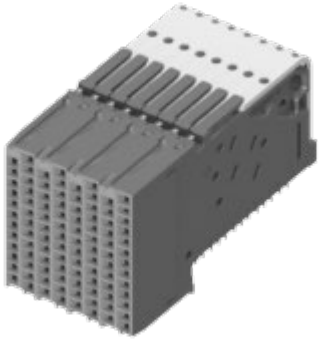
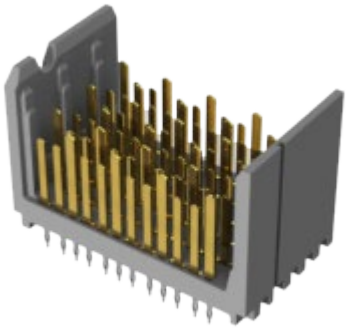
High Speed Characterization Report

HDTF-6-06-S-RA-LC-100



HDTM-6-06-1-S-VT-0-1



Description:
XCede® HD 1.80 mm Backplane Connector,
HDTF Right-Angle Receptacle mating with HDTM Vertical Header

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: 2/7/2023

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

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Connector Overview

The HDTx series is the XCede® HD 1.80mm pitch HDTF right-angle receptacle mating with the HDTM vertical backplane connector. At the time of testing, the HDTx connectors are available in 3-, 4-, and 6-pairs per column and 4, 6, and 8 columns. The HDTF-RA receptacle is available with 85-ohm or 100-ohm, standard (-LC) or high-speed (-HS) wafer options. The data in this report is applicable to the 100-ohm, -LC (Standard) wafer option.

Frequency Domain Data Summary

Bandwidth Chart – Single-Ended Insertion Loss

HDTx Connector Series

Figure 1

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

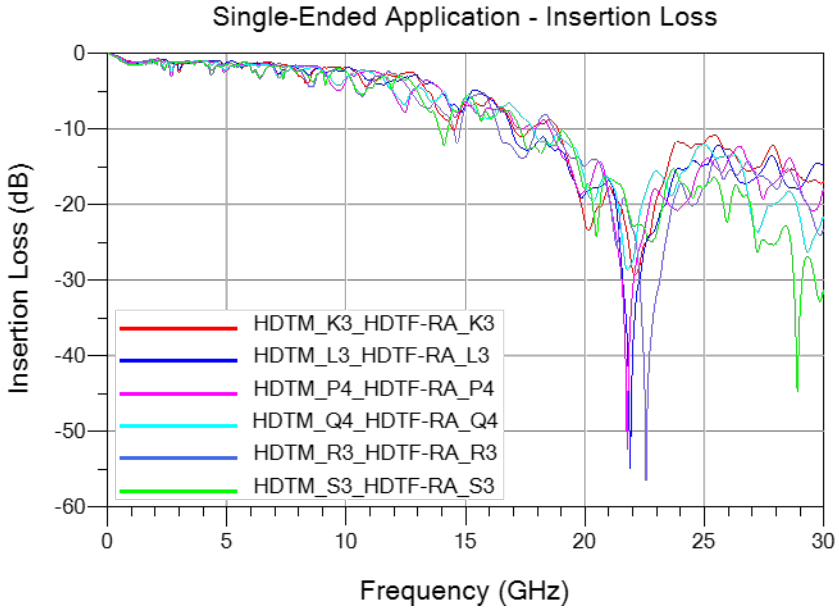

Figure 2

Bandwidth Chart – Differential Insertion Loss

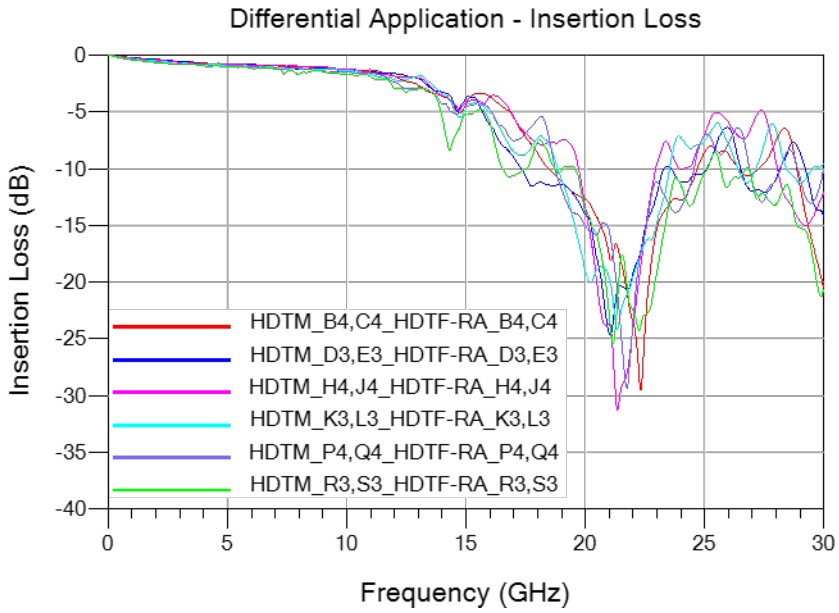

Figure 3

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

Time Domain Data Summary

Table 1 - Single-Ended Impedance (Ω)				
Driver	**Signal Rise-time**	**30ps**	**50ps**	**100ps**
HDTM_B4	Maximum Impedance	70.0	67.6	64.4
	Minimum Impedance	50.0	50.0	50.0
HDTM_C4	Maximum Impedance	78.2	74.3	67.1
	Minimum Impedance	49.6	49.8	49.9
HDTM_D3	Maximum Impedance	74.5	72.6	68.1
	Minimum Impedance	50.0	50.0	50.0
HDTM_E3	Maximum Impedance	76.3	75.2	71.0
	Minimum Impedance	49.2	49.4	49.8
HDTM_H4	Maximum Impedance	70.8	70.3	68.6
	Minimum Impedance	49.9	50.0	50.0
HDTM_J4	Maximum Impedance	78.8	77.6	73.5
	Minimum Impedance	50.0	50.0	50.0
HDTM_K3	Maximum Impedance	72.3	71.7	70.8
	Minimum Impedance	50.0	50.0	50.0
HDTM_L3	Maximum Impedance	77.7	76.3	74.4
	Minimum Impedance	50.0	50.0	50.0
HDTM_P4	Maximum Impedance	71.0	70.3	69.6
	Minimum Impedance	49.9	50.0	50.0
HDTM_Q4	Maximum Impedance	80.4	79.5	78.0
	Minimum Impedance	49.9	50.0	50.0
HDTM_R3	Maximum Impedance	73.4	73.0	72.8
	Minimum Impedance	50.0	50.0	50.0
HDTM_S3	Maximum Impedance	78.2	78.0	77.3
	Minimum Impedance	50.0	50.0	50.0

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Table 2 - Differential Impedance (Ω)				
Driver	**Signal Rise-time**	**30ps**	**50ps**	**100ps**
HDTM_B4,C4	Maximum Impedance	103.6	103.3	102.9
	Minimum Impedance	87.9	91.2	93.7
HDTM_D3,E3	Maximum Impedance	103.5	103.3	102.9
	Minimum Impedance	88.0	91.3	94.0
HDTM_H4,J4	Maximum Impedance	104.6	103.5	103.0
	Minimum Impedance	87.9	91.3	93.7
HDTM_K3,L3	Maximum Impedance	104.0	103.4	102.9
	Minimum Impedance	87.7	91.2	94.2
HDTM_P4,Q4	Maximum Impedance	104.0	103.4	103.0
	Minimum Impedance	85.3	89.3	92.2
HDTM_R3,S3	Maximum Impedance	104.8	104.3	103.8
	Minimum Impedance	87.6	91.1	94.2

Table 3 - Single-Ended Crosstalk (%)					
Input(tr)	**Driver**	**Receiver**	**30ps**	**50ps**	**100ps**
NEXT	HDTM_B4	HDTM_C4	18.1	17.4	14.9
	HDTM_A3	HDTM_B4	4.26	3.83	3.19
	HDTM_B3	HDTM_C4	3.28	3.08	2.57
	HDTM_D3	HDTM_E3	19.2	18.7	17.0
	HDTM_D3	HDTM_E4	3.57	3.26	2.61
	HDTM_E3	HDTM_F4	3.35	3.20	2.55
	HDTM_H4	HDTM_J4	19.4	19.0	18.1
	HDTM_K3	HDTM_L3	19.1	18.8	18.0
	HDTM_K3	HDTM_L4	3.58	3.26	2.54
	HDTM_L3	HDTM_M4	3.29	3.12	2.53
	HDTM_P4	HDTM_Q4	18.5	18.4	18.1
	HDTM_N3	HDTM_P4	3.54	3.23	2.58
	HDTM_P3	HDTM_Q4	3.33	3.17	2.56
	HDTM_R3	HDTM_S3	18.9	18.5	18.3

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FEXT	HDTM_B4	HDTF-RA_C4	1.92	1.73	1.52
	HDTM_A3	HDTF-RA_B4	2.70	2.50	2.12
	HDTM_B3	HDTF-RA_C4	1.92	1.73	1.52
	HDTM_D3	HDTF-RA_E3	5.97	5.51	4.76
	HDTM_D3	HDTF-RA_E4	2.42	2.06	1.68
	HDTM_E3	HDTF-RA_F4	1.83	1.57	1.38
	HDTM_H4	HDTF-RA_J4	7.22	6.85	5.81
	HDTM_K3	HDTF-RA_L3	6.55	6.31	5.71
	HDTM_K3	HDTF-RA_L4	2.27	2.11	1.87
	HDTM_L3	HDTF-RA_M4	2.53	1.88	1.47
	HDTM_P4	HDTF-RA_Q4	6.73	6.64	6.36
	HDTM_N3	HDTF-RA_P4	2.58	2.18	1.85
	HDTM_P3	HDTF-RA_Q4	2.89	2.12	1.53
	HDTM_R3	HDTF-RA_S3	7.59	6.71	6.45

Table 4 - Differential Crosstalk (%)

