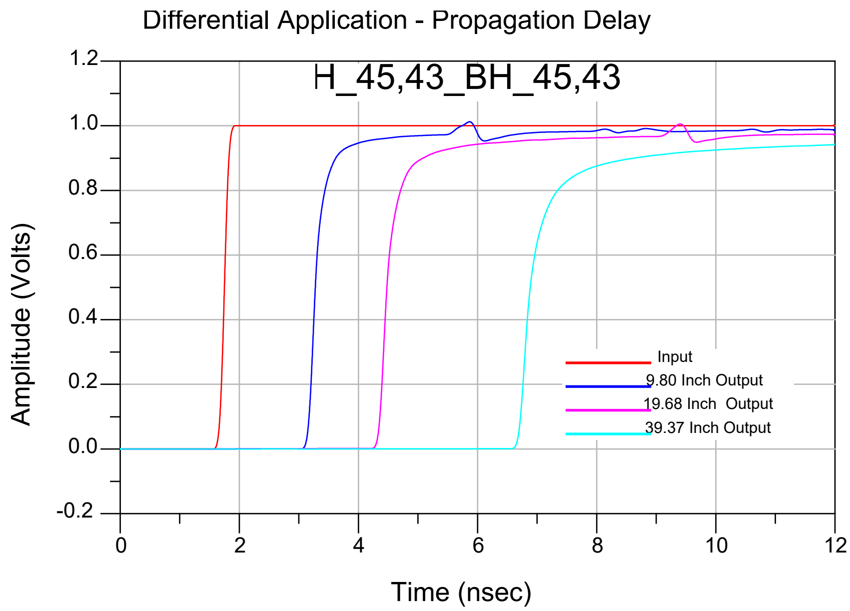

Figure 55

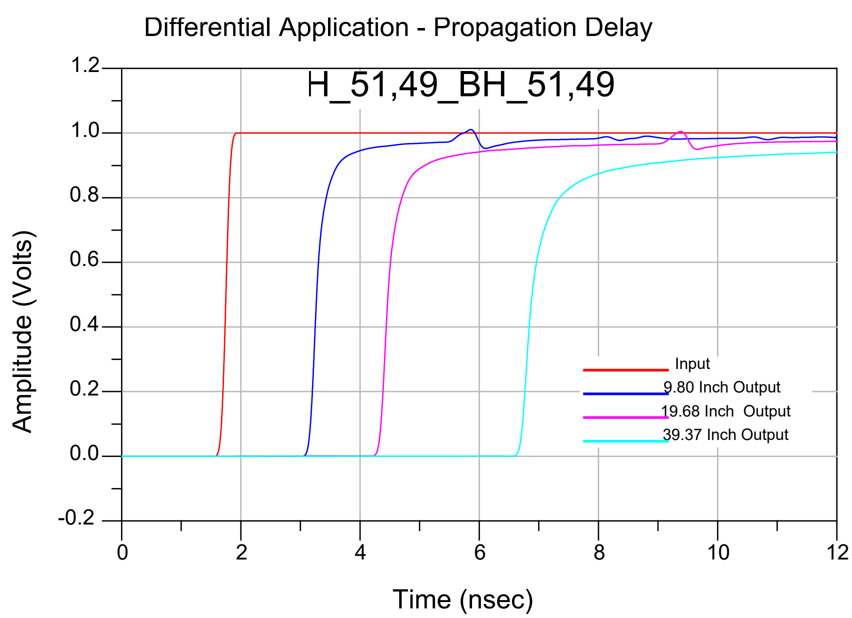

Figure 56

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

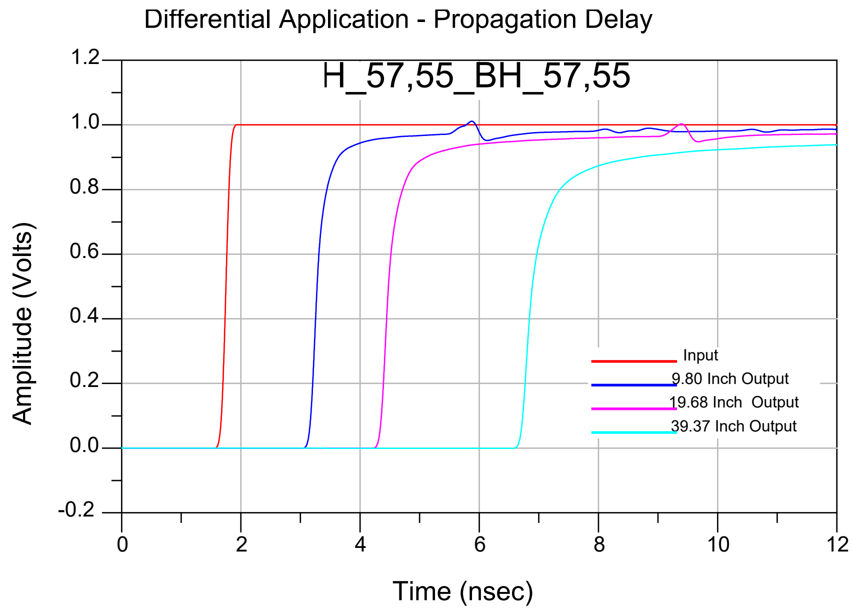

Figure 57

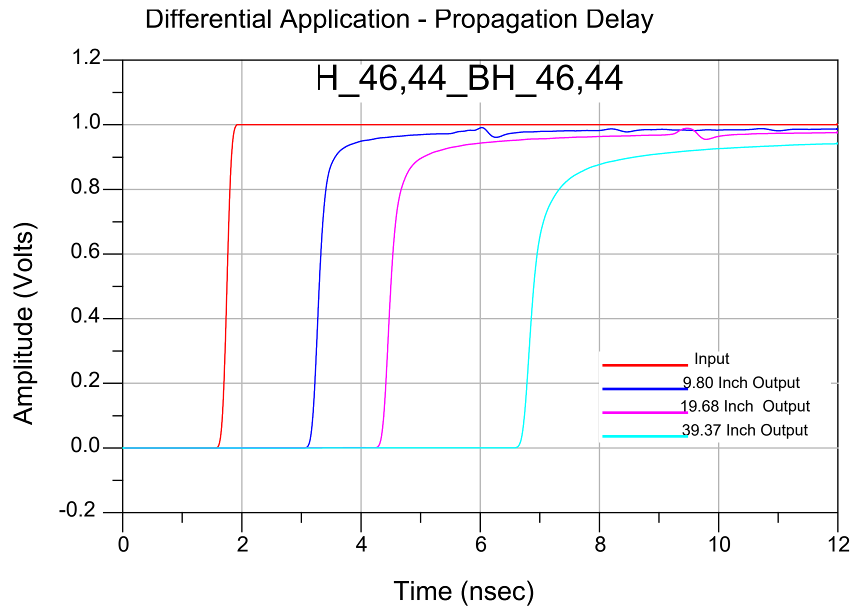

Figure 58

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: 2/27/2025

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

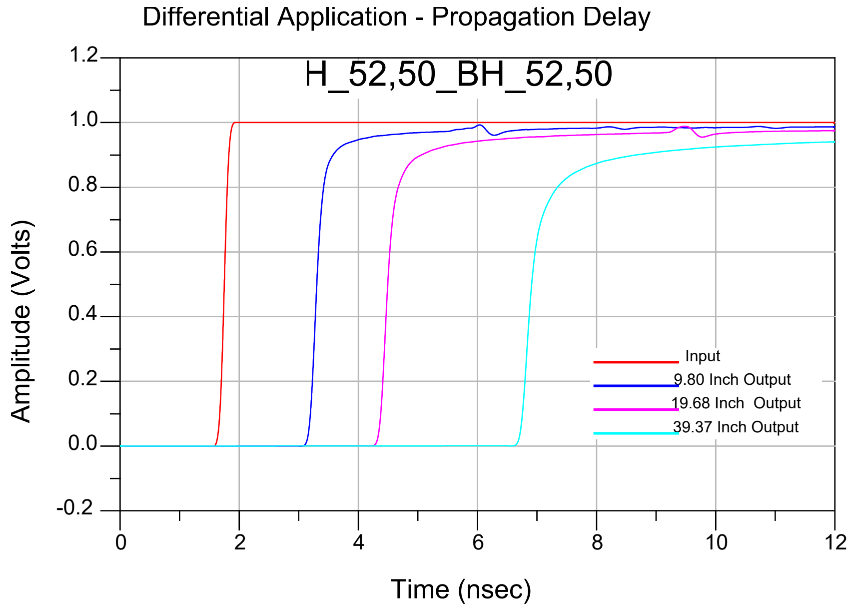

Figure 59

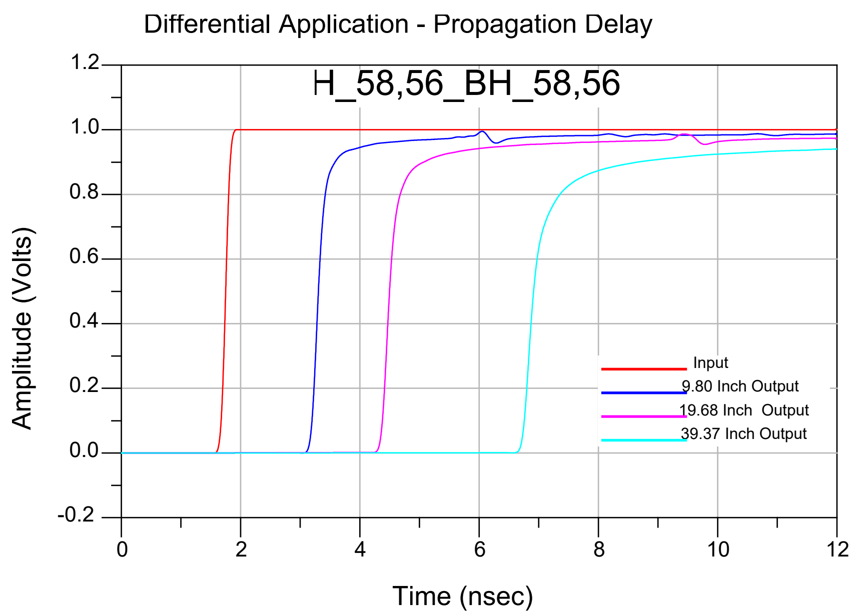

Figure 60

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Appendix C – Product and Test System Descriptions

Product Description

Product test samples are 0.50 mm (.0197") pitch HLCD Cable Assemblies. The part numbers are HLCD-30-09.80-TH-BH-1, HLCD-30-19.68-TH-BH-1 and HLCD-30-39.37-TH-BH-1, they mate with LSHM-130-02.5-X-DV-A-S. The cable assembly consists of two micro-coaxial ribbon cables that contain 30 lines each. A photo of the mated test article mounted to SI test boards is shown below.

The coax cable assembly terminations had a particular signal line configuration. The respective signal line numbers are shown in table 3 below. There is a total of 30 positions per row. 2.4mm jack numbers on the test boards correspond to the assembly line numbers. All adjacent lines are terminated where applicable.

1	**3**	5	**7**	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	**43**	**45**	47	**49**	**51**	53	**55**	**57**	59
2	**4**	6	**8**	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	**44**	**46**	48	**50**	**52**	54	**56**	**58**	60

Table 3: Respective signal line numbers as viewed from End 1

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. Displayed on the following pages is information for the HLCD/AFR calibration structure and directives for mating HLCD fixtures.

