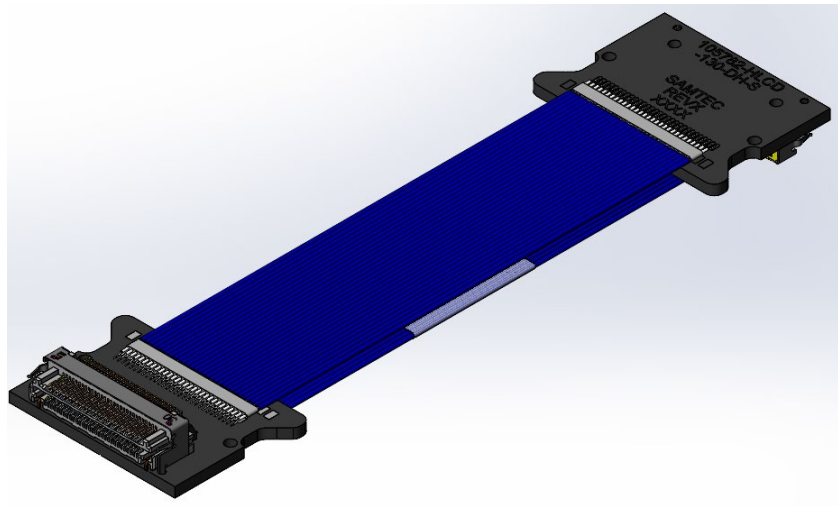




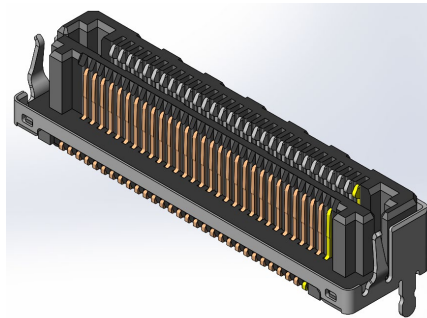
High Speed Characterization Report

HLCD-30-XX. XX-TD-BD-2



Mated with:

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



Description:

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

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch

Table of Contents

Cable Assembly Overview	1
Frequency Domain Data Summary	2
Bandwidth Figures – Single-Ended Insertion Loss	2
Bandwidth Figures – Differential Insertion Loss	3
Time Domain Data Summary	5
Characterization Details	7
Differential and Single-Ended Data	7
Cable assembly Signal to Ground Ratio	7
Frequency Domain Data	9
Time Domain Data	9
Appendix A – Frequency Domain Responses	10
Single-Ended Application – Insertion Loss	10
Single-Ended Application – Return Loss	11
Single-Ended Application – NEXT Configurations	13
Single-Ended Application – FEXT Configurations	14
Differential Application – Insertion Loss	16
Differential Application – Return Loss	17
Differential Application – NEXT Configurations	19
Differential Application – FEXT Configurations	20
Differential Application – Differential to Common Mode Conversion	22
Appendix B – Time Domain Responses	24
Single-Ended Application – Input Pulse	24
Single-Ended Application – Cable assembly Impedance	24
Single-Ended Application – Cable assembly Impedance	25
Single-Ended Application – Propagation Delay	27
Differential Application – Input Pulse	29
Differential Application – Cable assembly Impedance	29
Differential Application – Cable assembly Impedance	30
Differential Application – Propagation Delay	33
Appendix C – Product and Test System Descriptions	36
Product Description	36
Test System Description	36
PCB-LSHMDV-112313-SIG-0 Test Fixtures	36
PCB Fixtures	37
Appendix D – Test and Measurement Setup	38
N5225B Measurement Setup	38
Test Instruments	38
Test Cables & Adapters	38
Appendix E - Frequency and Time Domain Measurements	39
Frequency (S-Parameter) Domain Procedures	39
Time Domain Procedures	39
Propagation Delay (TDT)	39
Impedance (TDR)	40
Appendix F – Glossary of Terms	40

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

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 right-angle LSHM-DH 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-TD-BD-2 assembly is wired to facilitate a Pin 1 to Pin 2 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. Both ends of the HLCD-30-XX.XX-TD-BD-2 have a black transition PCB.

Length	Part Number	End 1	End 2
9.80 inches	HLCD-30-09.80-TD-BD-2	TD	BD
19.68 inches	HLCD-30-19.68-TD-BD-2	TD	BD
39.37 inches	HLCD-30-39.37-TD-BD-2	TD	BD

Table 1: Sample Description



Figure 1: Test Sample

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch

Frequency Domain Data Summary

Bandwidth Figures – Single-Ended Insertion Loss

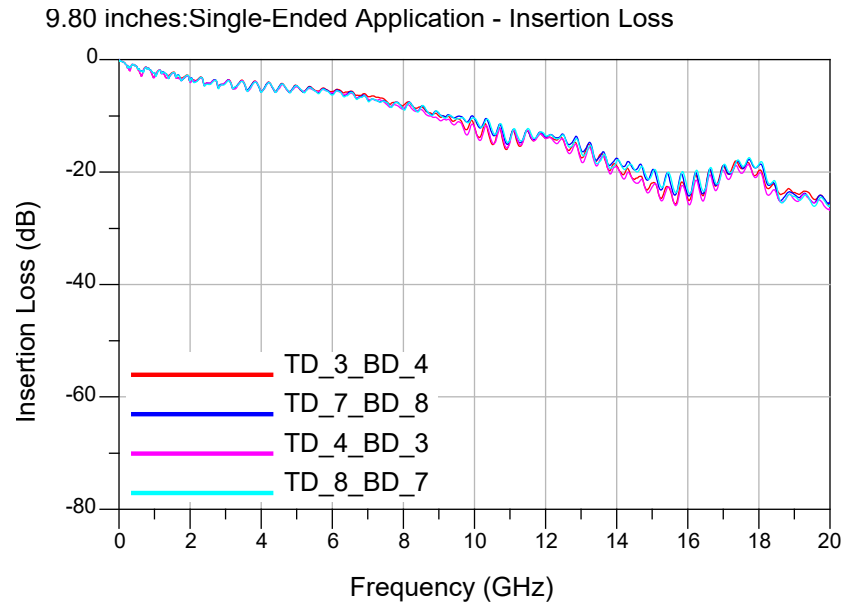


Figure 2

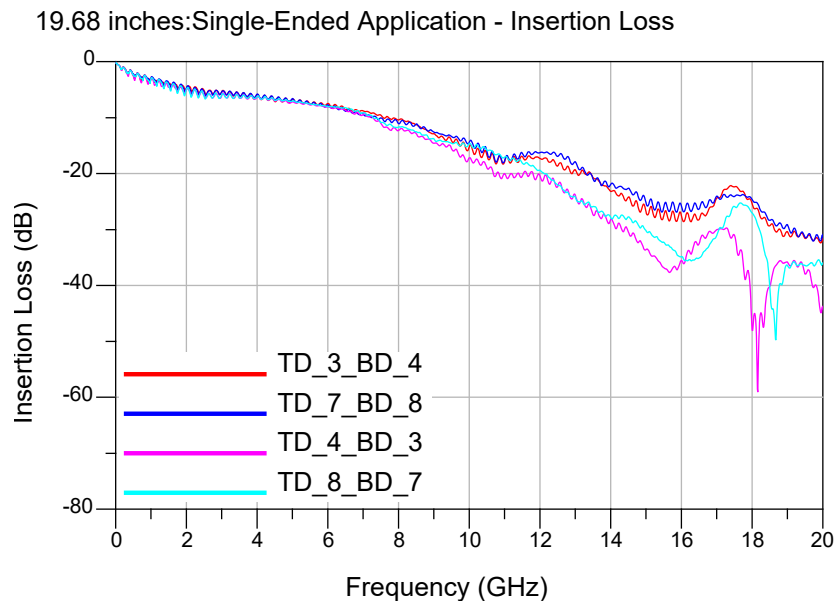


Figure 3

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch

39.37 inches:Single-Ended Application - Insertion Loss

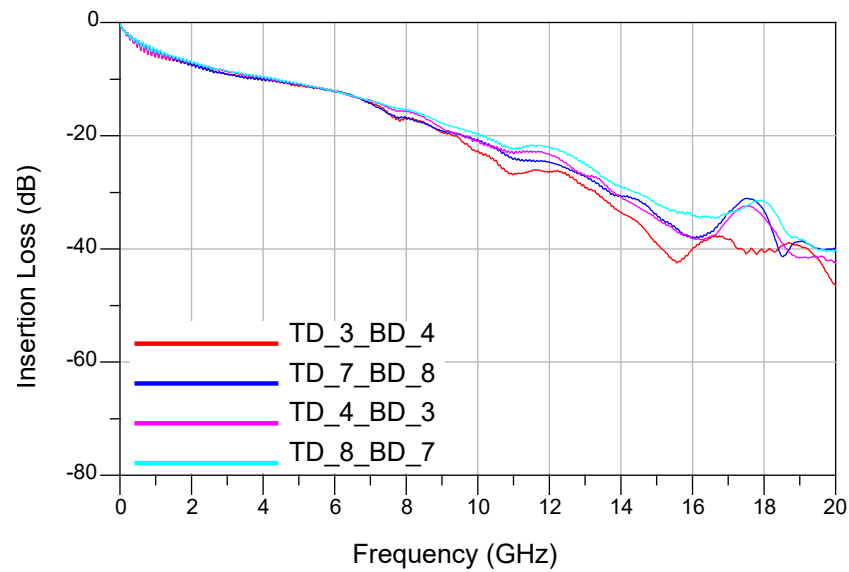


Figure 4

Bandwidth Figures – Differential Insertion Loss

9.80 inches:Differential Application - Insertion Loss

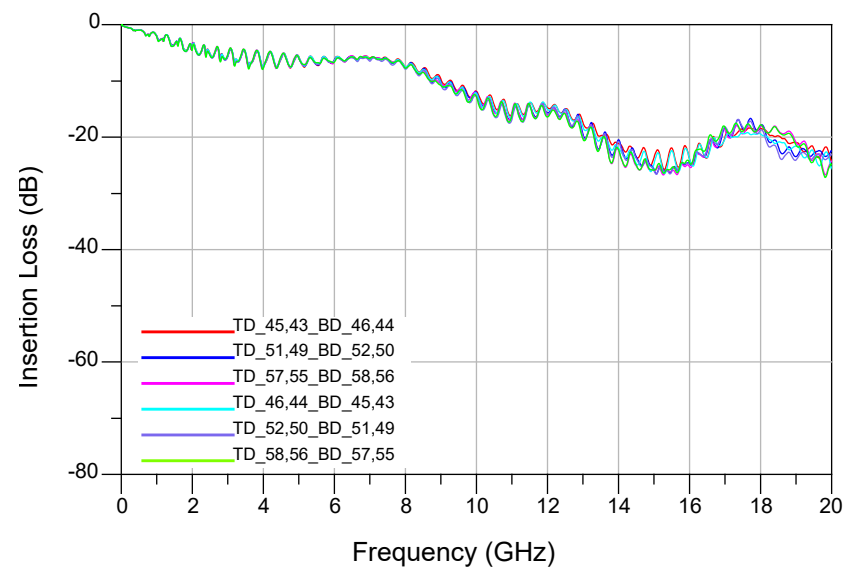
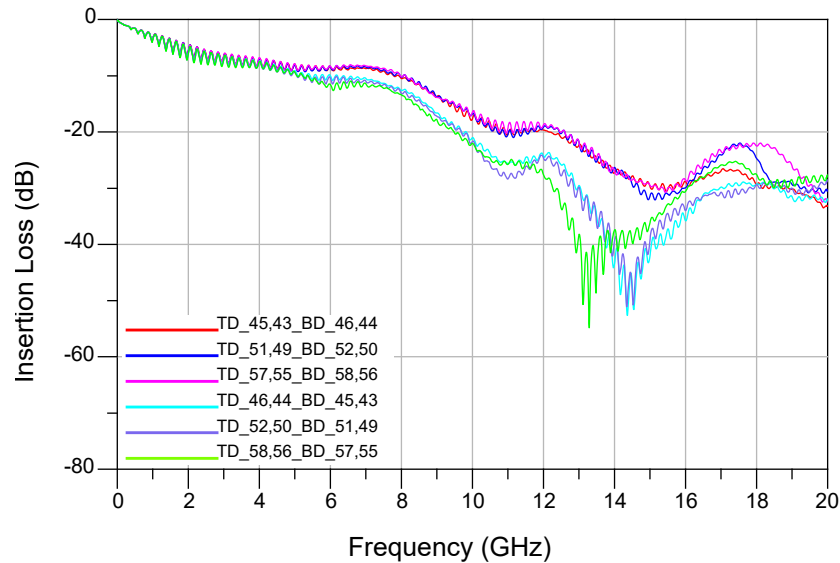