Input(tr)	Driver	Receiver	30ps	50ps	100ps
NEXT	HDTF-RA_B4,C4	HDTF-RA_E4,F4	1.11	0.68	0.22
	HDTF-RA_E4,F4	HDTF-RA_H4,J4	0.31	0.26	0.22
	HDTF-RA_G3,H3	HDTF-RA_K3,L3	0.36	0.29	0.23
	HDTF-RA_L4,M4	HDTF-RA_P4,Q4	0.36	0.28	0.21
	HDTF-RA_P4,Q4	HDTF-RA_S4,T4	0.37	0.29	0.23
	HDTF-RA_G3,H3	HDTF-RA_L4,M4	0.20	0.13	<0.1
	HDTF-RA_K3,L3	HDTF-RA_N3,P3	0.44	0.32	0.24
FEXT	HDTM_B4,C4	HDTF-RA_E4,F4	0.26	0.18	<0.1
	HDTM_E4,F4	HDTF-RA_H4,J4	0.23	0.17	<0.1
	HDTM_G3,H3	HDTF-RA_K3,L3	0.28	0.18	0.10
	HDTM_L4,M4	HDTF-RA_P4,Q4	0.23	0.17	<0.1
	HDTM_P4,Q4	HDTF-RA_S4,T4	0.24	0.16	<0.1
	HDTM_G3,H3	HDTF-RA_L4,M4	<0.1	<0.1	<0.1
	HDTM_K3,L3	HDTF-RA_N3,P3	0.33	0.21	0.10

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Table 5 - Propagation Delay (Mated Connector)	
HDTM_B4_HDTF-RA_B4	150 ps
HDTM_C4_HDTF-RA_C4	149 ps
HDTM_D3_HDTF-RA_D3	179 ps
HDTM_E3_HDTF-RA_E3	184 ps
HDTM_H4_HDTF-RA_H4	206 ps
HDTM_J4_HDTF-RA_J4	206 ps
HDTM_K3_HDTF-RA_K3	242 ps
HDTM_L3_HDTF-RA_L3	243 ps
HDTM_P4_HDTF-RA_P4	270 ps
HDTM_Q4_HDTF-RA_Q4	266 ps
HDTM_R3_HDTF-RA_R3	303 ps
HDTM_S3_HDTF-RA_S3	296 ps
HDTM_B4,C4_HDTF-RA_B4,C4	140 ps
HDTM_D3,E3_HDTF-RA_D3,E3	173 ps
HDTM_H4,J4_HDTF-RA_H4,J4	198 ps
HDTM_K3,L3_HDTF-RA_K3,L3	235 ps
HDTM_P4,Q4_HDTF-RA_P4,Q4	262 ps
HDTM_R3,S3_HDTF-RA_R3,S3	294 ps

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

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 differentially 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.

For this connector, the following configurations were evaluated:

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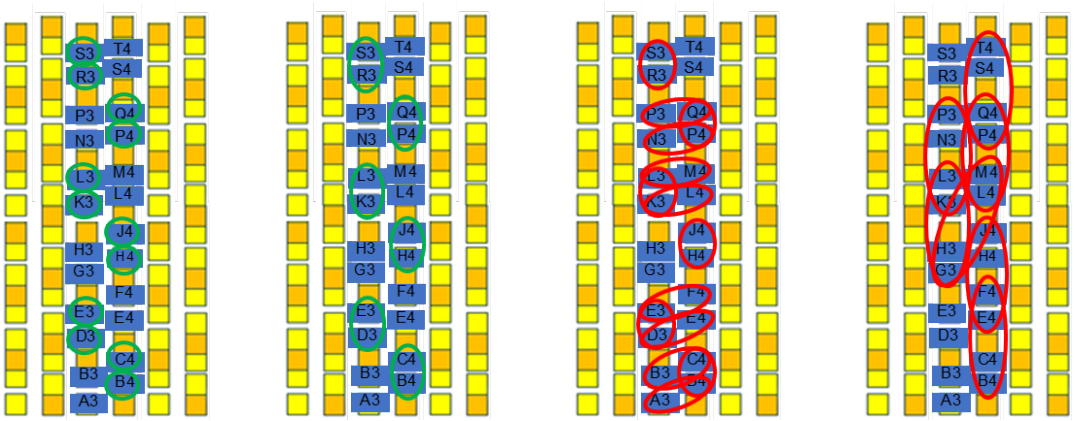

Single-Ended & Differential Impedance (denoted by green circles):

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

Single-Ended & 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.

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 30 ps and 100 ps.

For this report, measured rise times were at 20%-80% 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 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 80 mils of PCB trace on the HDTF-RA and HDTM 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. 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.

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 Responses

Single-Ended Application – Insertion Loss

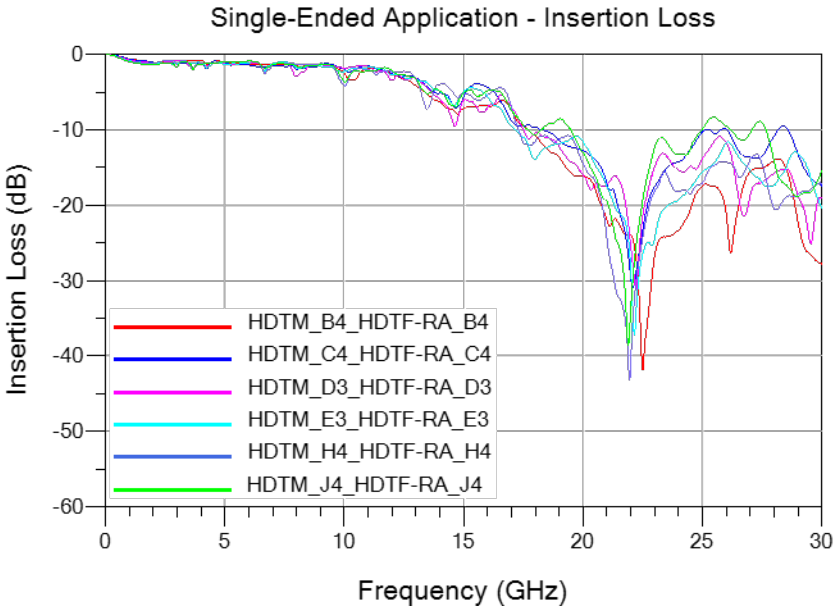

Figure 4

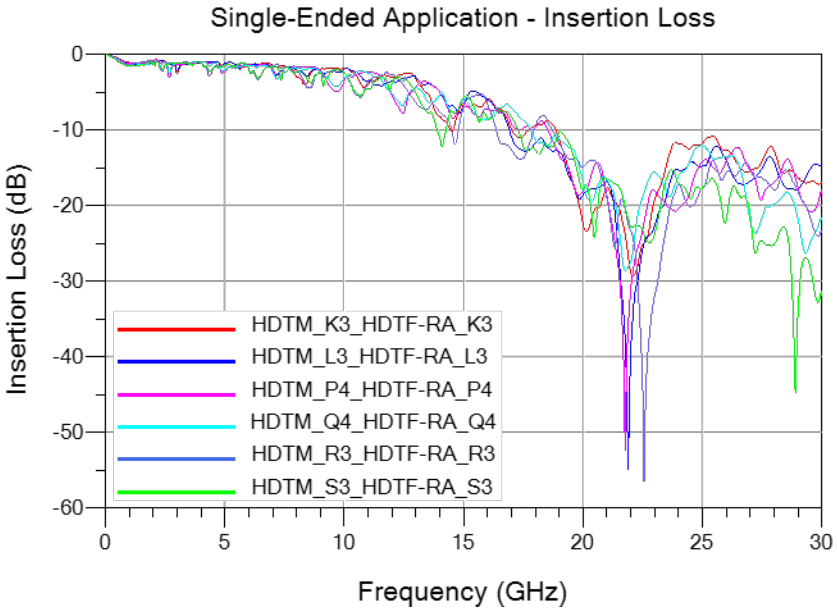

Figure 5

Series: HDTF-RA / HDTM
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Differential Application – Insertion Loss