PCB-LSHMDV-112313-SIG-0 Test Fixtures

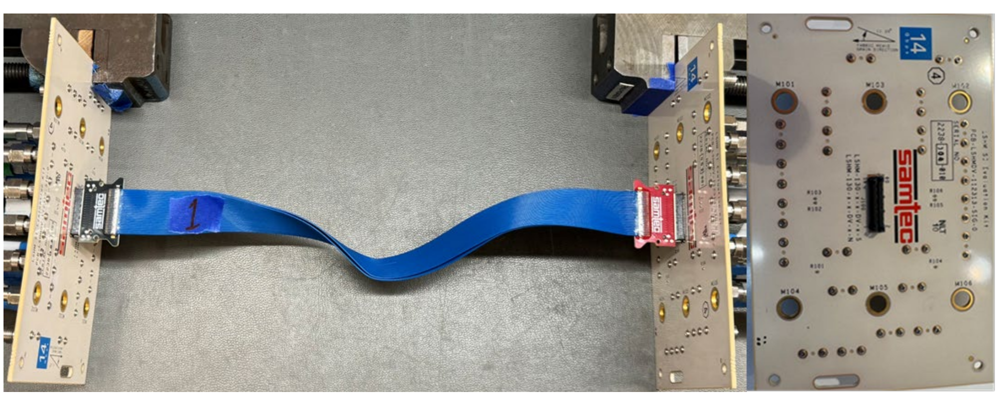

Figure 61

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

PCB Fixtures

The test fixtures used are as follows:

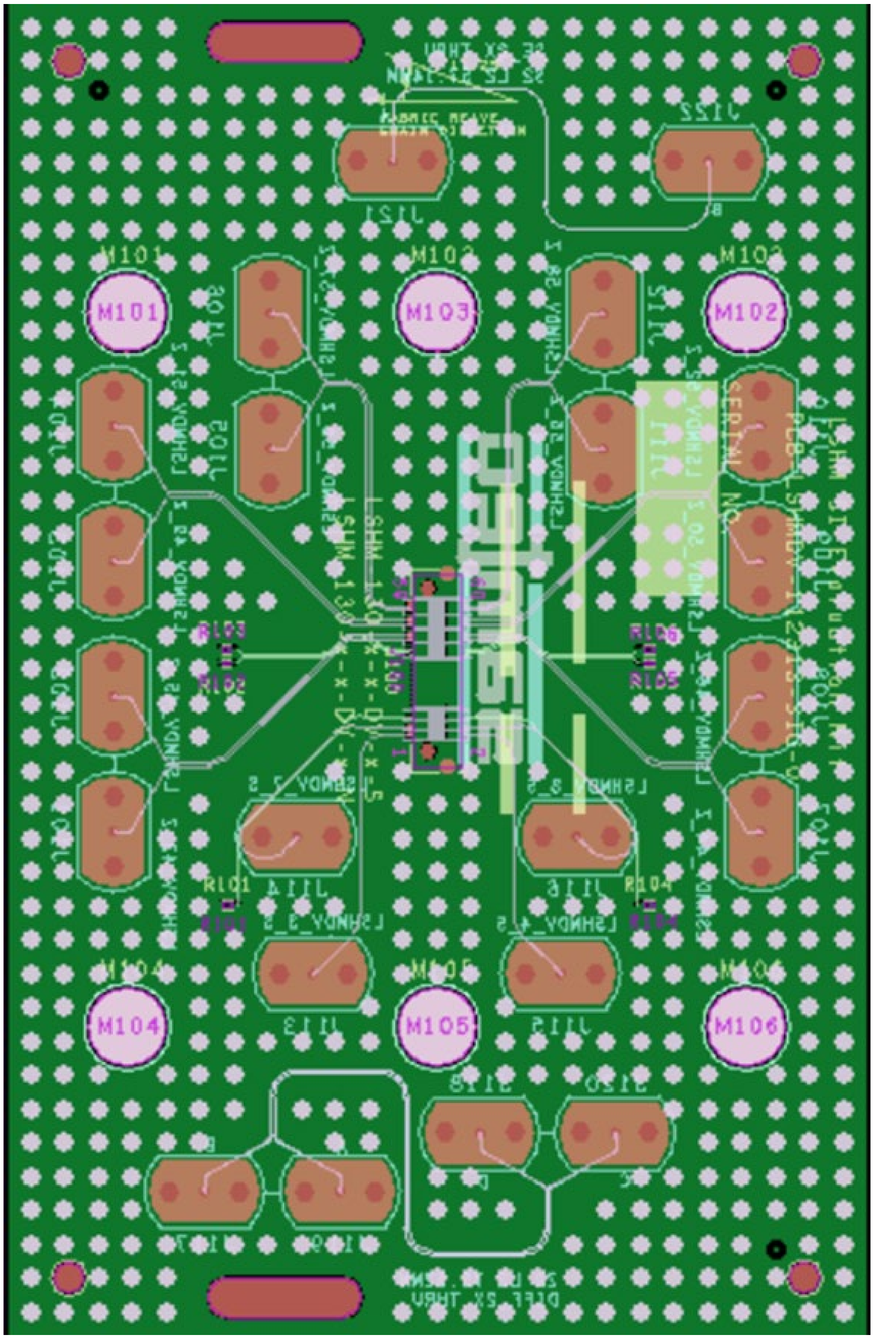

Figure 62

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

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 – 20 GHz
Number of points – 2000
IFBW – 1 KHz

N5225B Measurement Setup

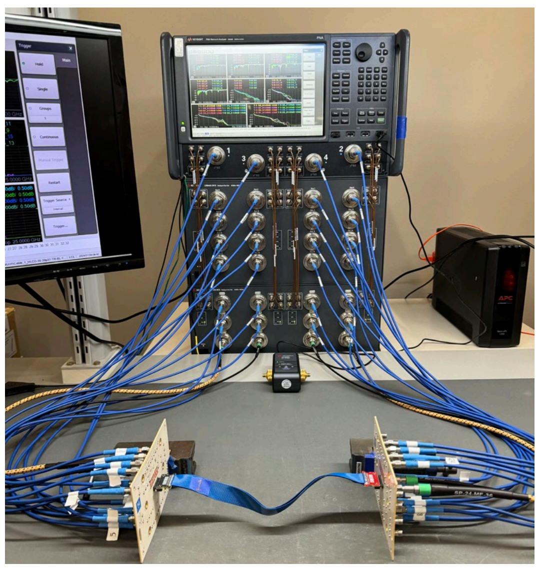

Figure 63

Test Instruments

QTY	Description
1	Keysight N5225B PNA Network Analyzer
1	1.85mm e-cal N4694-60003

Test Cables & Adapters

QTY	Description
32	1m Junkosha 2.4mm male to female cables

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm 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 AFR calibration standards, the SI test boards and the selection of the PCB vendor.

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

Time Domain Procedures

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

The Time Domain responses were generated using Keysight ADS 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/Documents/WebFiles/Technical_Library/Reference/Articles/tech-note_using-PLTS-for-time-domain-data_web.pdf

Propagation Delay (TDT)

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

Series: HLCD-TH-BH-1
Description: High Speed Hermaphroditic Cable, 0.50mm 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 impedance measurements in this report.

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

Appendix F – Glossary of Terms

ADS – Keysight Advanced Design System
AFR – Automatic Fixture Removal
PCB – Printed Circuit Board
SUT – System Under Test
SOLT – acronym used to define Short, Open, Load & Thru Calibration Standards
TDR – Time Domain Reflectometry
TDT – Time Domain Transmission