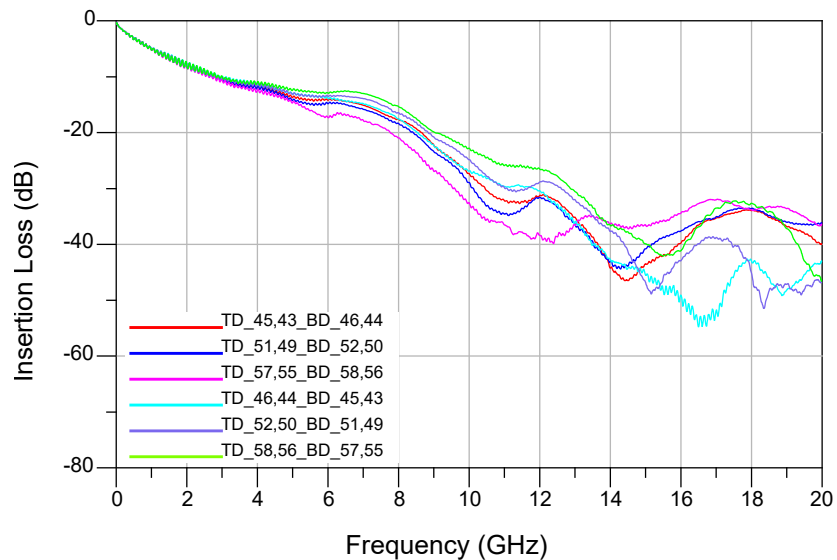
Figure 5

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch

19.68 inches:Differential Application - Insertion Loss

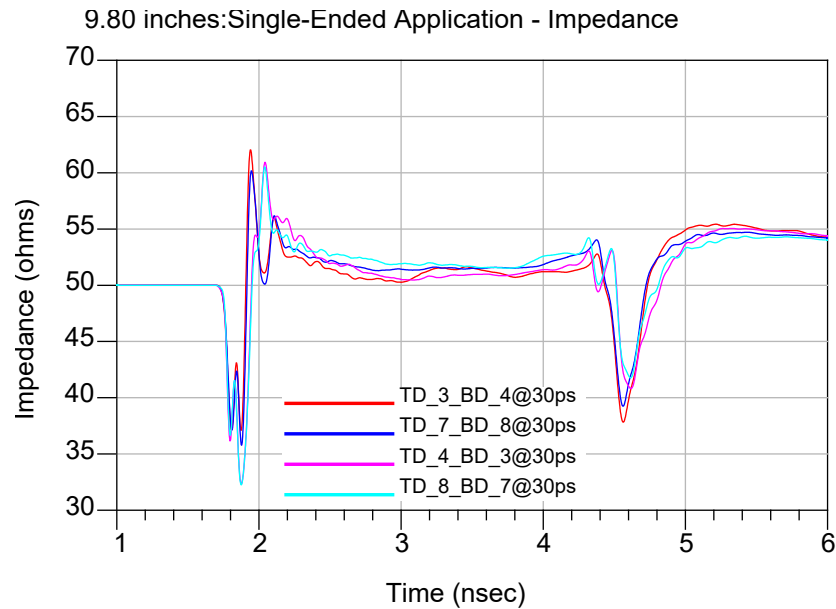
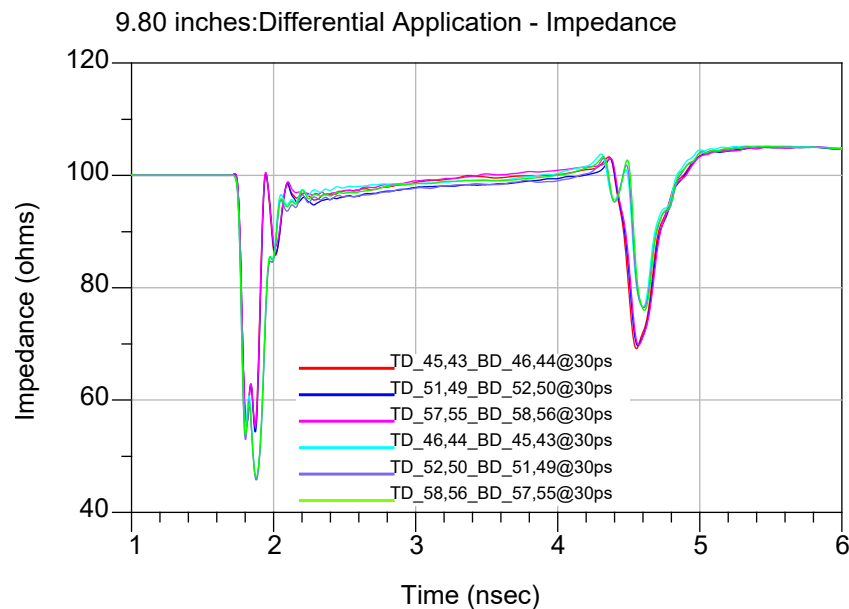
**Figure 6**

39.37 inches:Differential Application - Insertion Loss

**Figure 7**

Series: HLCD-TD-BD-2**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.

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch

Table 2 - Propagation Delay (Cable Assembly)				
Driver	Receiver	9.80 inches	19.68 inches	39.37 inches
TD_3	BD_4	1.494 ns	2.691 ns	5.113 ns
TD_7	BD_8	1.494 ns	2.692 ns	5.114 ns
TD_4	BD_3	1.492 ns	2.706 ns	5.093 ns
TD_8	BD_7	1.488 ns	2.704 ns	5.090 ns
TD_45,43	BD_46,44	1.482 ns	2.684 ns	5.092 ns
TD_51,49	BD_52,50	1.485 ns	2.689 ns	5.096 ns
TD_57,55	BD_58,56	1.489 ns	2.693 ns	5.100 ns
TD_46,44	BD_45,43	1.479 ns	2.682 ns	5.081 ns
TD_52,50	BD_51,49	1.481 ns	2.685 ns	5.090 ns
TD_58,56	BD_57,55	1.485 ns	2.687 ns	5.098 ns

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

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

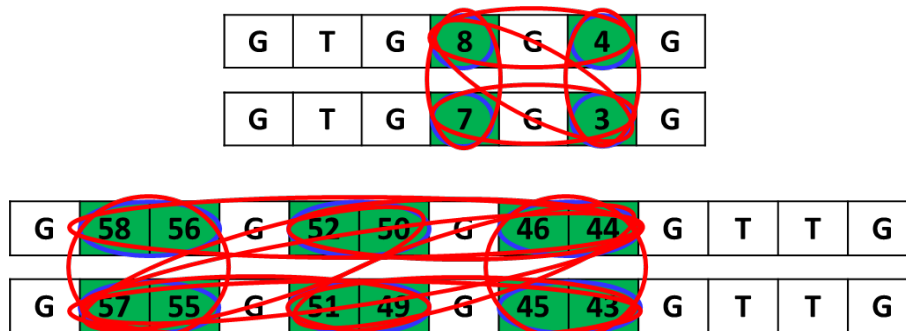
Samtec cable assemblies are most often designed for generic applications and can be implemented using various signal and ground pin assignments. In high-speed systems, provisions must be made in the interconnect for signal return currents. Such paths are often referred to as "ground". In some cable assemblies, 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.

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

For this cable assembly, the following configurations are evaluated:



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.

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.

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 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.

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

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-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch

Appendix A – Frequency Domain Responses

Single-Ended Application – Insertion Loss

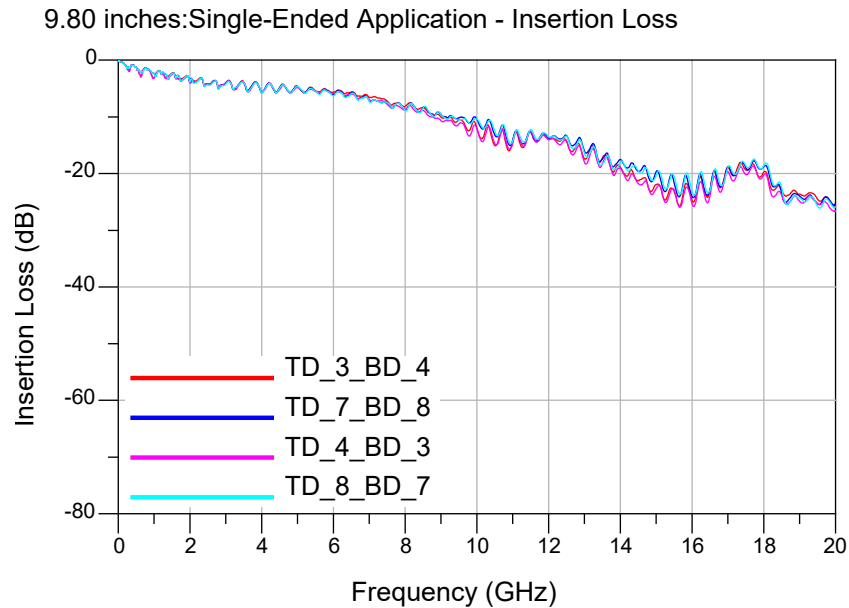


Figure 10

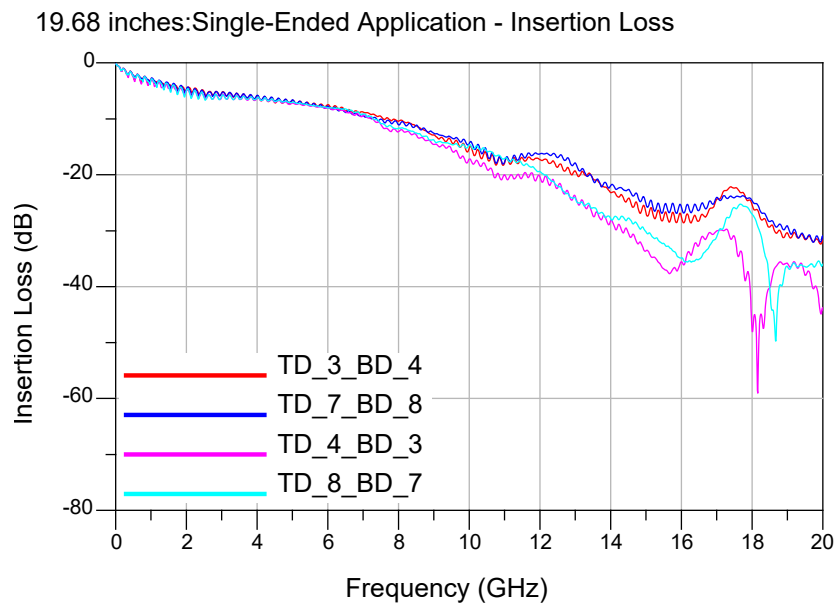


Figure 11

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch

39.37 inches:Single-Ended Application - Insertion Loss

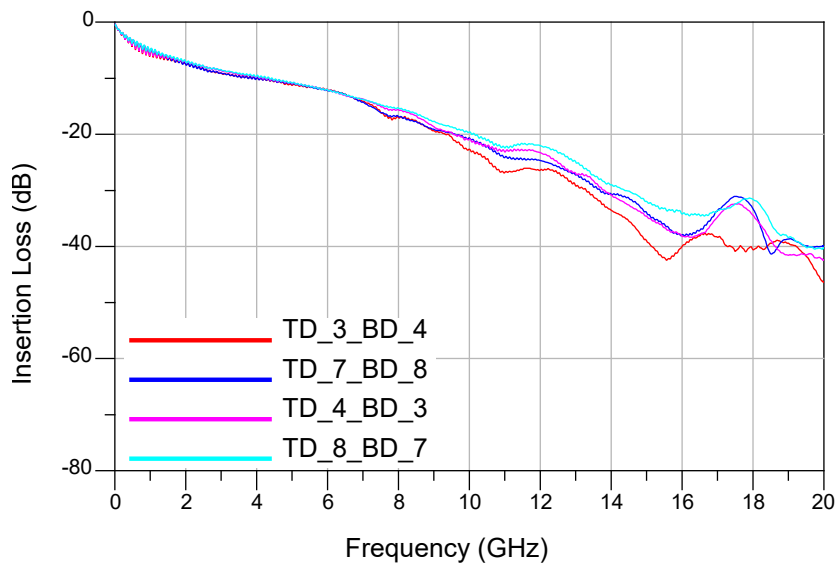


Figure 12

Single-Ended Application – Return Loss

9.80 inches:Single-Ended Application - Return Loss

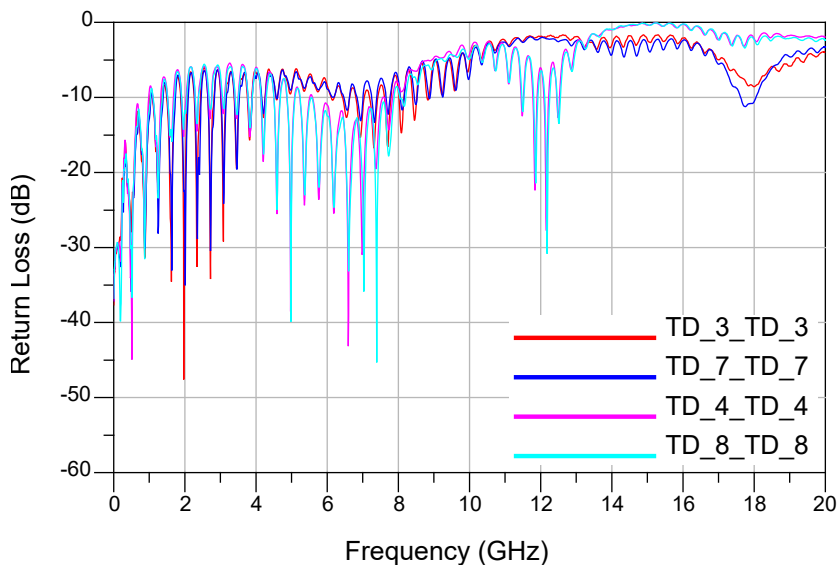
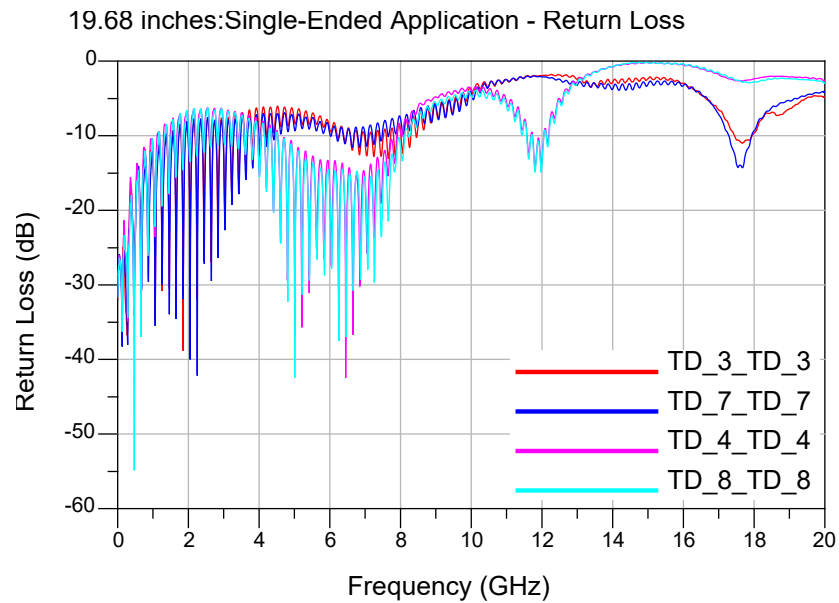
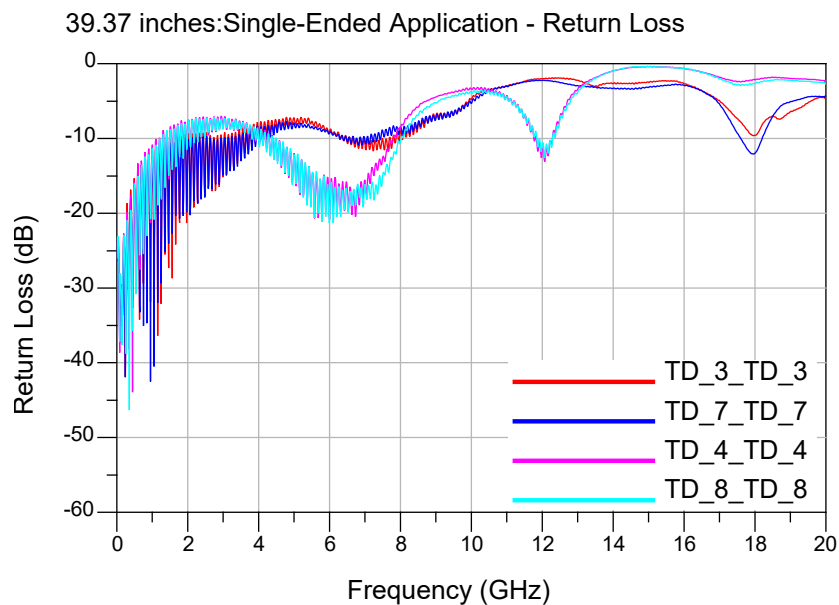