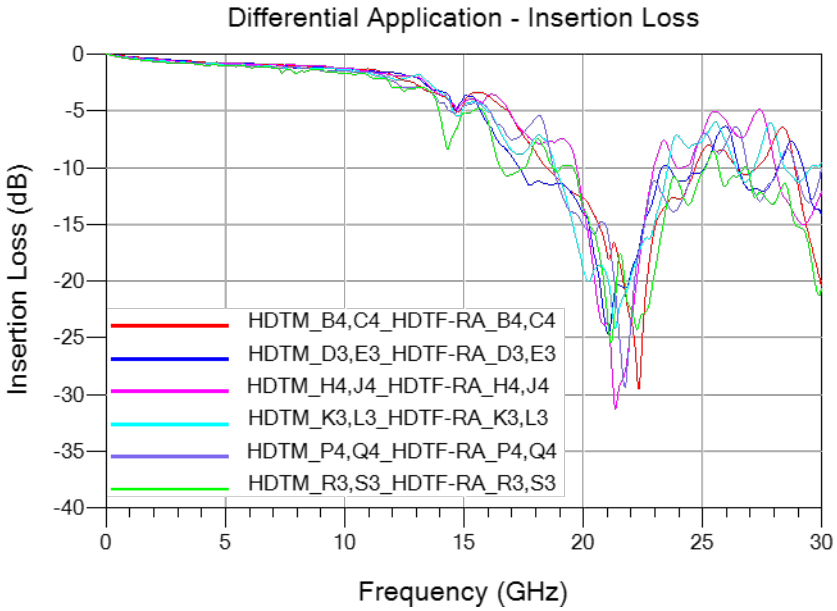

Figure 6

Single-Ended Application – Return Loss

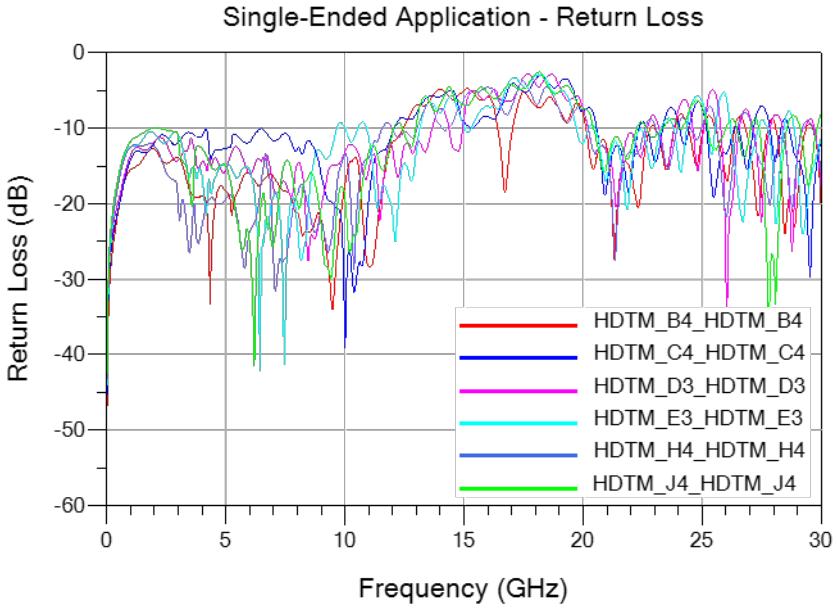

Figure 7

Series: HDTF-RA / HDTM
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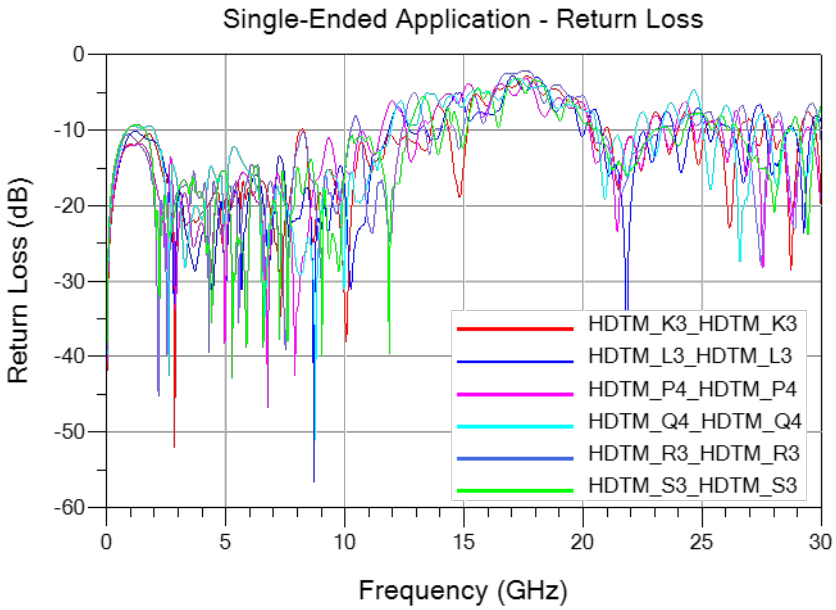

Figure 8

Differential Application – Return Loss

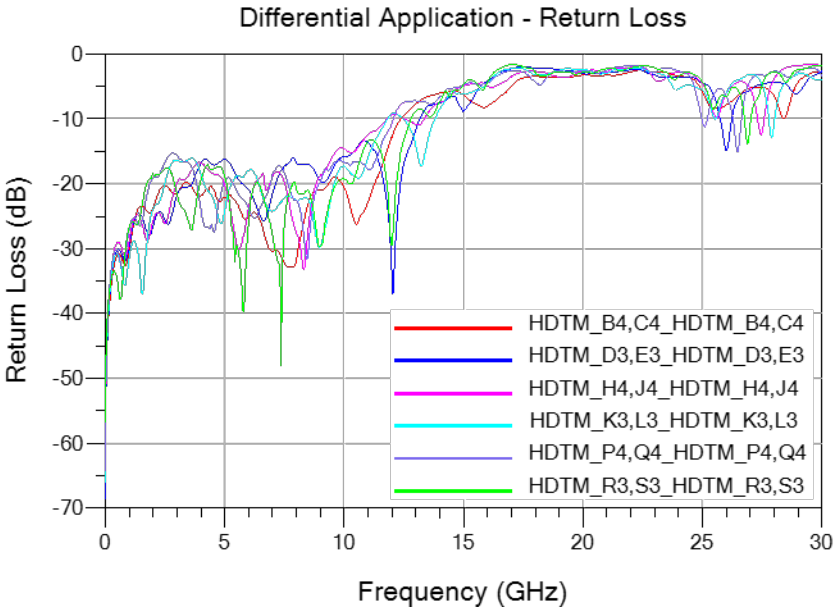

Figure 9

Series: HDTF-RA / HDTM
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Single-Ended Application – NEXT Configurations

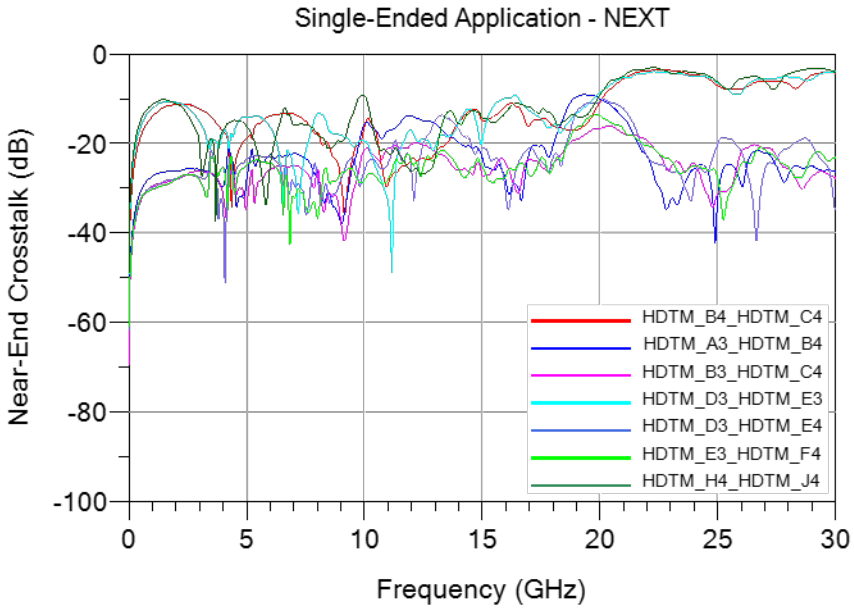

Figure 10

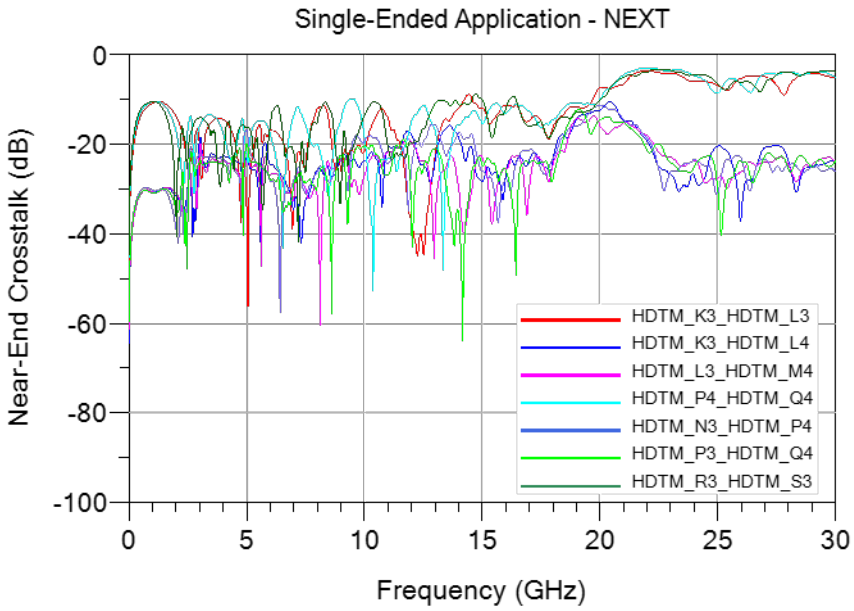

Figure 11

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

Differential Application – NEXT Configurations

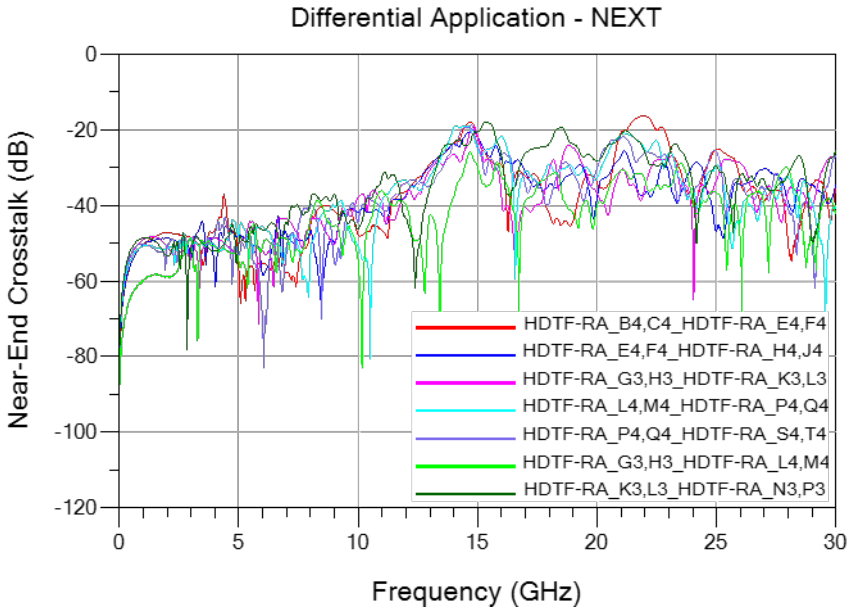

Figure 12

Single-Ended Application – FEXT Configurations

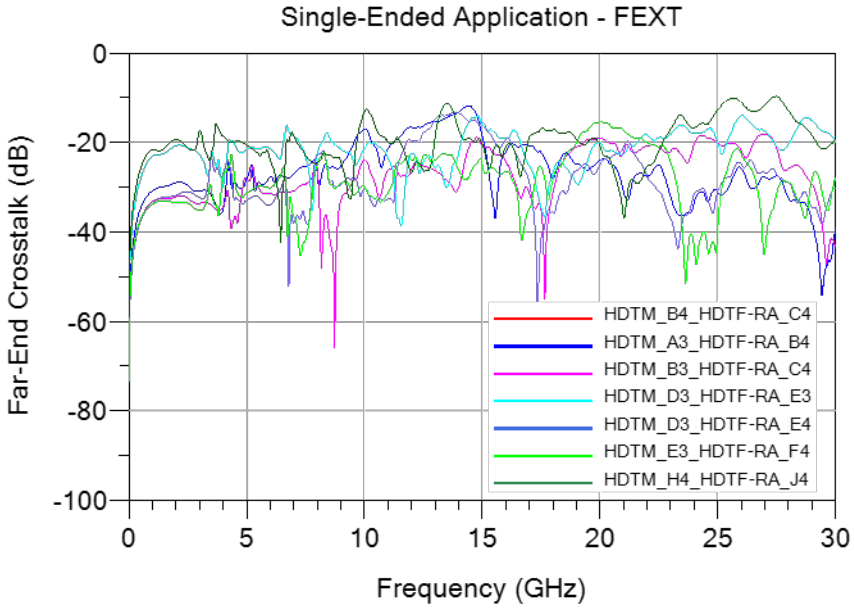

Figure 13

Series: HDTF-RA / HDTM
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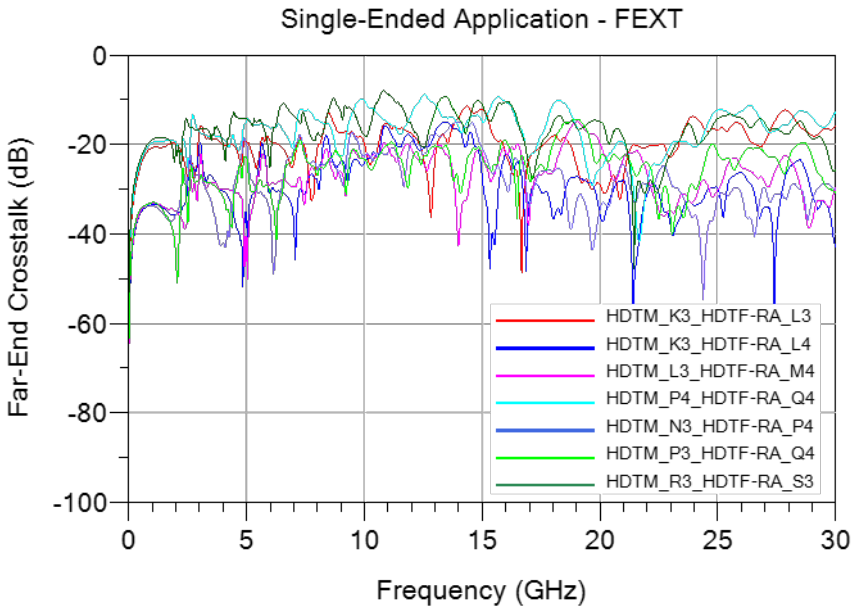

Figure 14

Differential Application – FEXT Configurations

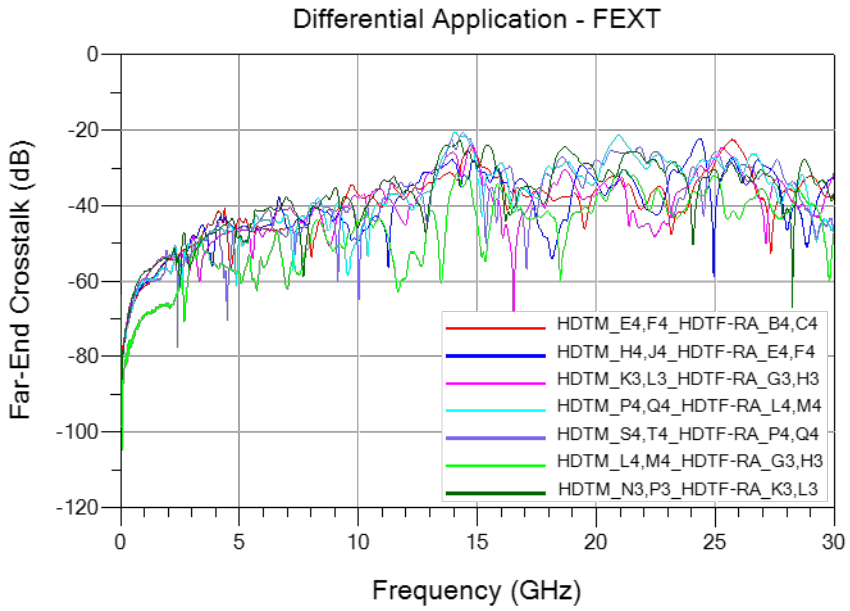

Figure 15

Series: HDTF-RA / HDTM
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Appendix B – Time Domain Responses

Single-Ended Application – Impedance

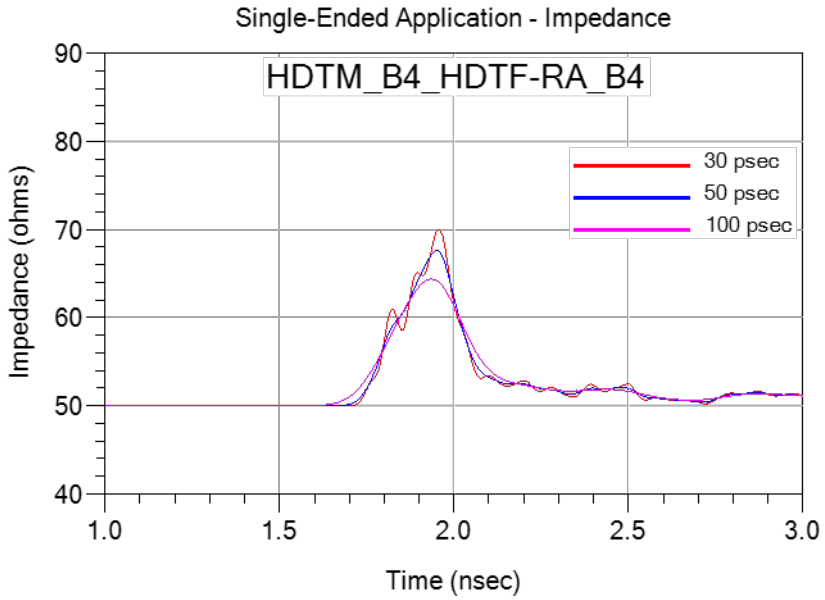

Figure 16

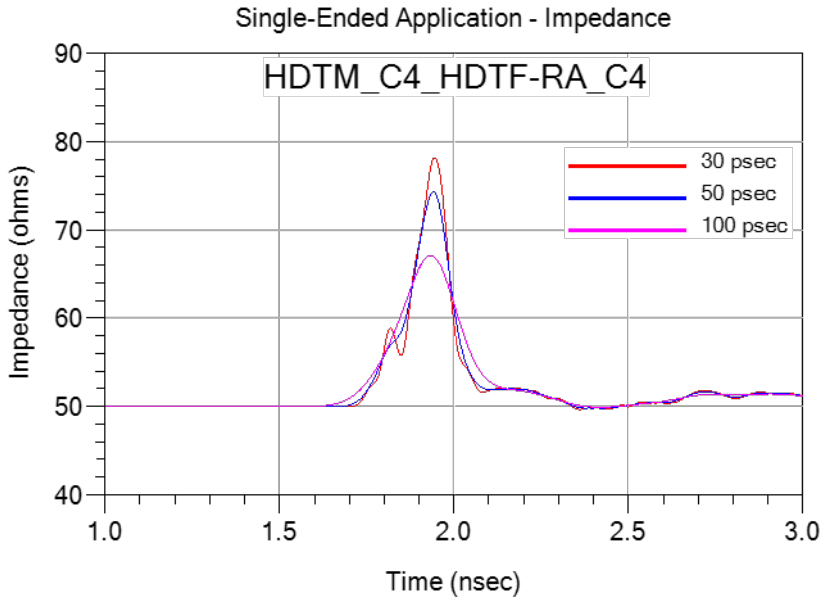

Figure 17

Series: HDTF-RA / HDTM
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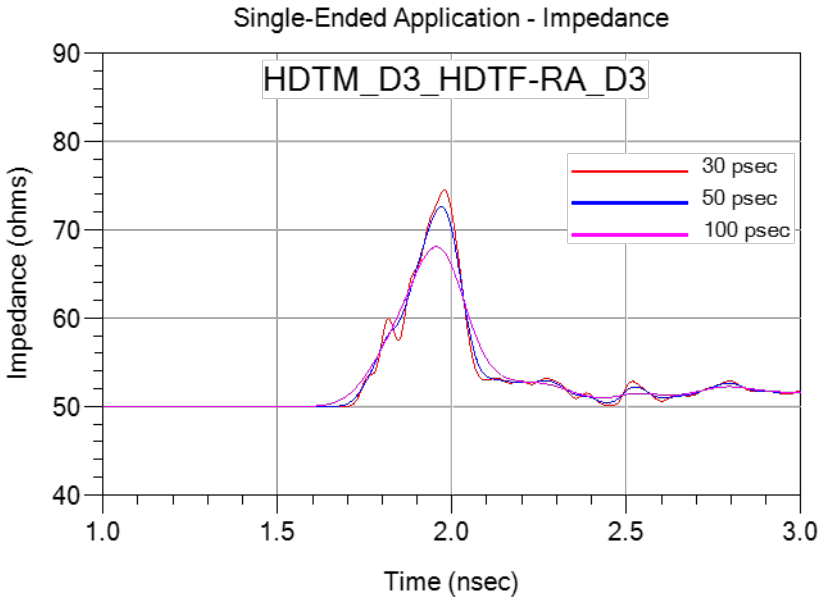