Figure 13

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch**Figure 14****Figure 15**

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Single-Ended Application – NEXT Configurations

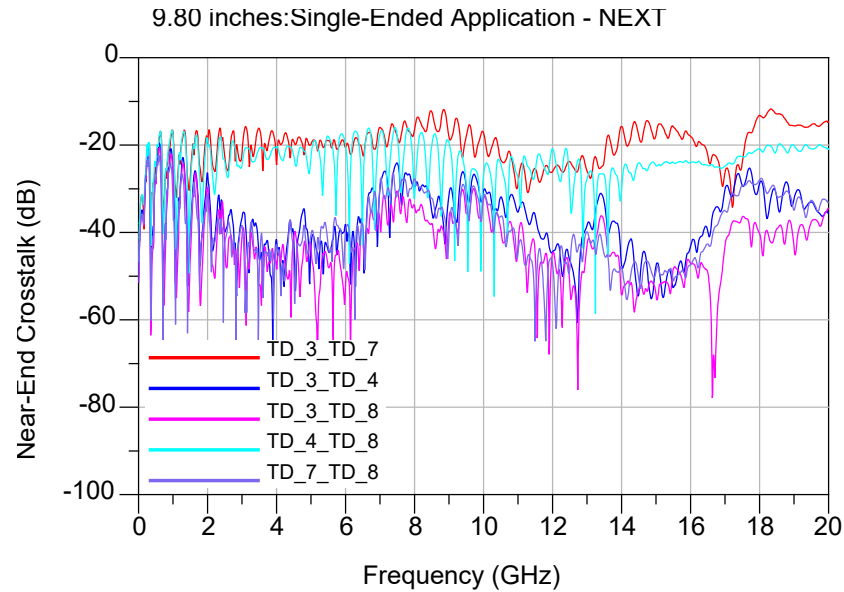


Figure 16

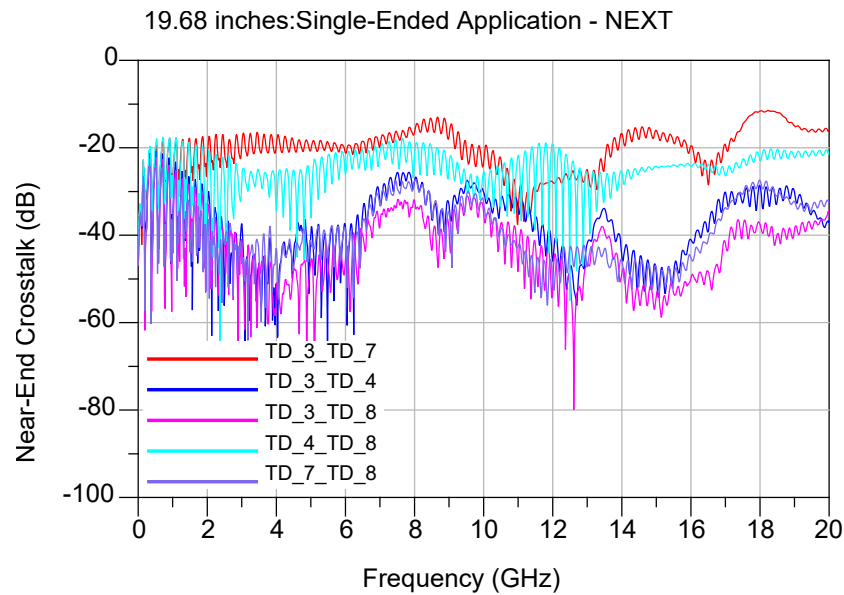


Figure 17

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

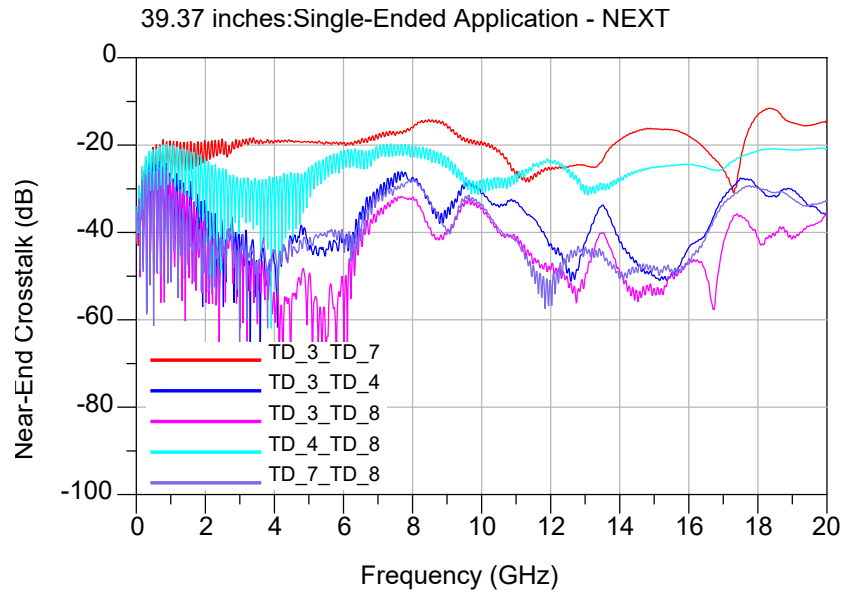


Figure 18

Single-Ended Application – FEXT Configurations

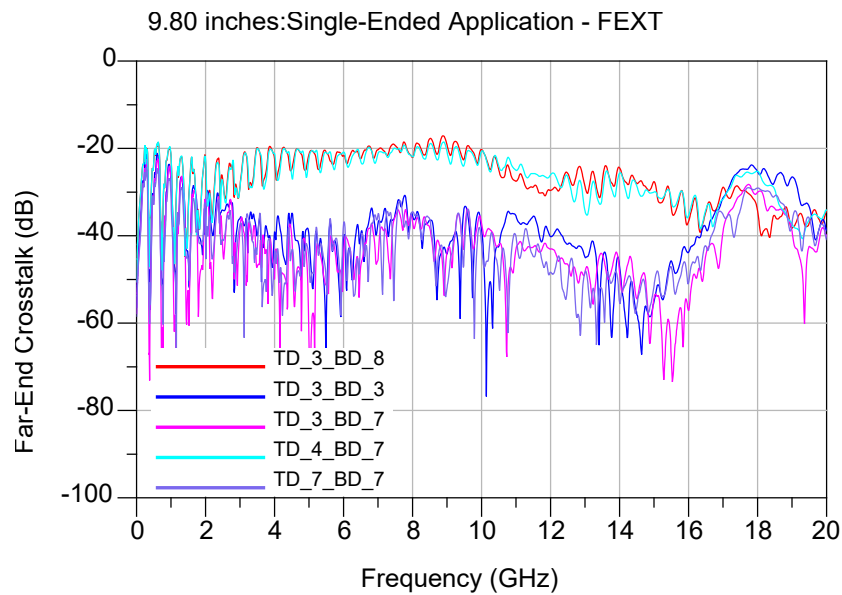


Figure 19

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

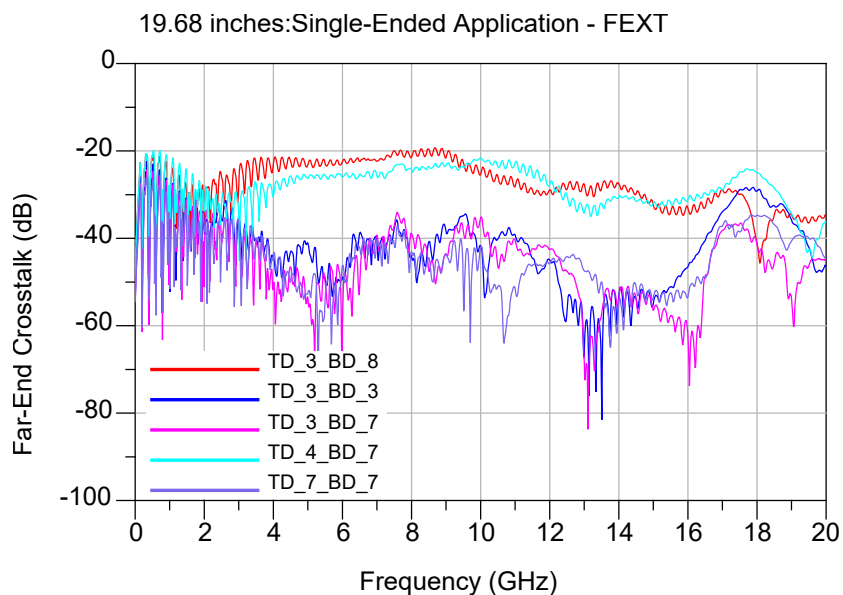


Figure 20

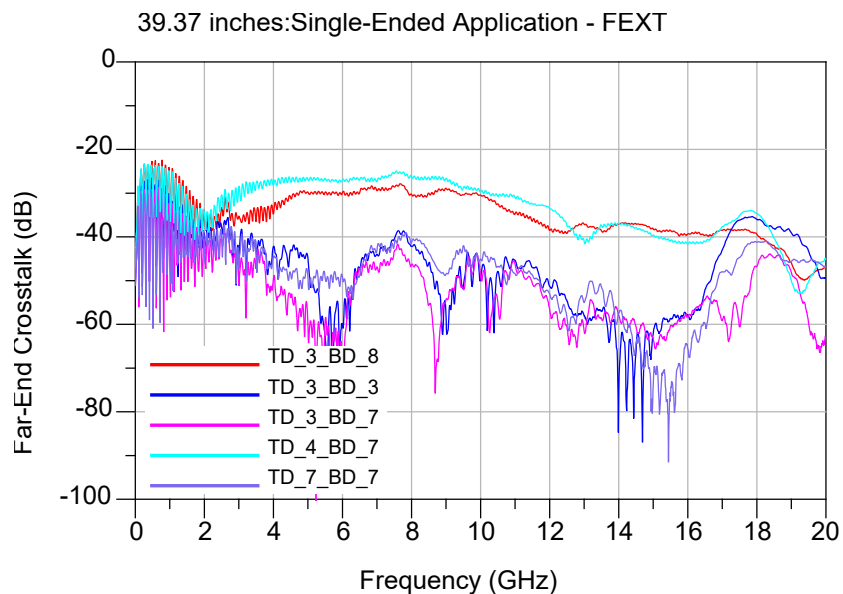
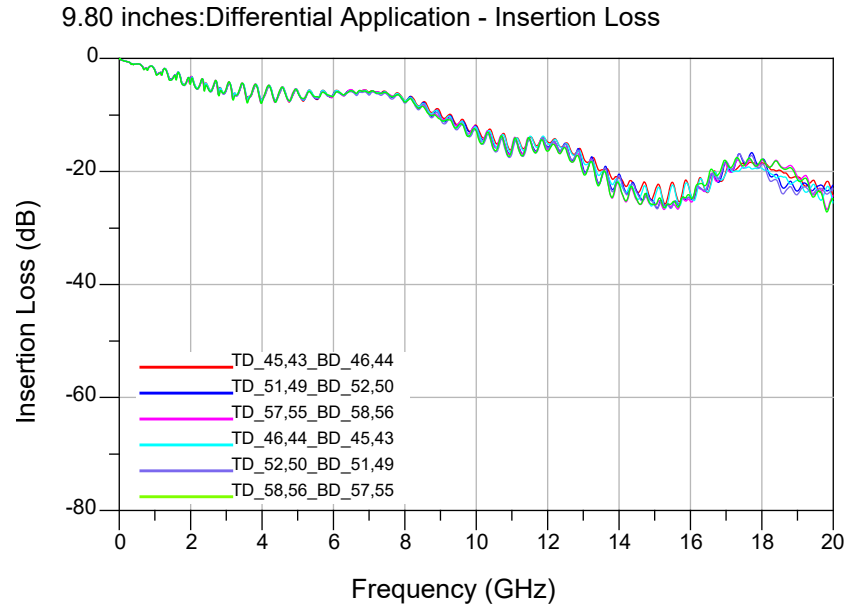
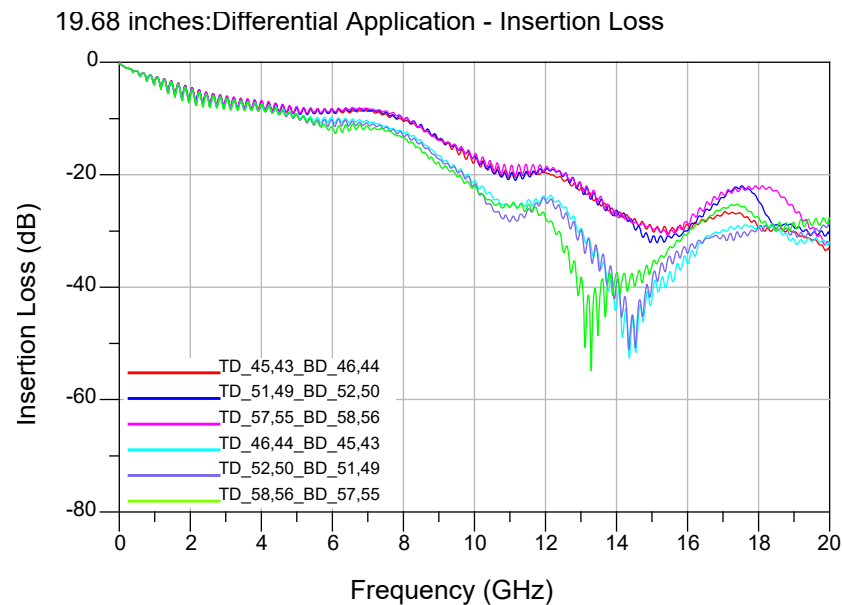