Figure 18

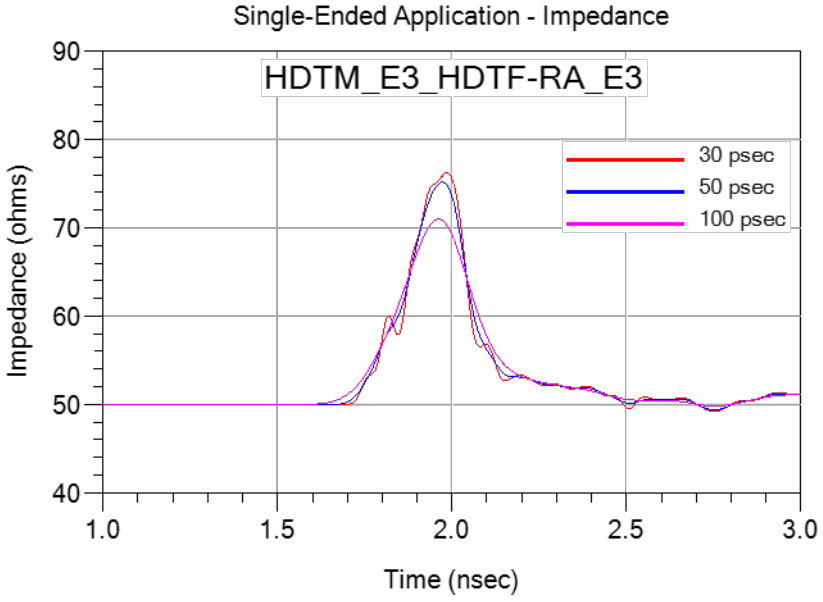

Figure 19

Series: HDTF-RA / HDTM
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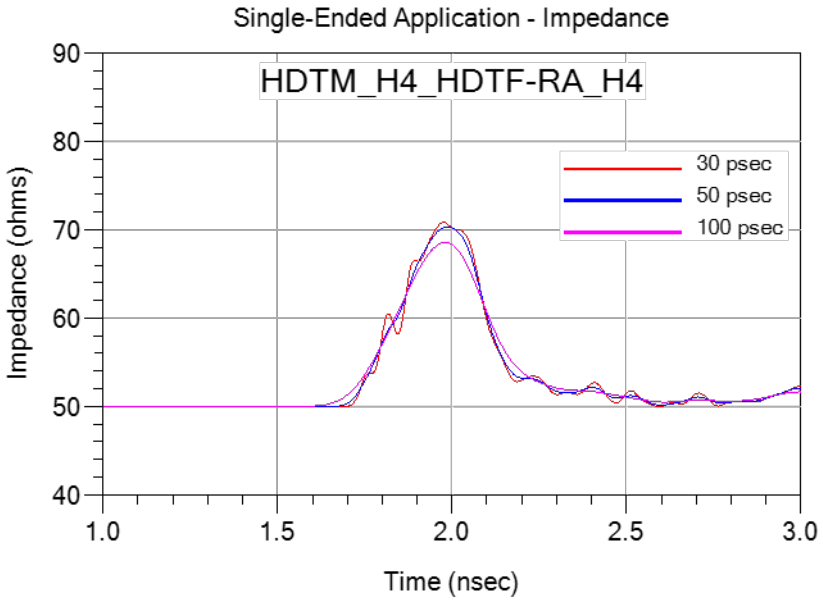

Figure 20

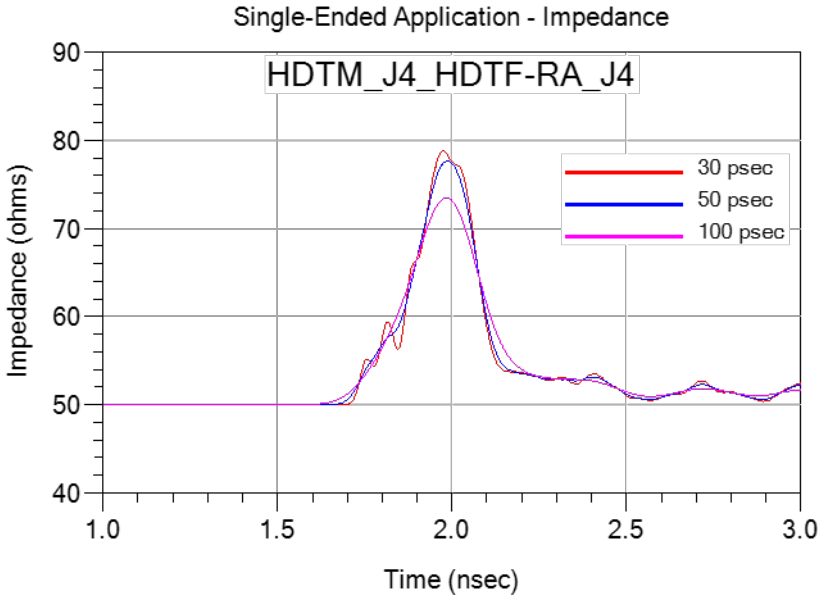

Figure 21

Series: HDTF-RA / HDTM
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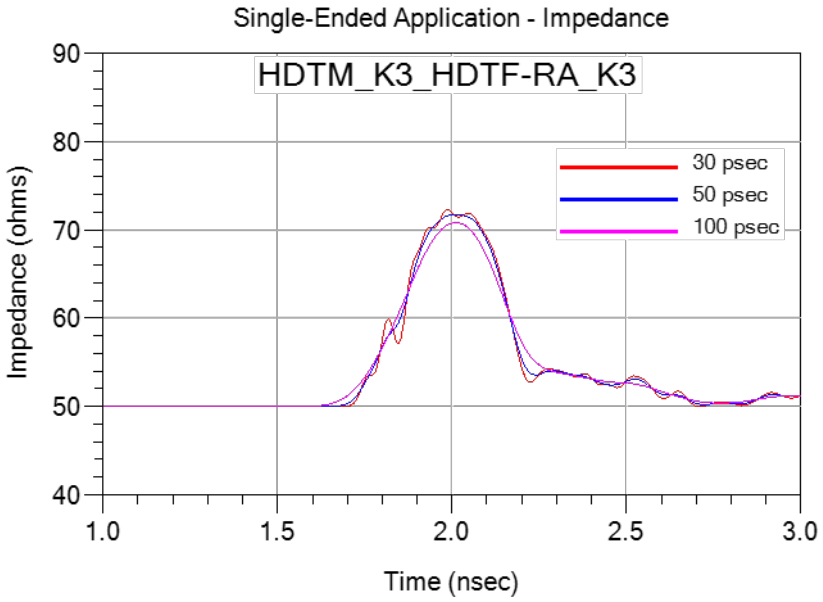

Figure 22

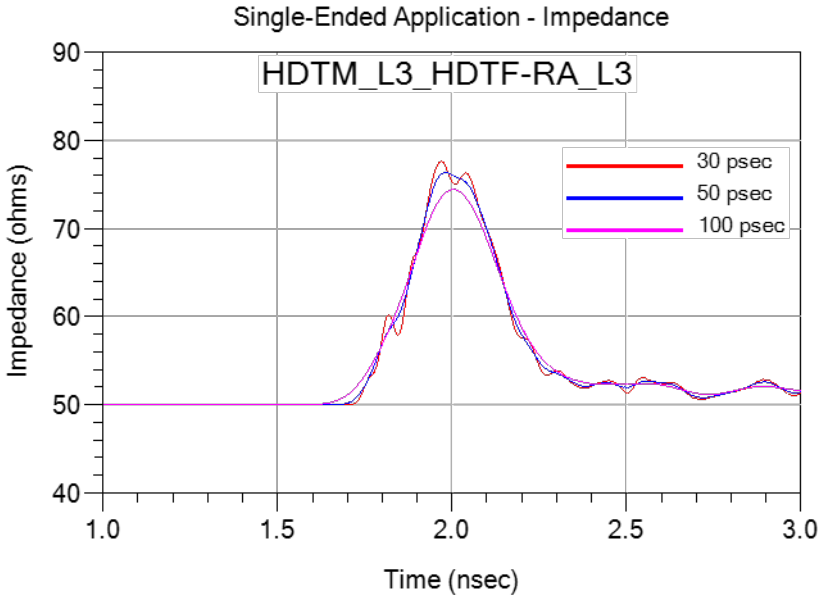

Figure 23

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

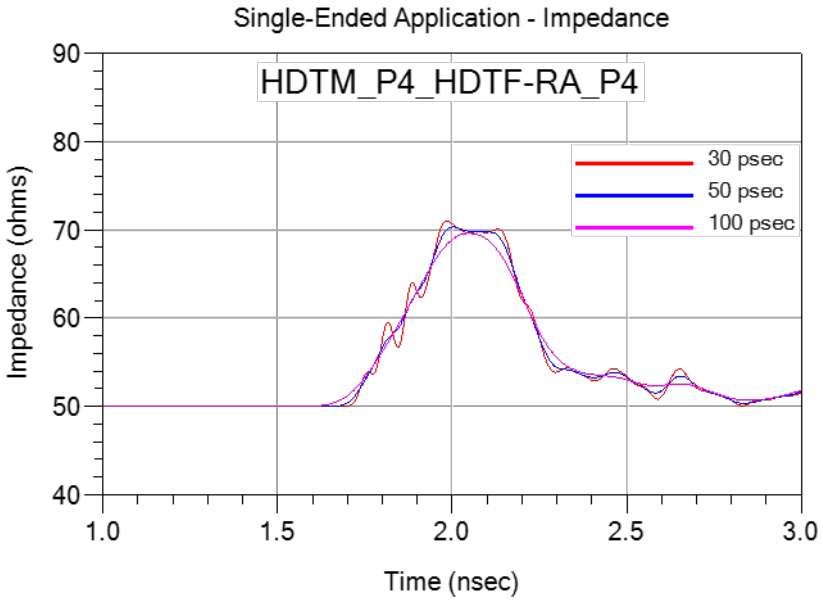

Figure 24

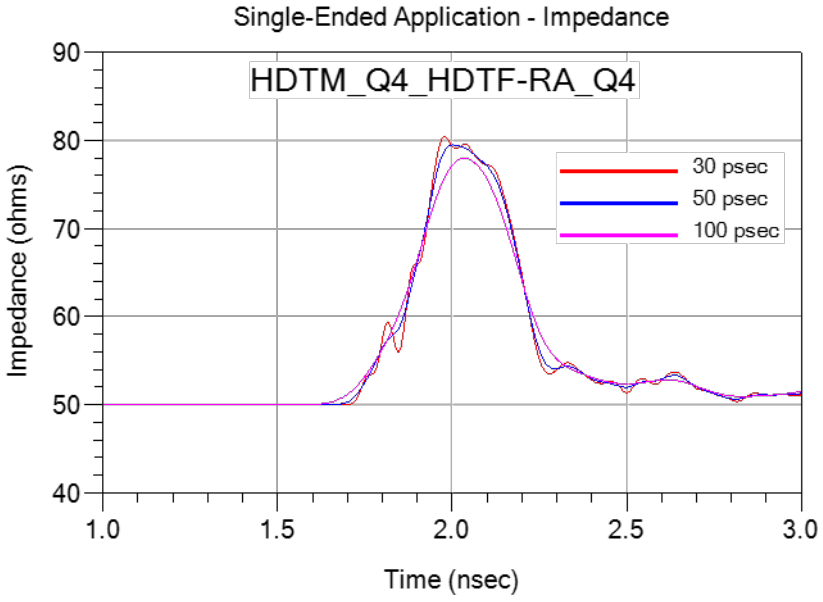

Figure 25

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

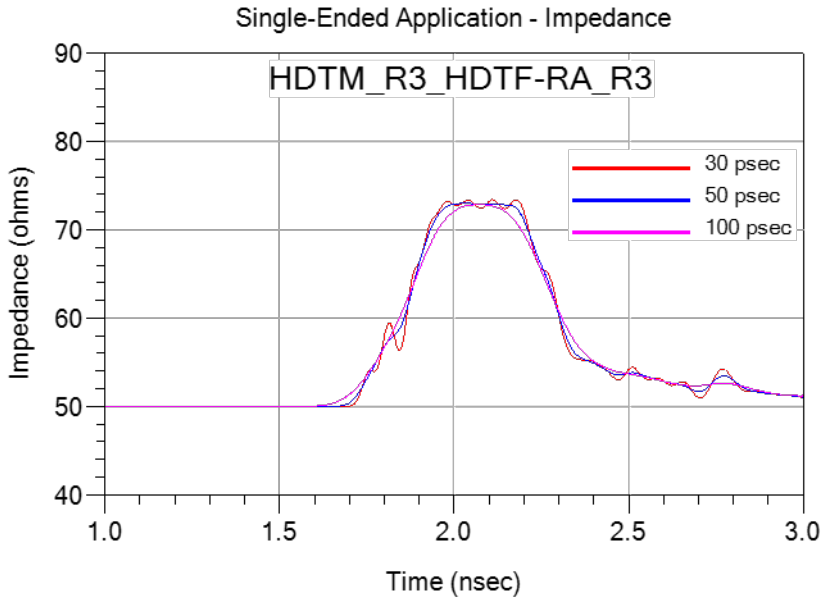

Figure 26

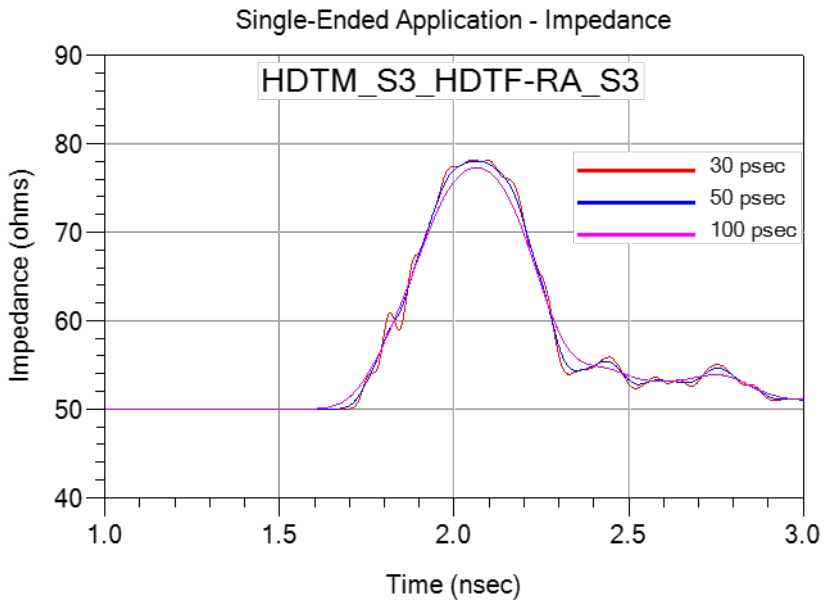

Figure 27

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

Differential Application – Impedance

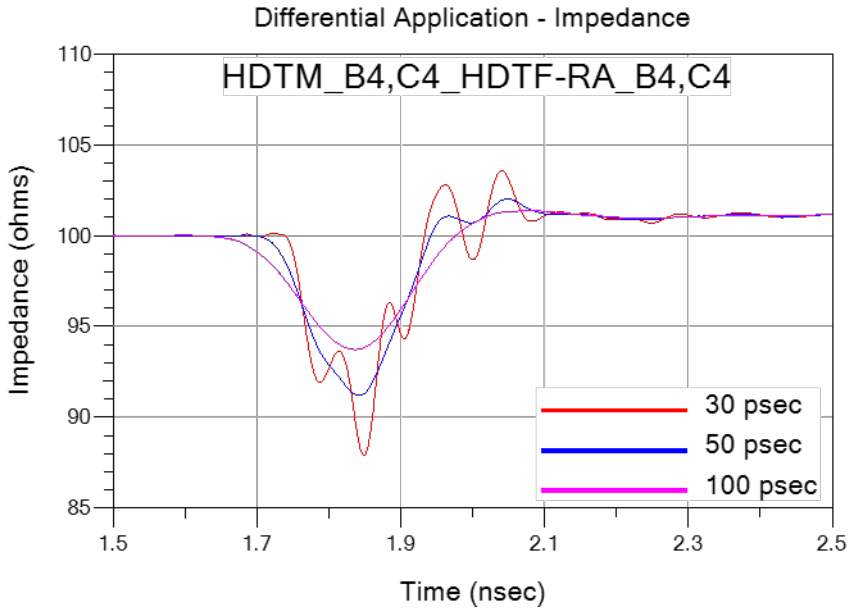

Figure 28

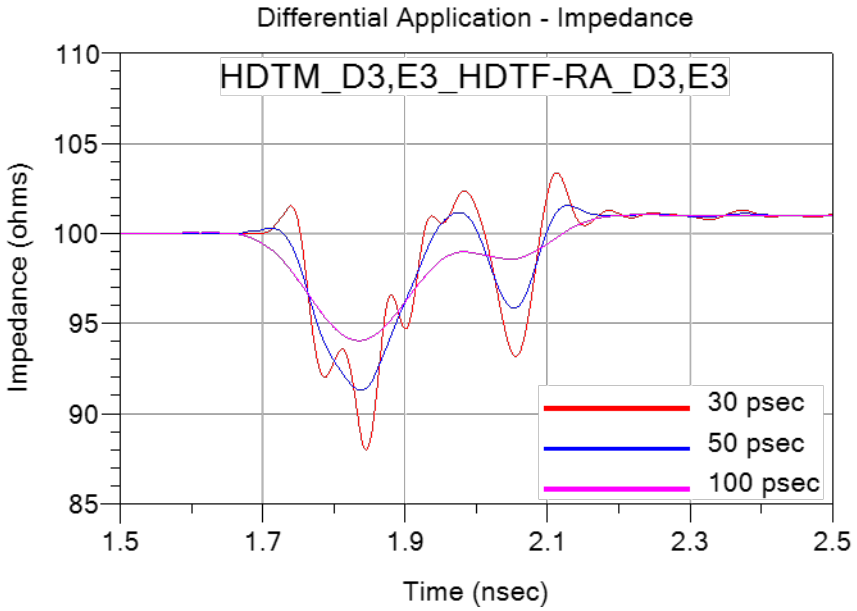

Figure 29

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