Figure 21

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch**Differential Application – Insertion Loss****Figure 22****Figure 23**

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

39.37 inches:Differential Application - Insertion Loss

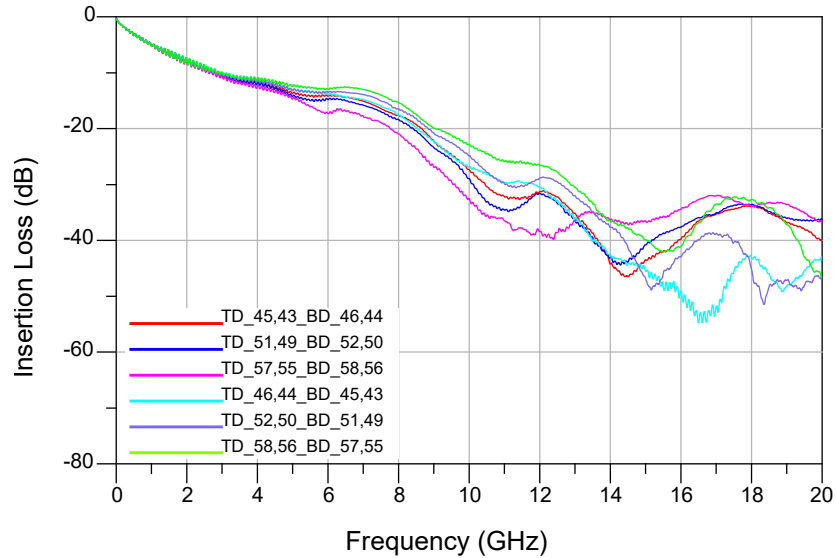


Figure 24

Differential Application – Return Loss

9.80 inches:Differential Application - Return Loss

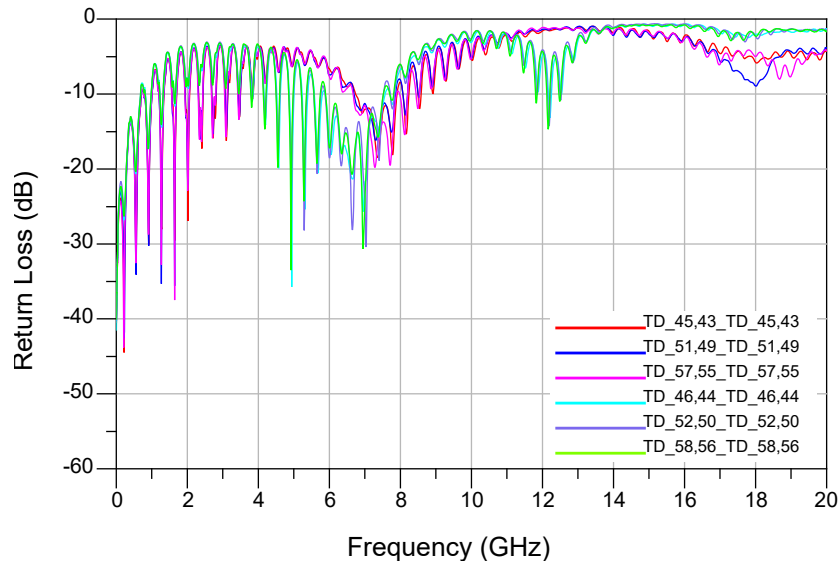
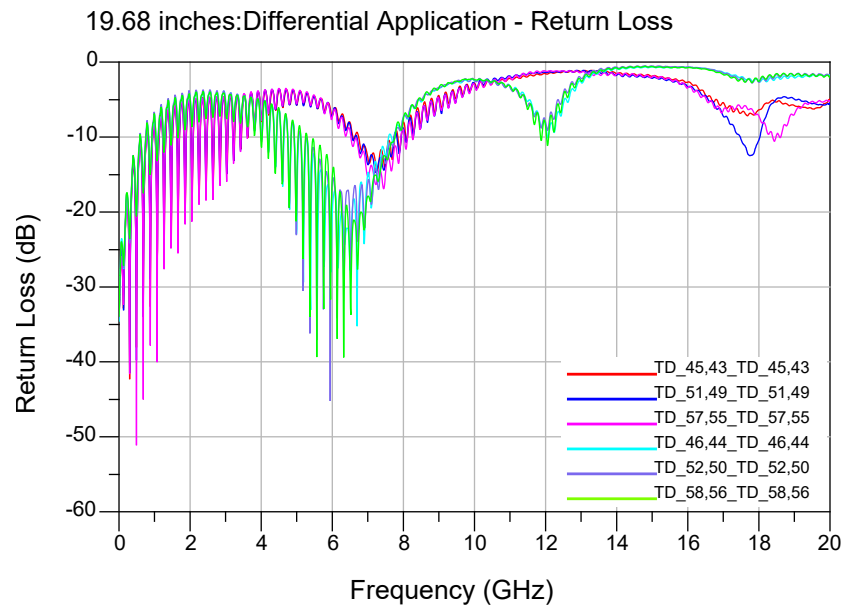
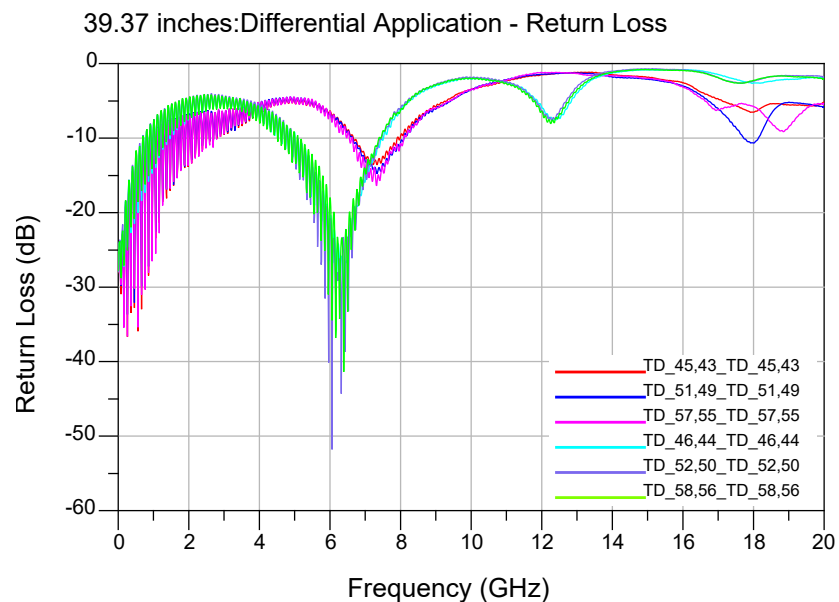


Figure 25

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch**Figure 26****Figure 27**

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Differential Application – NEXT Configurations