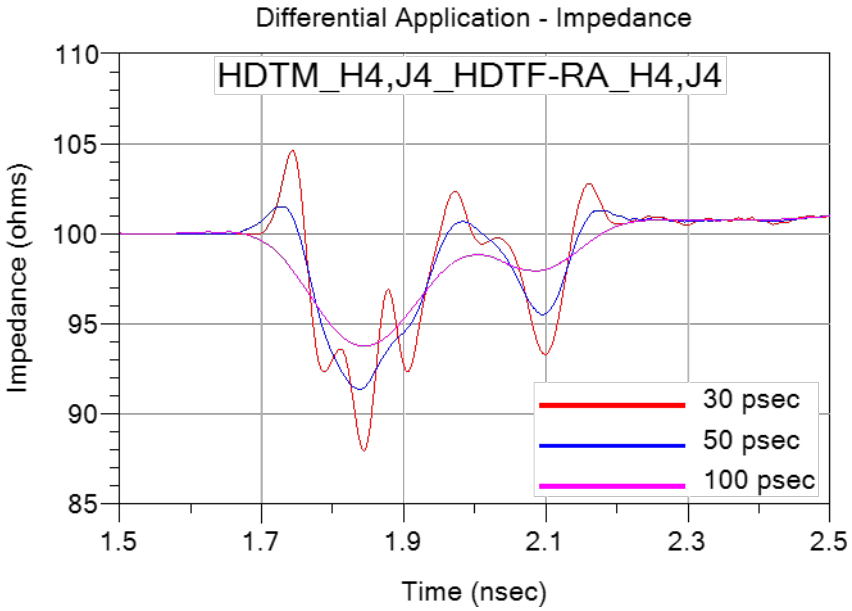

Figure 30

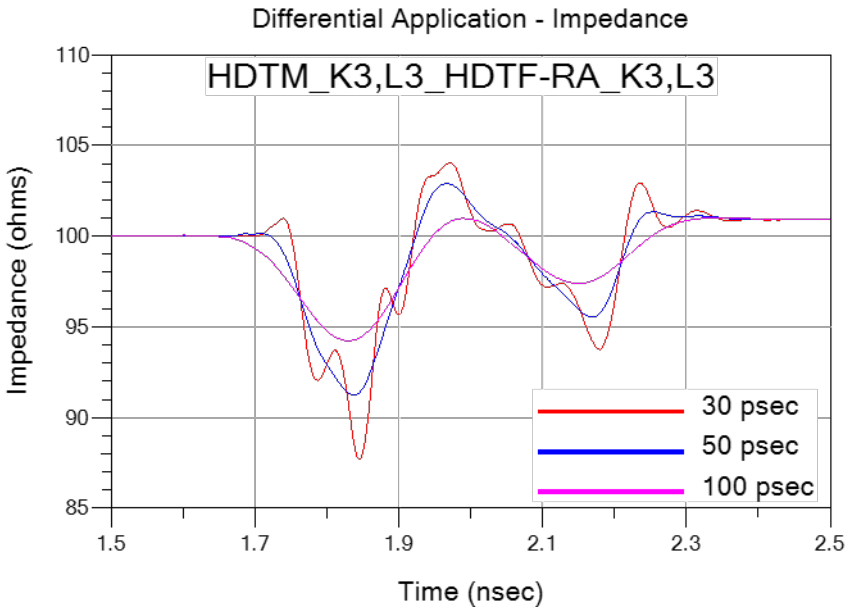

Figure 31

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

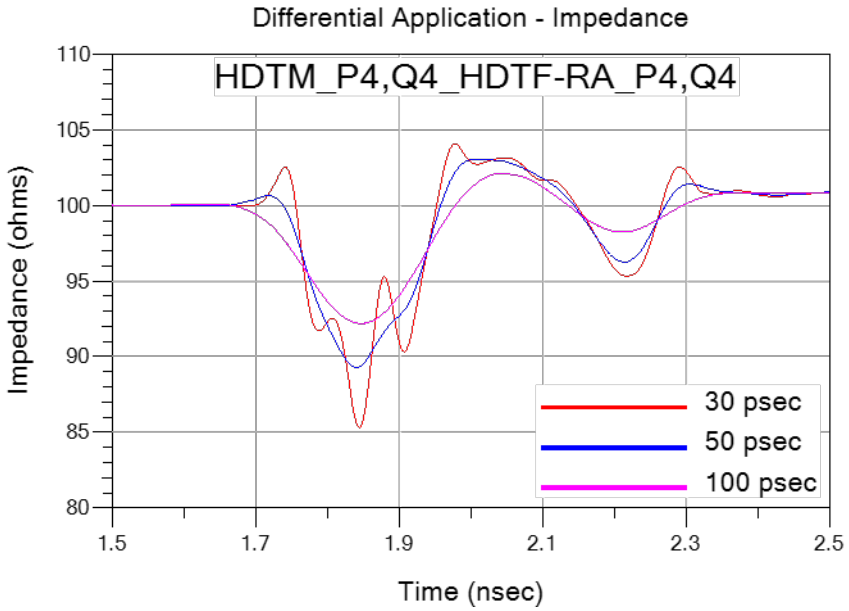

Figure 32

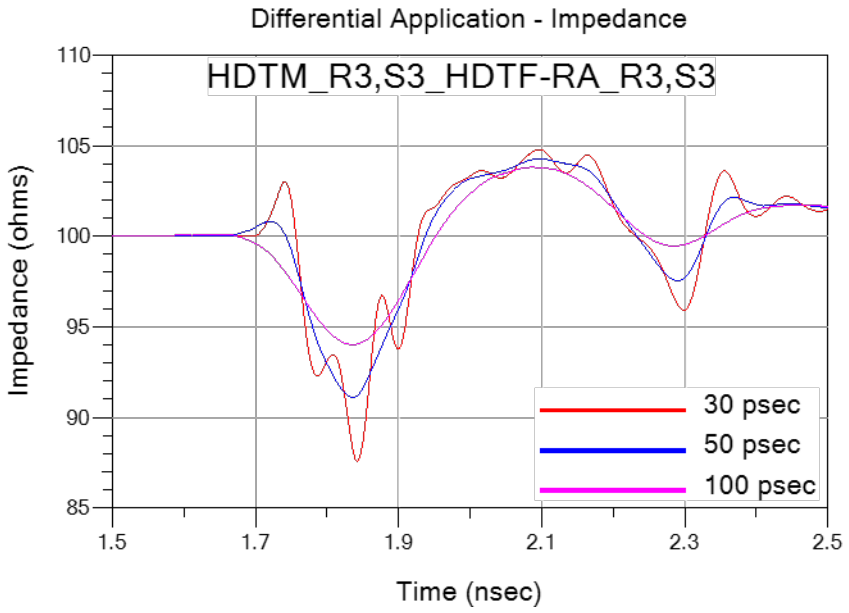

Figure 33

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

Single-Ended Application – Propagation Delay

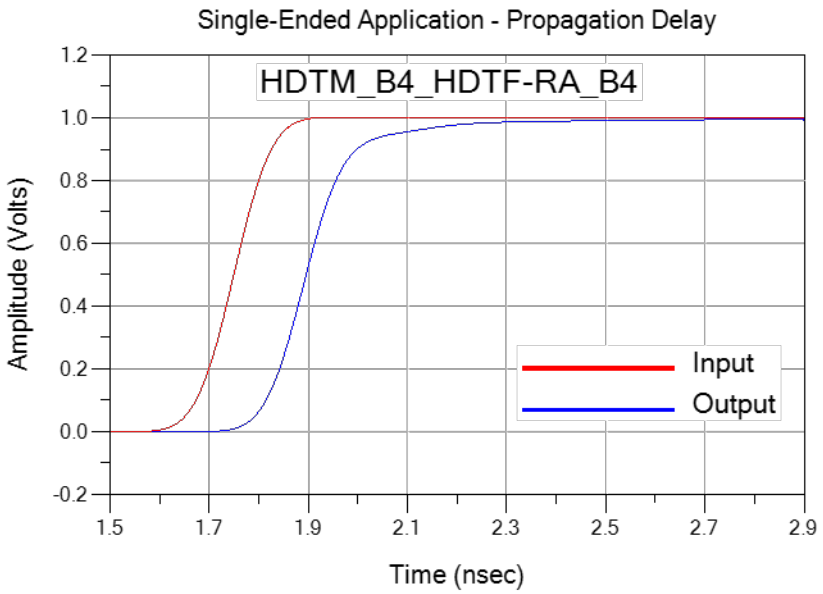

Figure 34

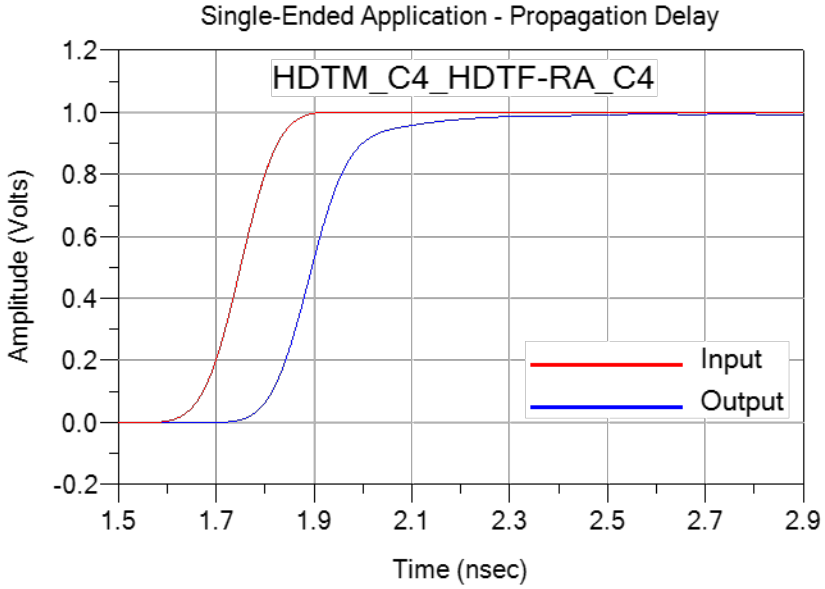

Figure 35

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

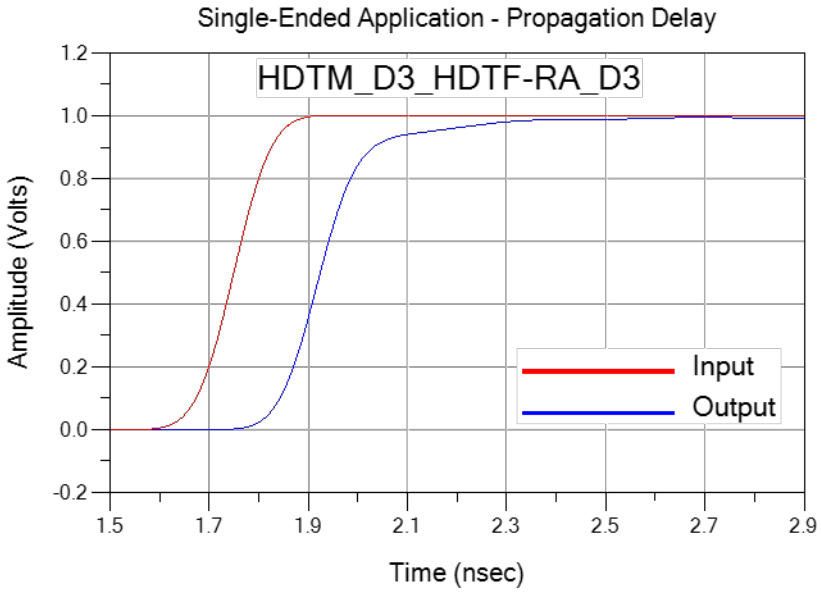

Figure 36

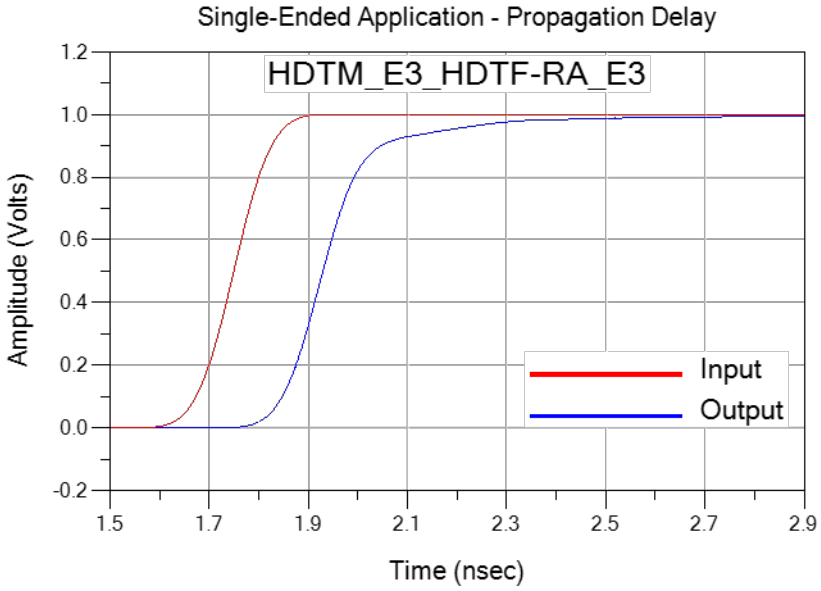