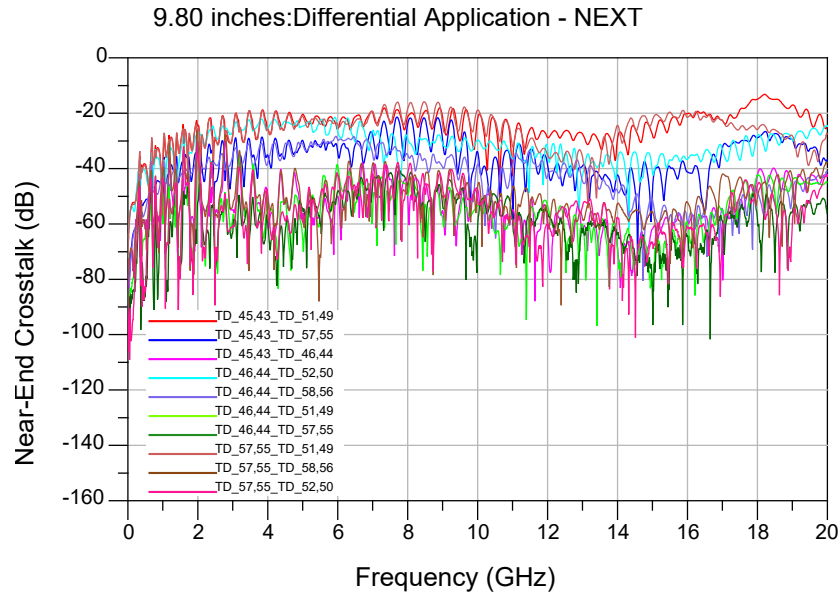


Figure 28

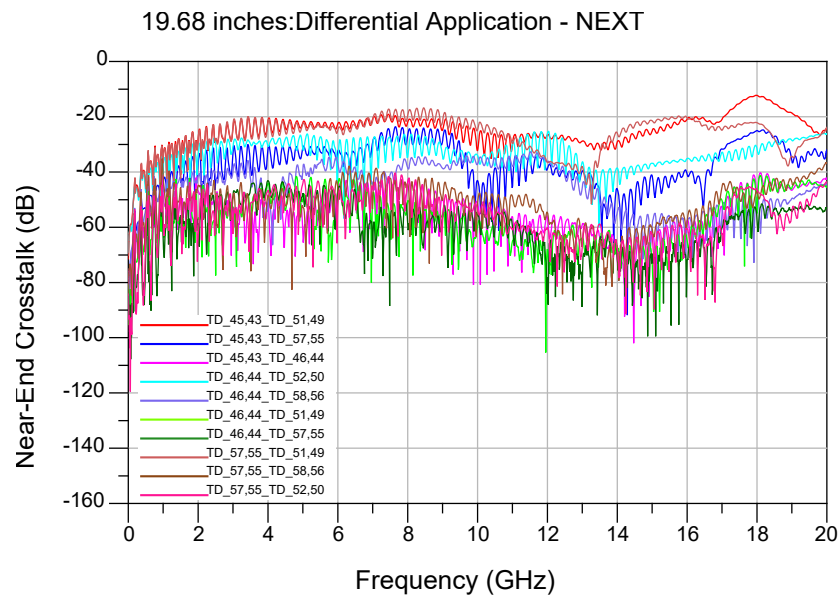


Figure 29

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

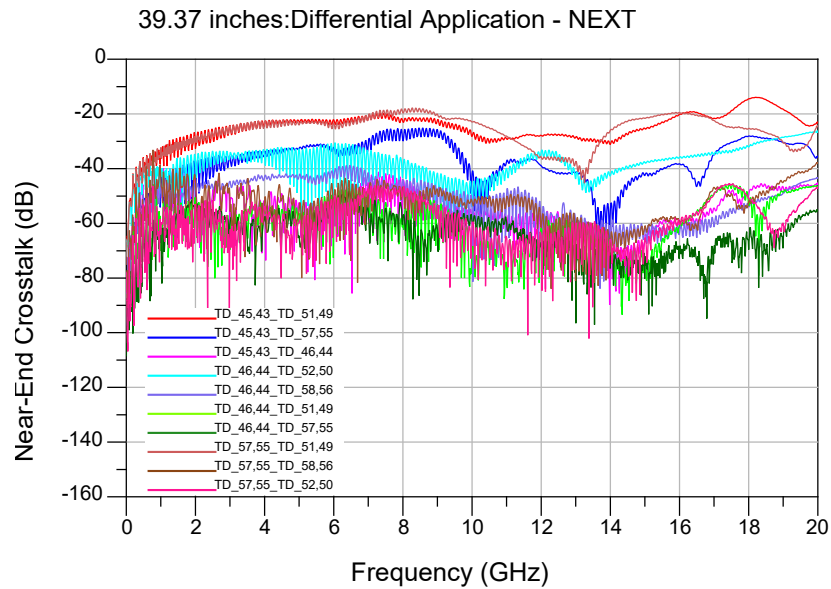


Figure 30

Differential Application – FEXT Configurations

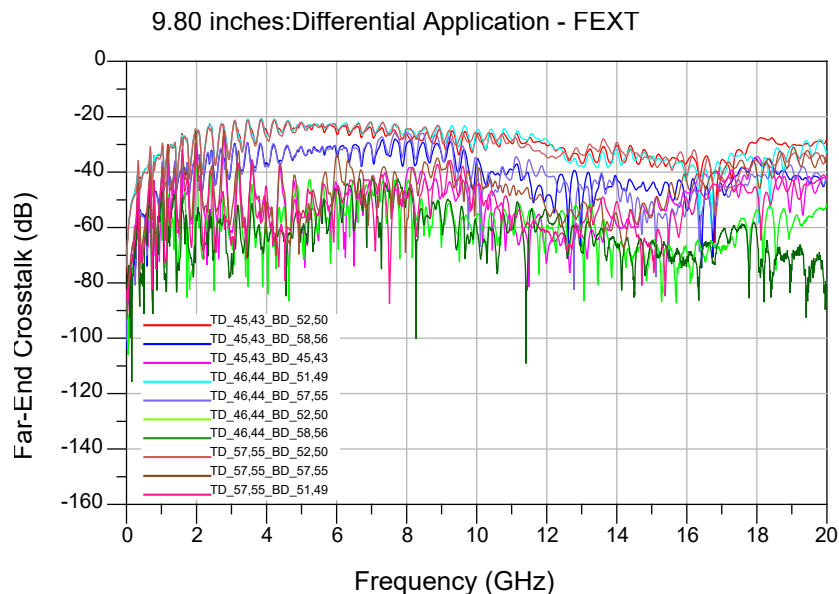


Figure 31

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

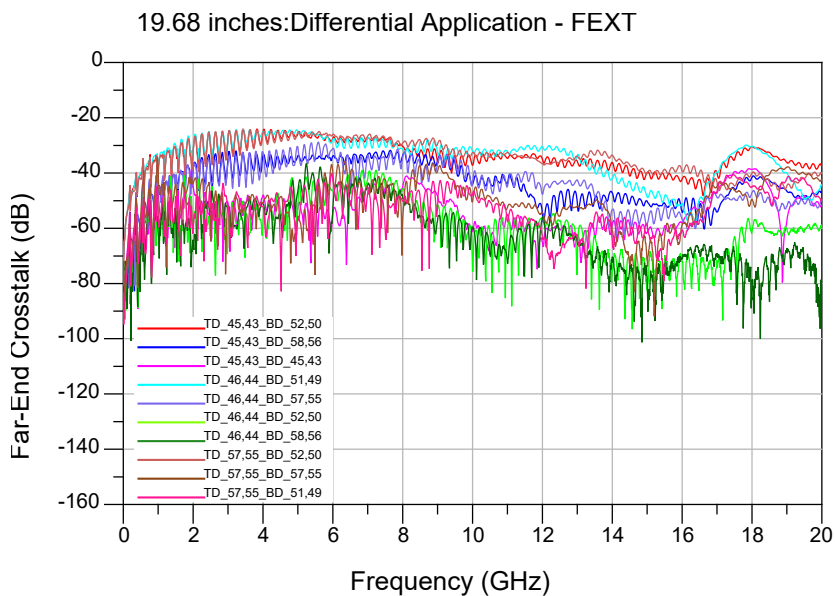


Figure 32

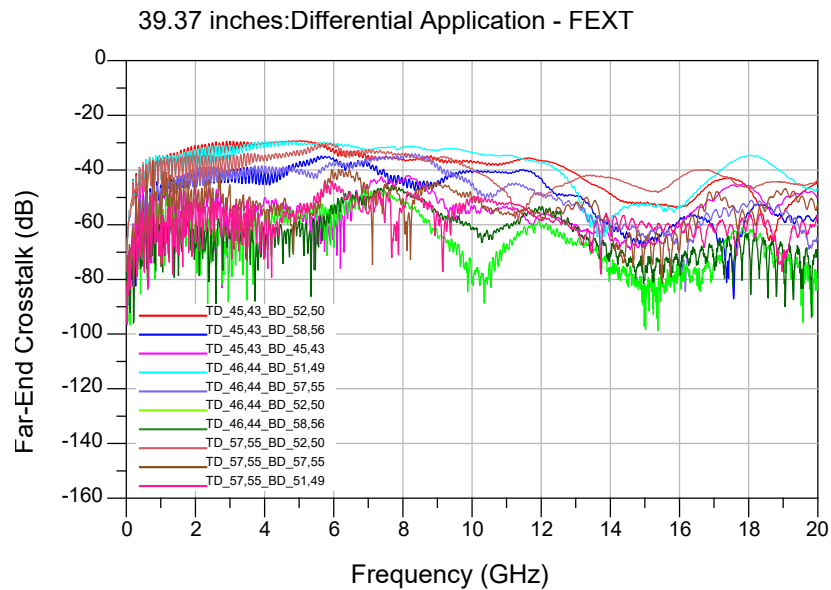


Figure 33

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Differential Application – Differential to Common Mode Conversion

9.80 inches:Differential to Common Mode Conversion - SCD21

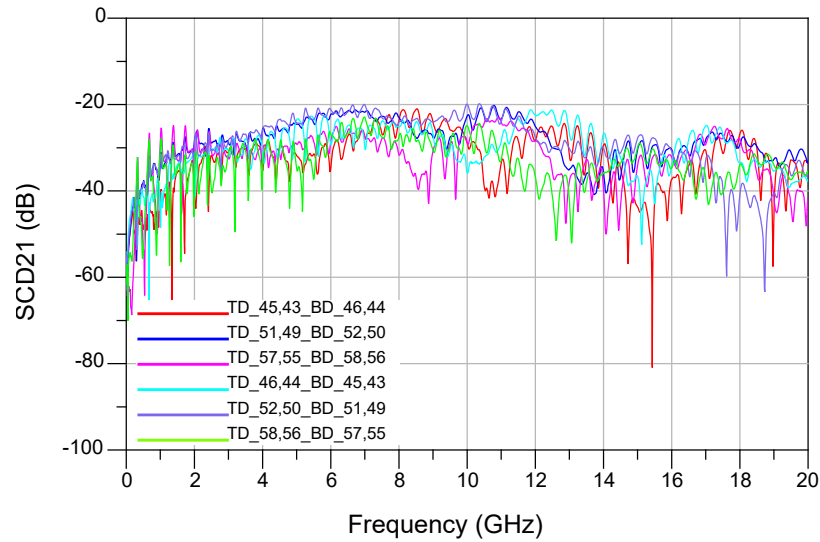


Figure 34

19.68 inches:Differential to Common Mode Conversion - SCD21

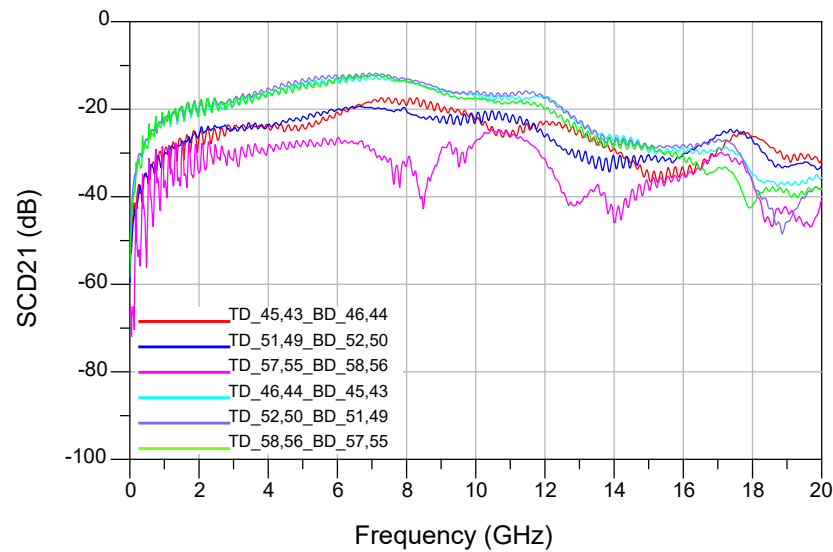
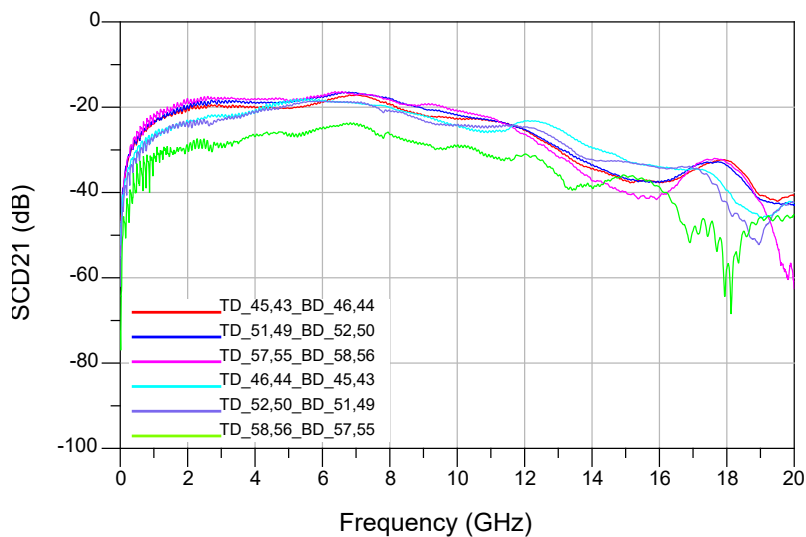


Figure 35

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch

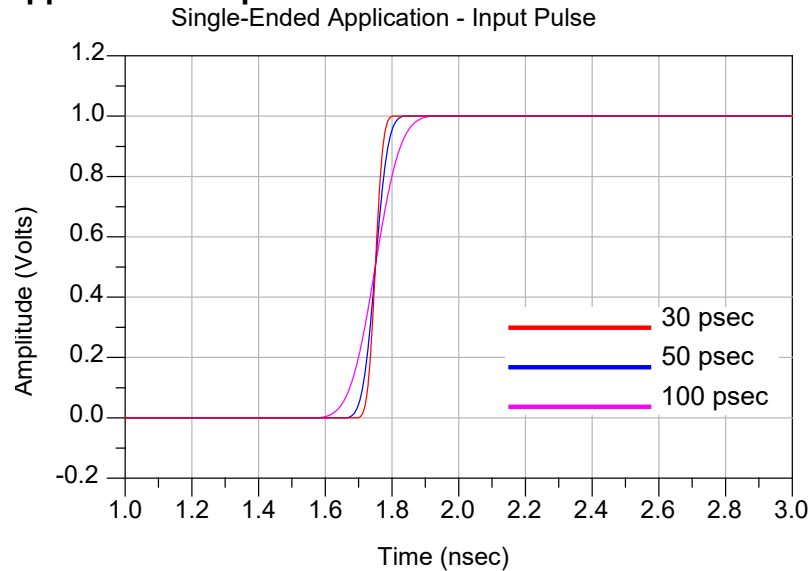
39.37 inches:Differential to Common Mode Conversion - SCD21

**Figure 36**

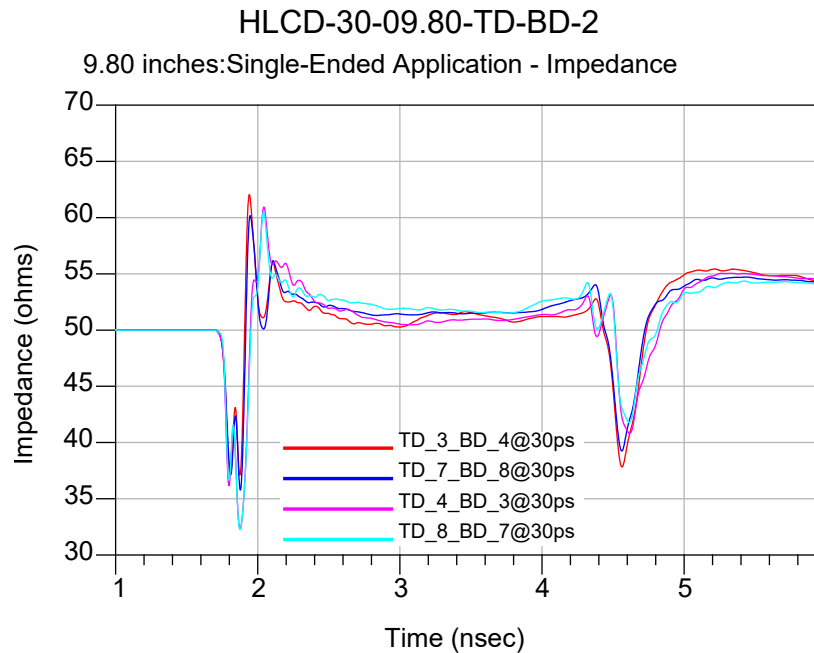
Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch

Appendix B – Time Domain Responses

Single-Ended Application – Input Pulse

**Figure 37**

Single-Ended Application – Cable Assembly Impedance Summary

**Figure 38**

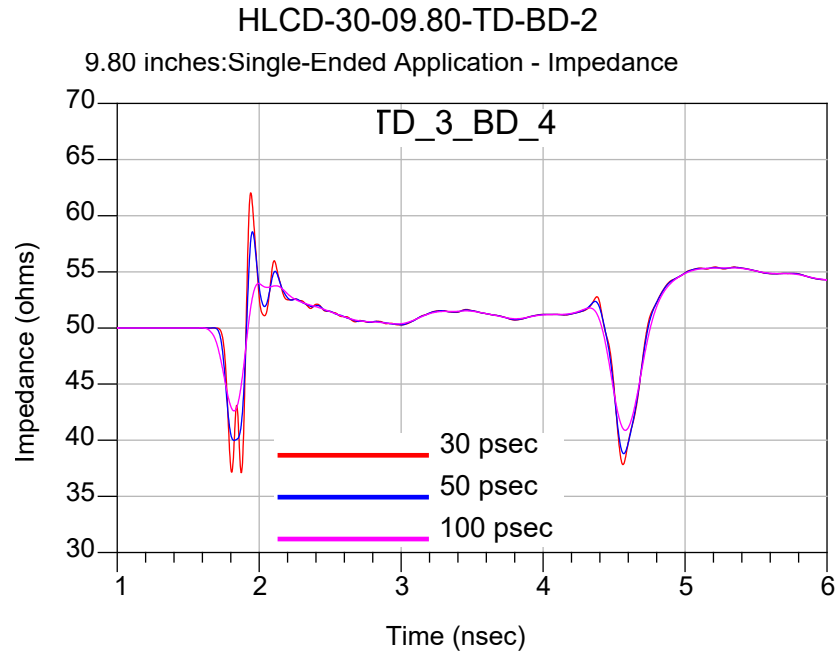
Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch**Single-Ended Application – Cable Assembly Impedance**

Figure 39

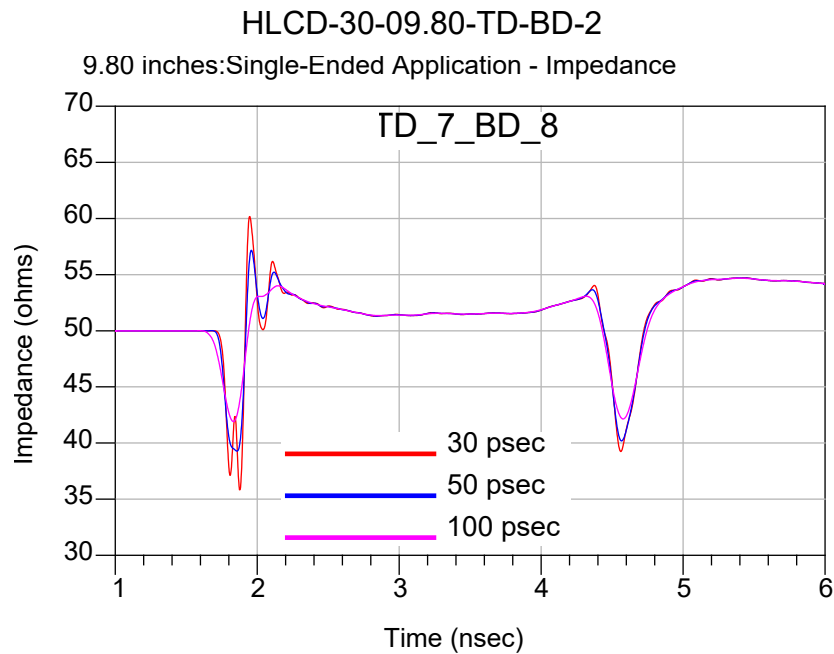


Figure 40

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch

HLCD-30-09.80-TD-BD-2

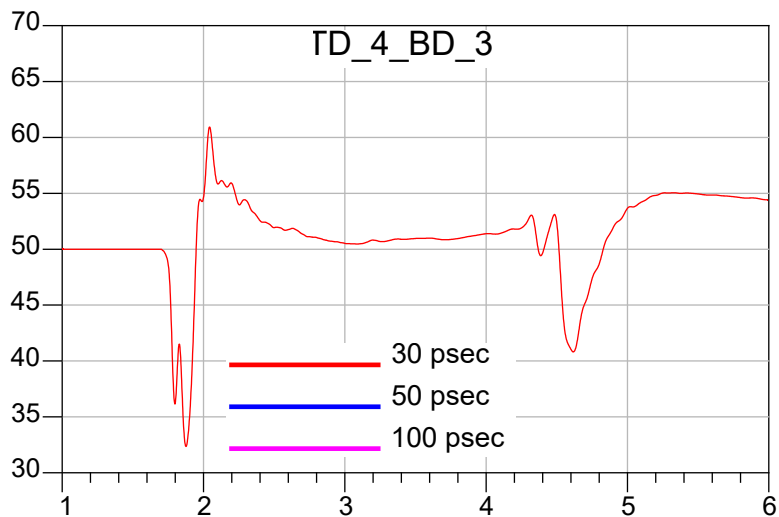


Figure 41

HLCD-30-09.80-TD-BD-2

9.80 inches:Single-Ended Application - Impedance

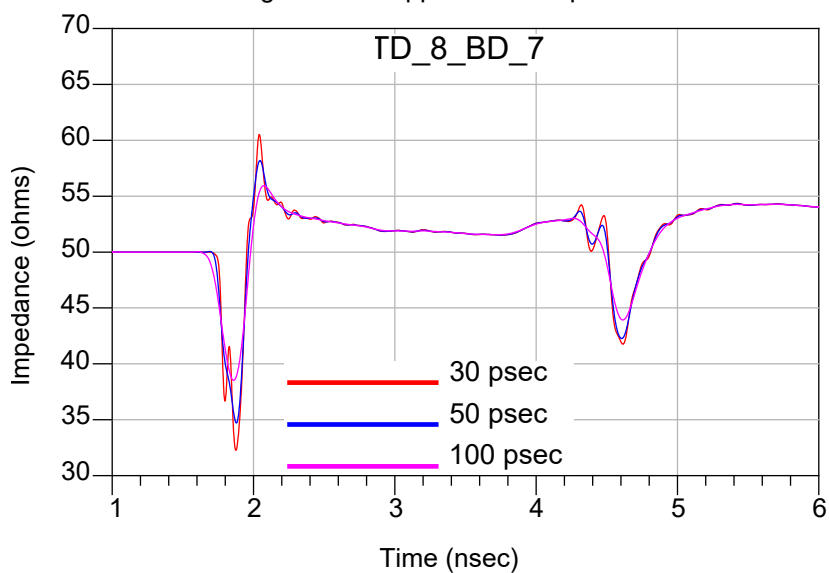
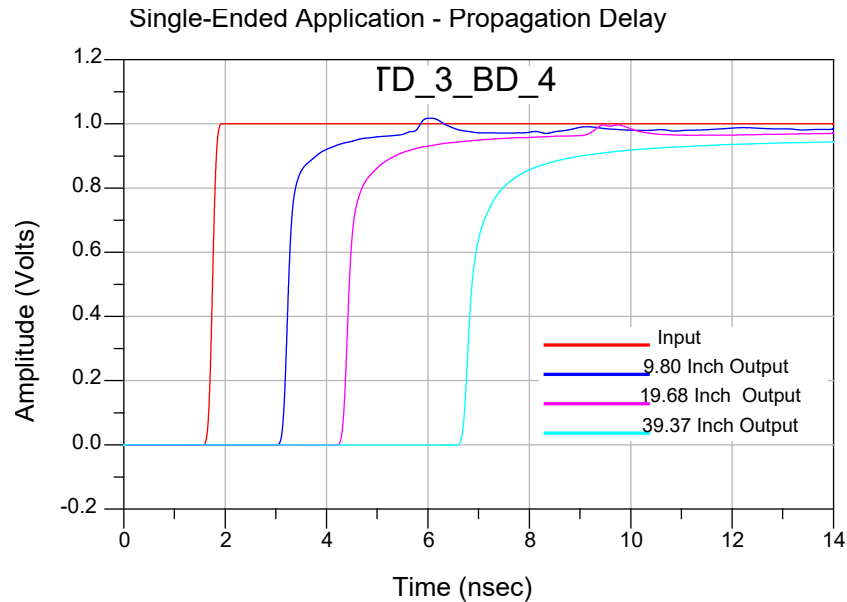
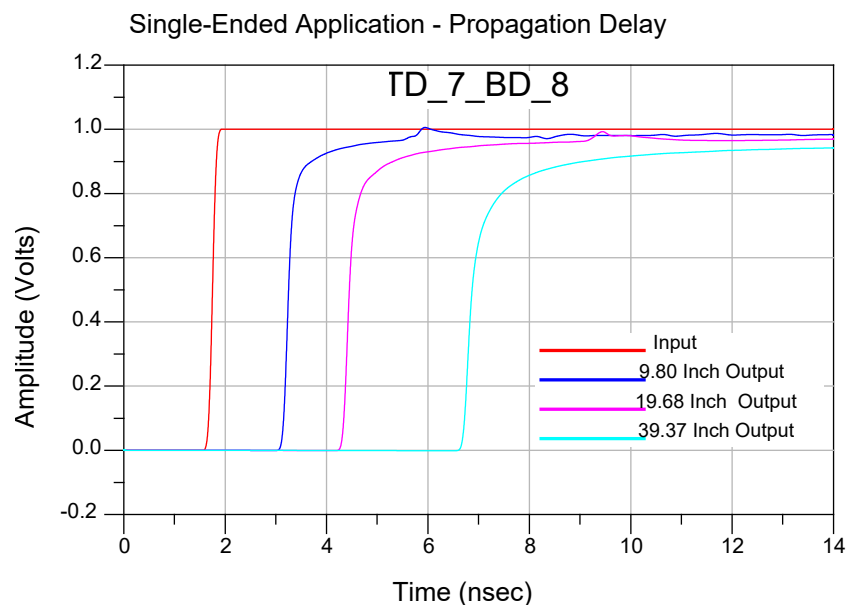
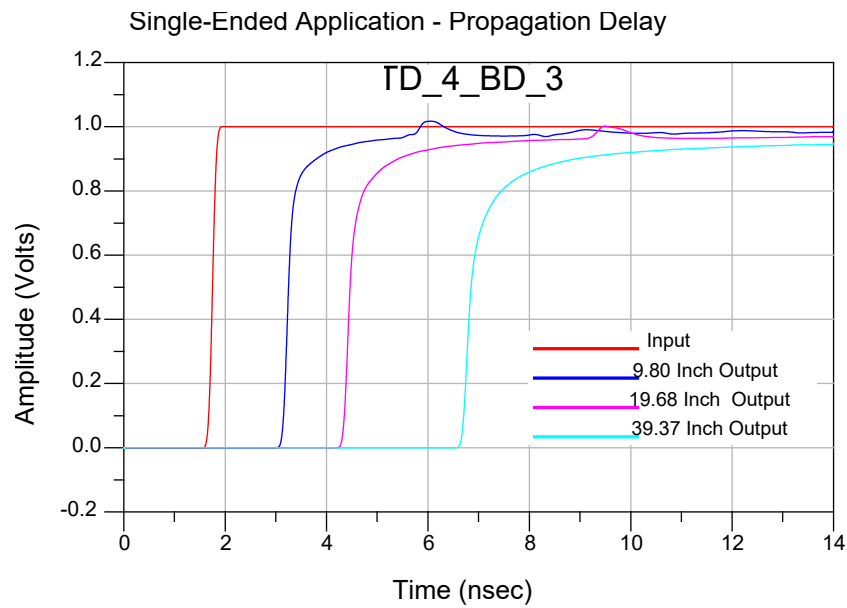
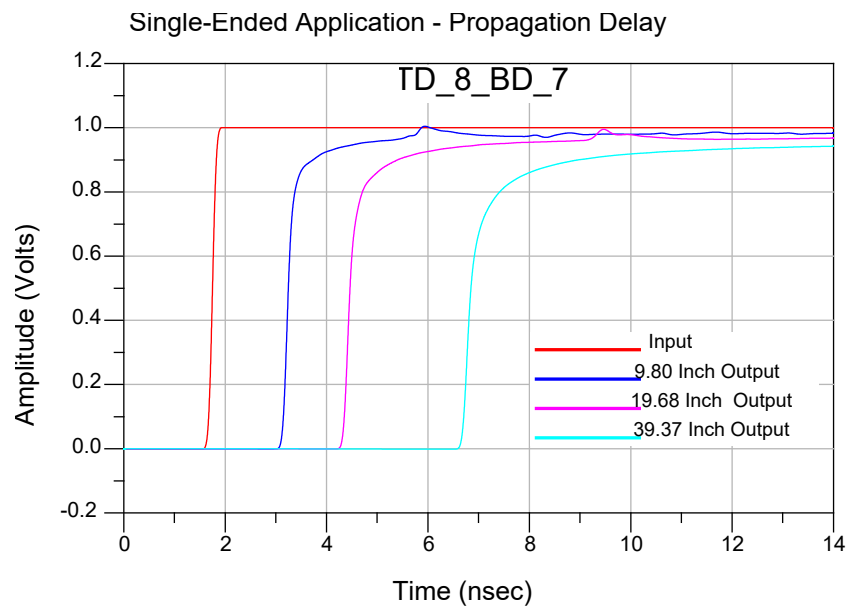


Figure 42

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch**Single-Ended Application – Propagation Delay****Figure 43****Figure 44**

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch**Figure 45****Figure 46**

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Differential Application – Input Pulse

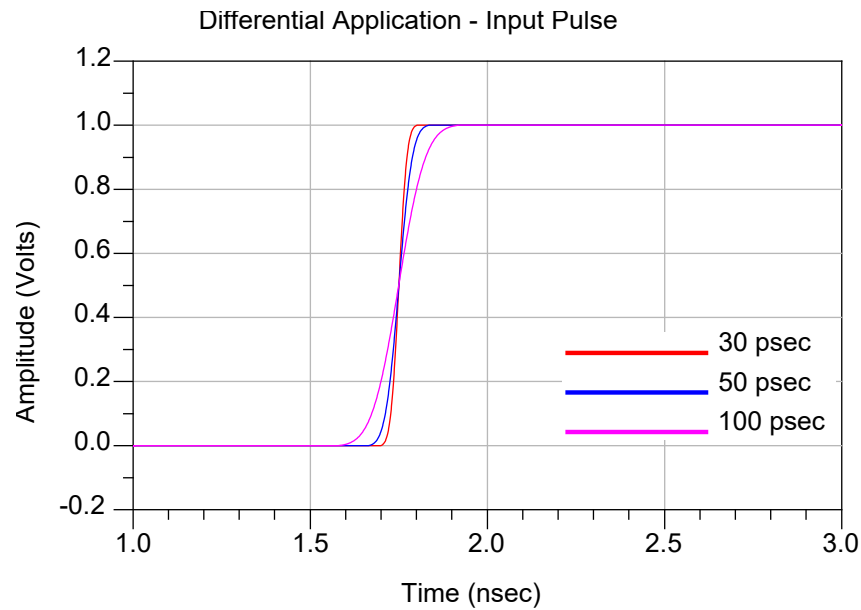


Figure 47

Differential Application – Cable Assembly Impedance Summary

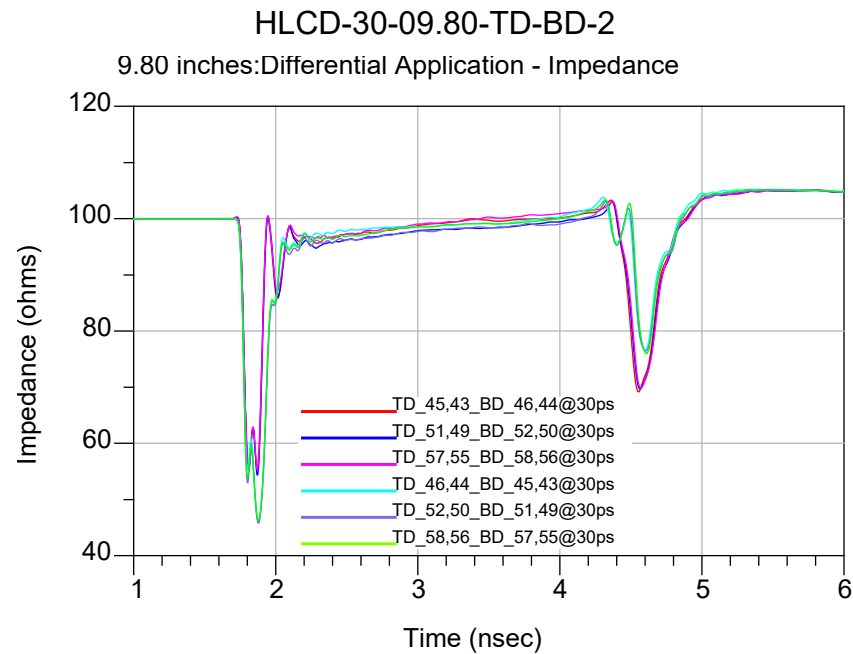
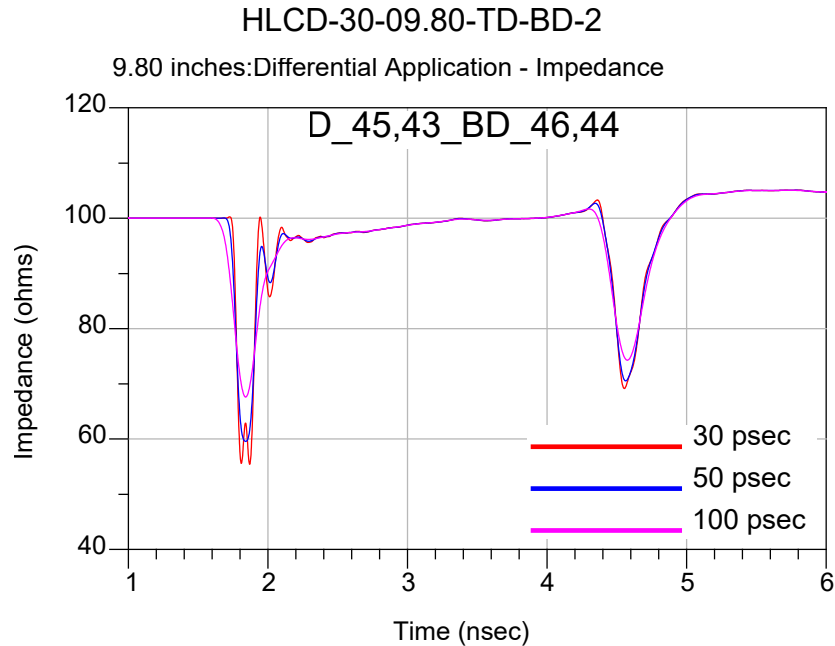
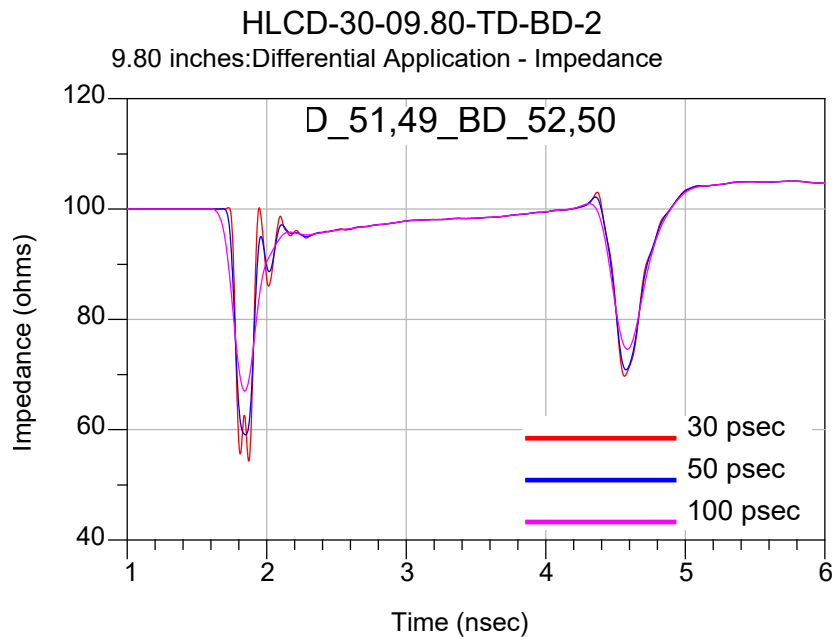
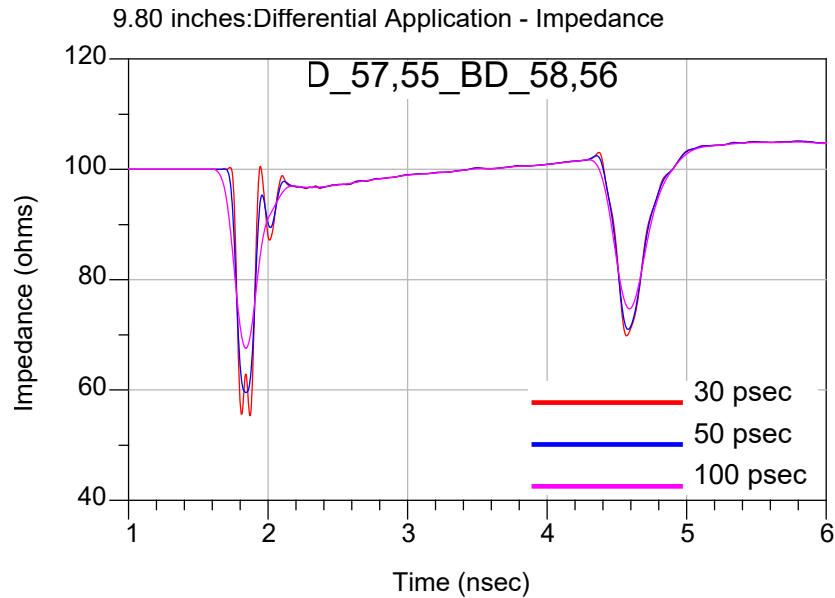
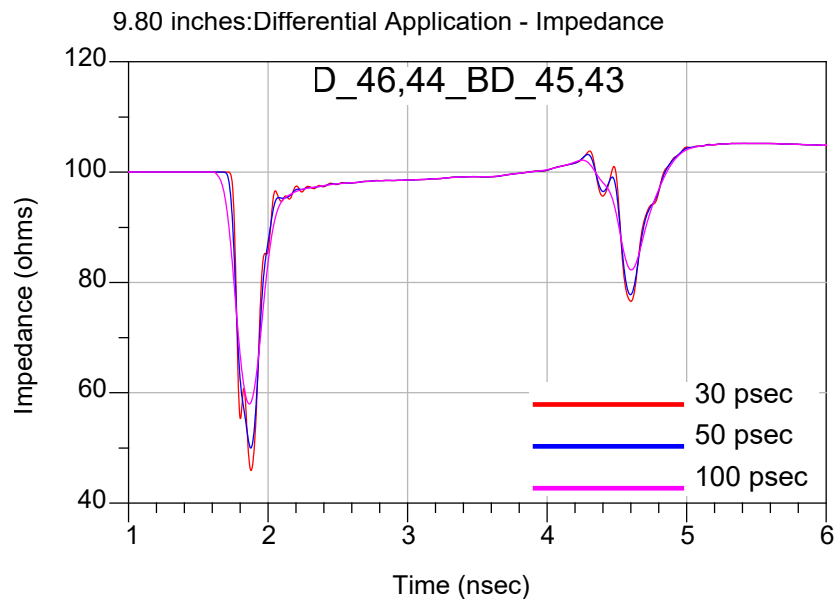


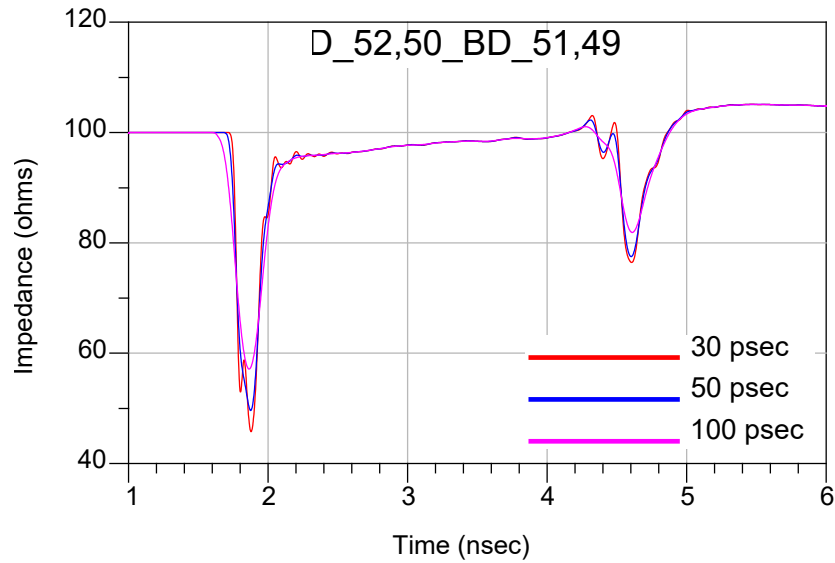
Figure 48

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch**Differential Application – Cable Assembly Impedance****Figure 49****Figure 50**

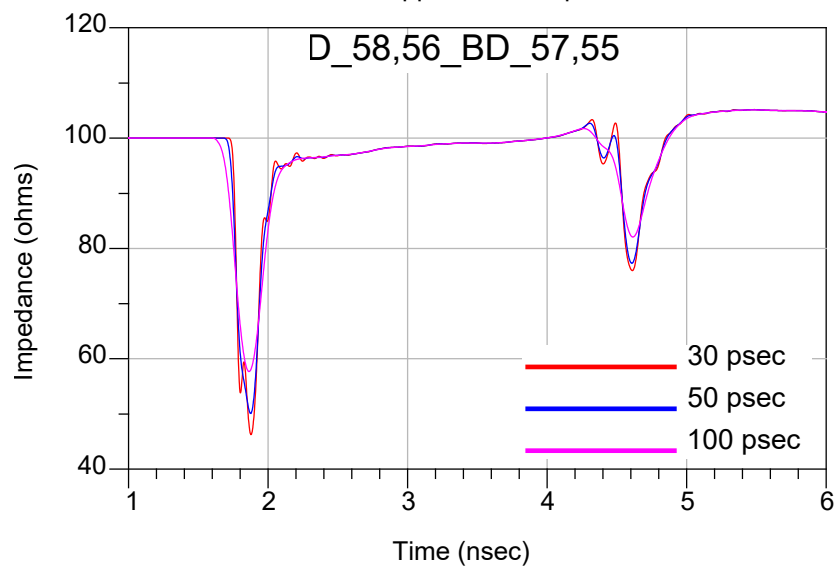
Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch**HLCD-30-09.80-TD-BD-2****Figure 51****HLCD-30-09.80-TD-BD-2****Figure 52**

Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch**HLCD-30-09.80-TD-BD-2**

9.80 inches:Differential Application - Impedance

**Figure 53****HLCD-30-09.80-TD-BD-2**

9.80 inches:Differential Application - Impedance

**Figure 54**

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

Differential Application – Propagation Delay

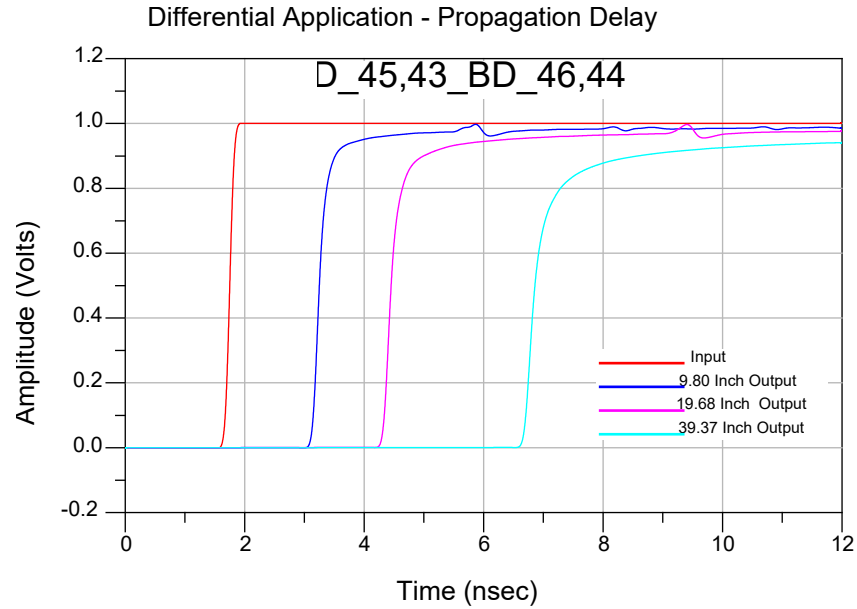


Figure 55

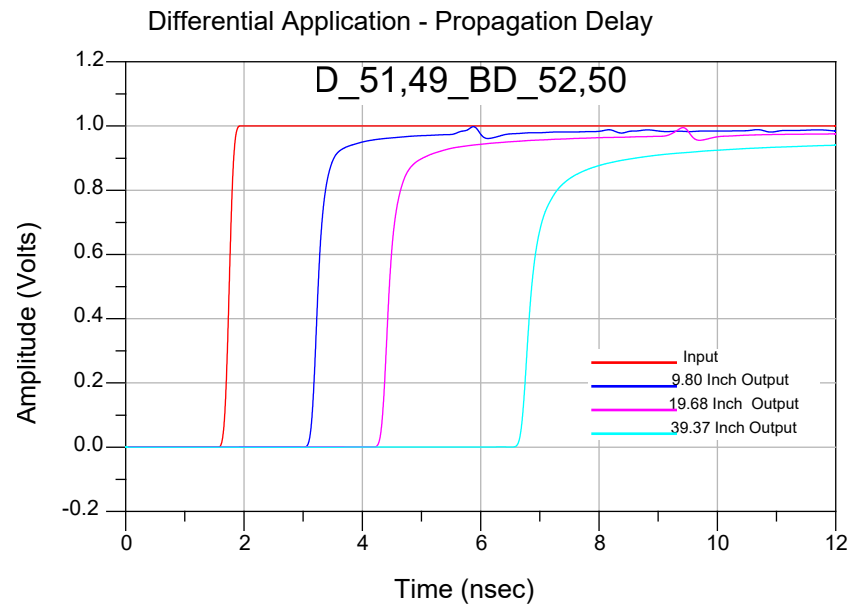


Figure 56

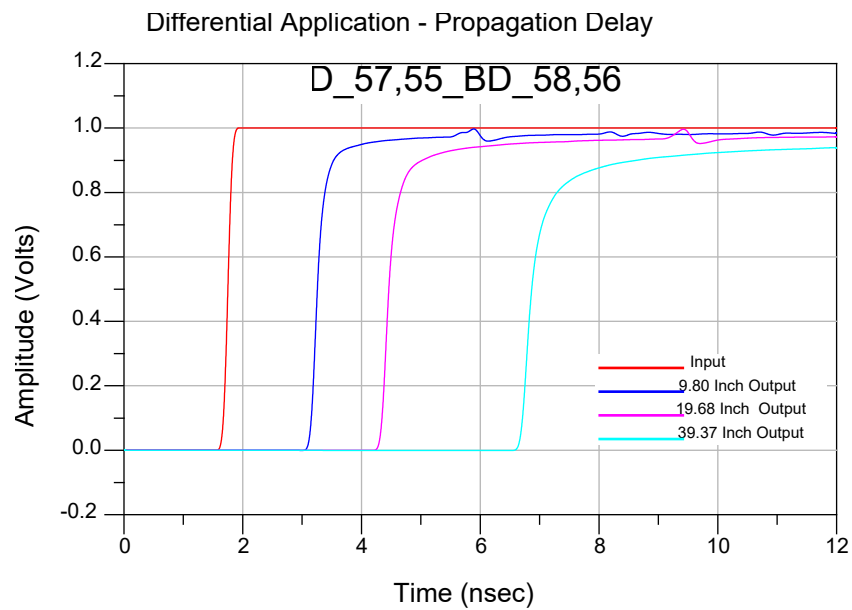
Series: HLCD-TD-BD-2**Description:** High Speed Hermaphroditic Cable, 0.50mm Pitch

Figure 57

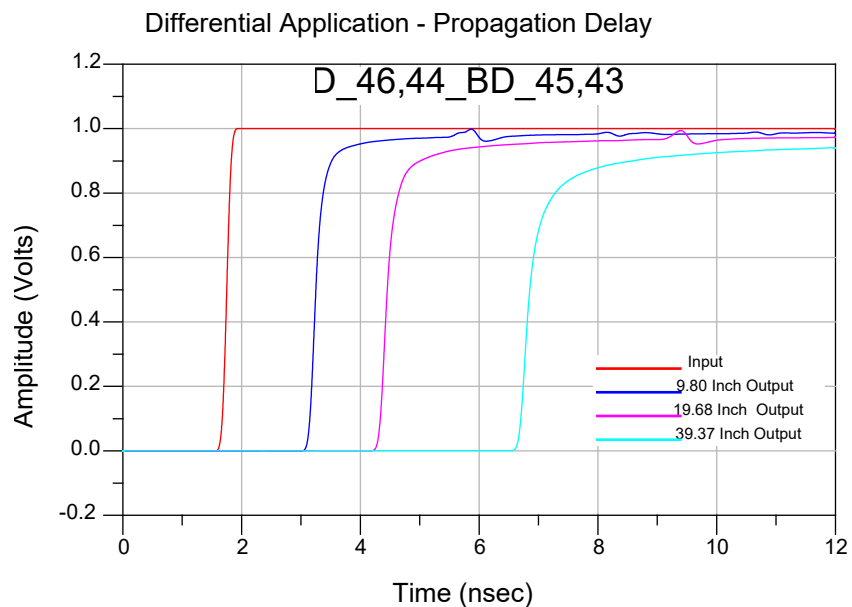


Figure 58

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

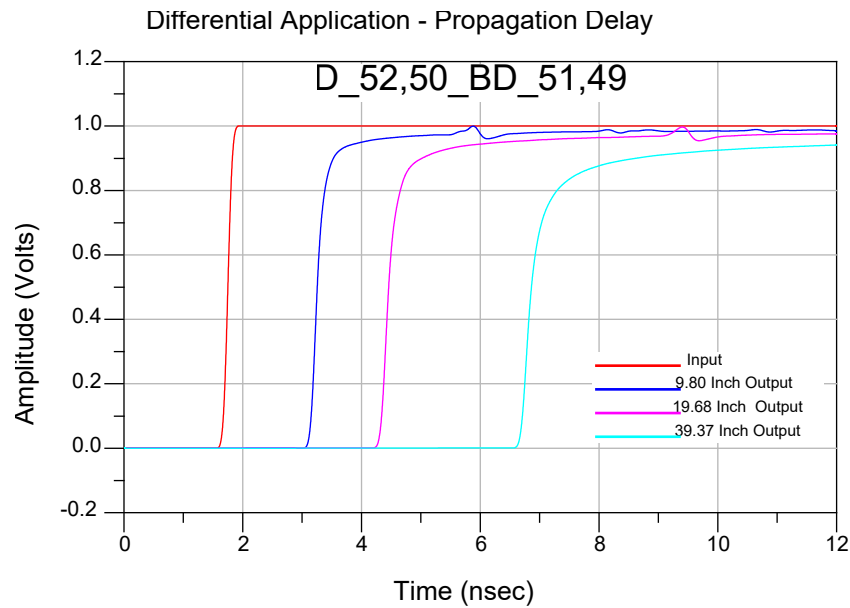


Figure 59

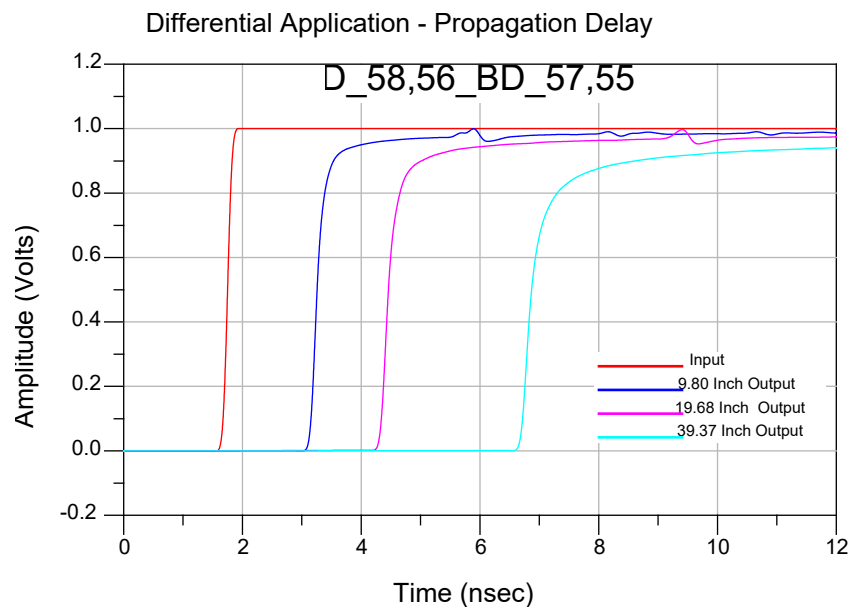


Figure 60

Series: HLCD-TD-BD-2

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-TD-BD-2, HLCD-30-19.68-TD-BD-2 and HLCD-30-39.37-TD-BD-2, 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

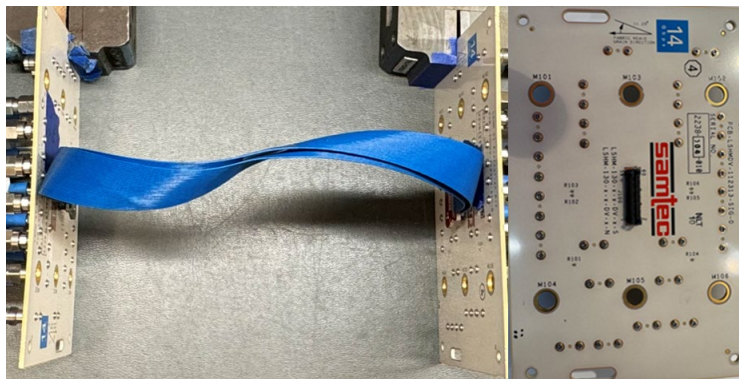


Figure 61

Series: HLCD-TD-BD-2

Description: High Speed Hermaphroditic Cable, 0.50mm Pitch

PCB Fixtures

The test fixtures used are as follows:

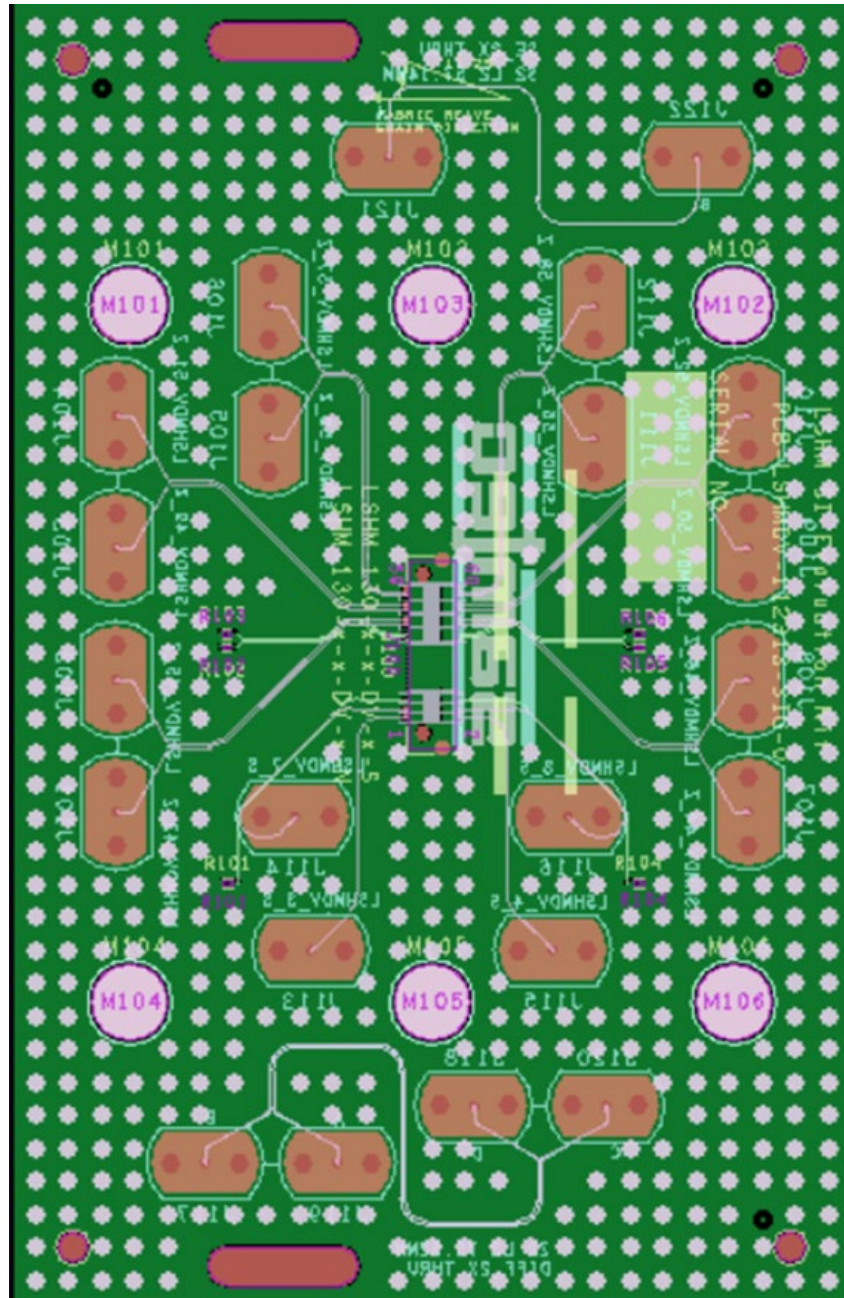


Figure 62

Series: HLCD-TD-BD-2

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

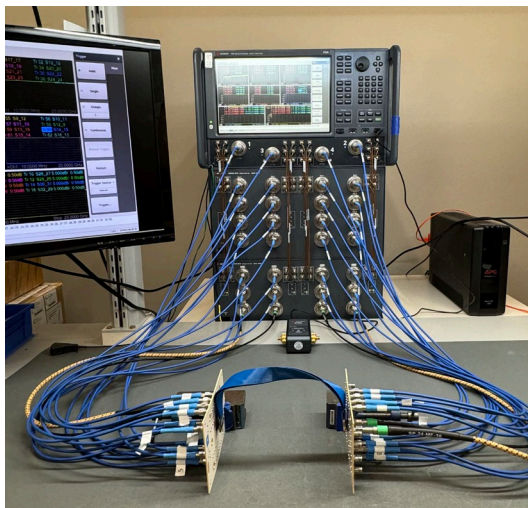


Figure 63

Test Instruments

<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

Series: HLCD-TD-BD-2

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-TD-BD-2

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