Figure 37

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

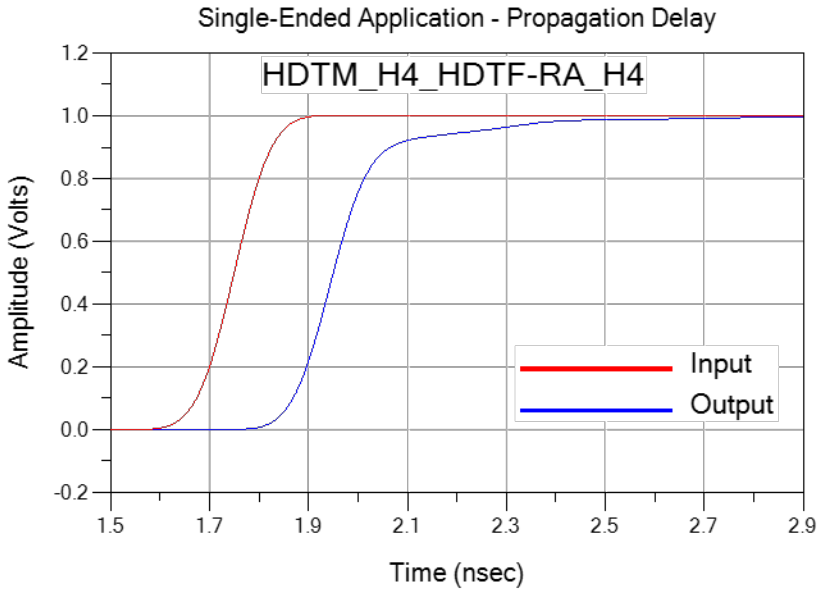

Figure 38

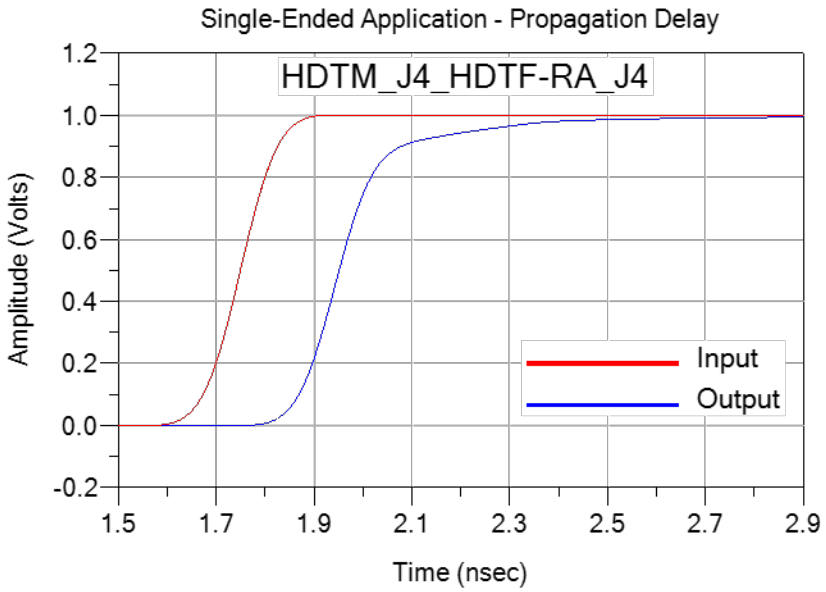

Figure 39

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

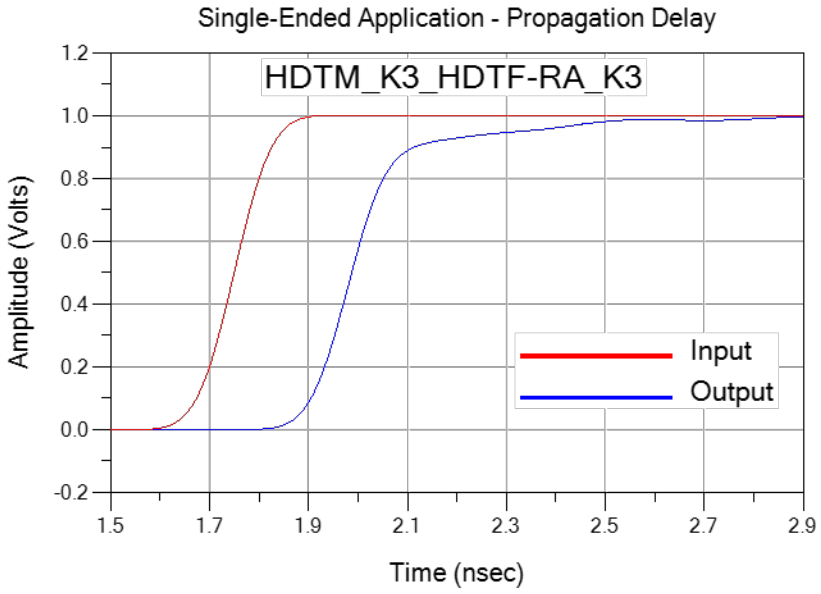

Figure 40

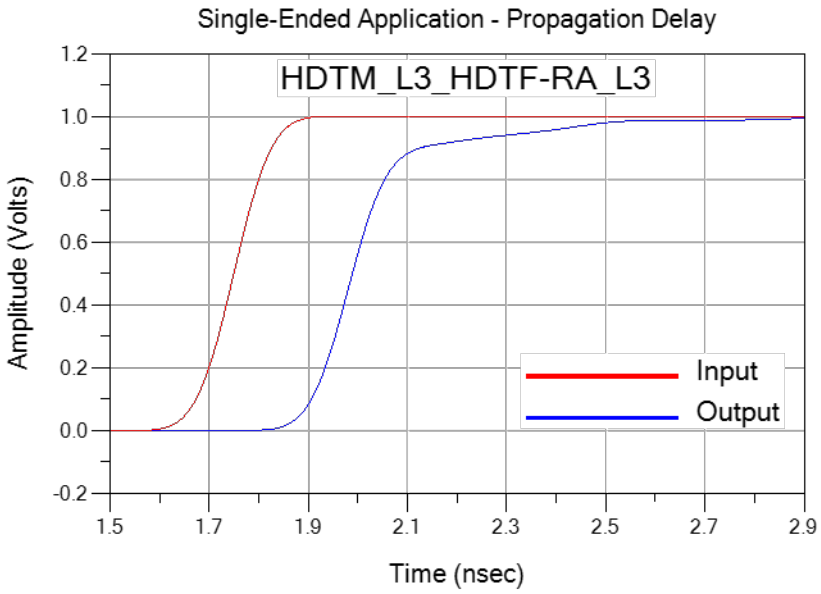

Figure 41

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

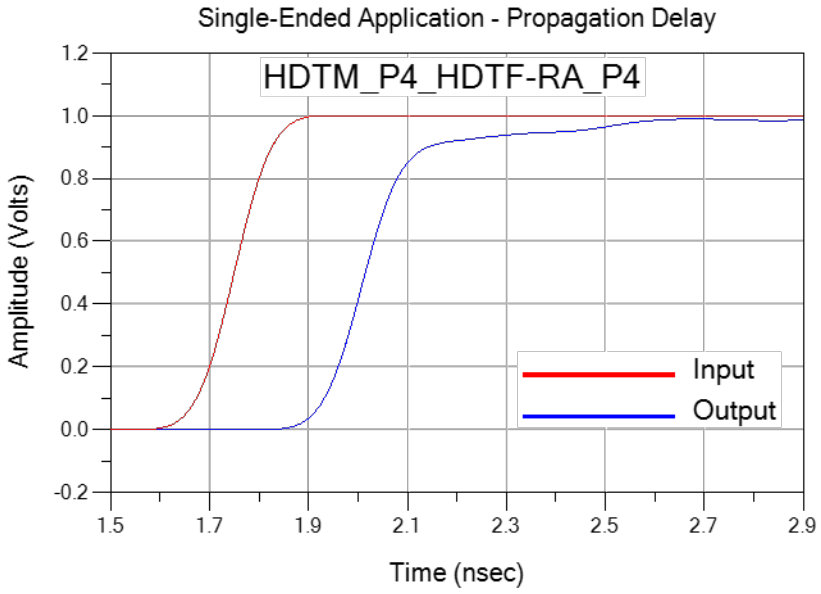

Figure 42

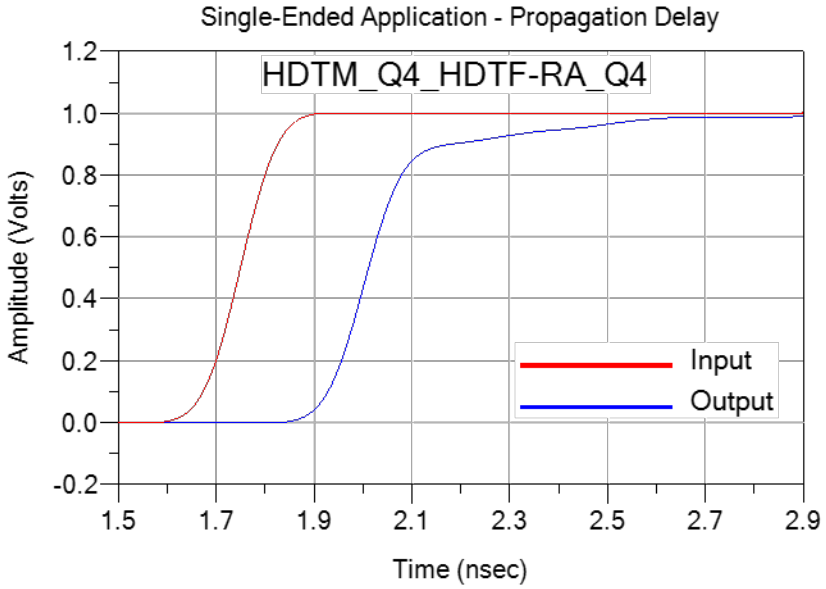

Figure 43

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

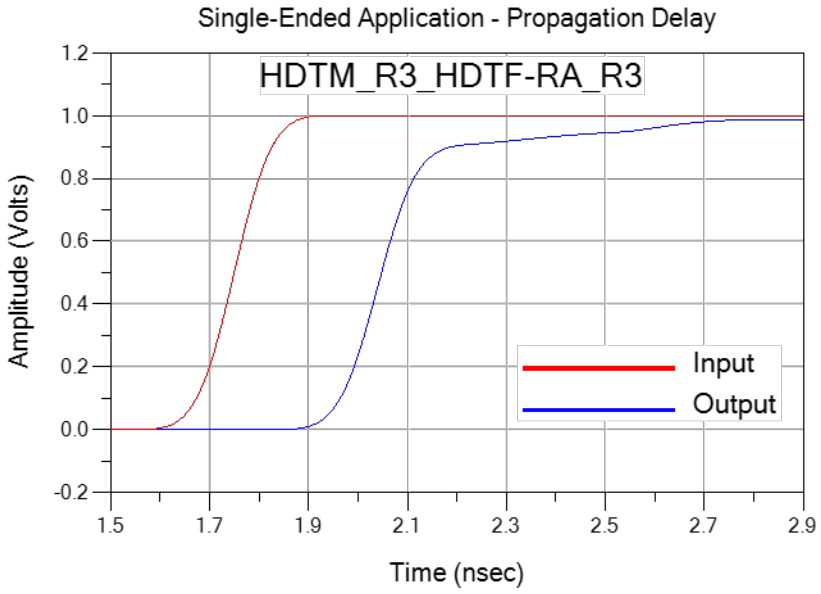

Figure 44

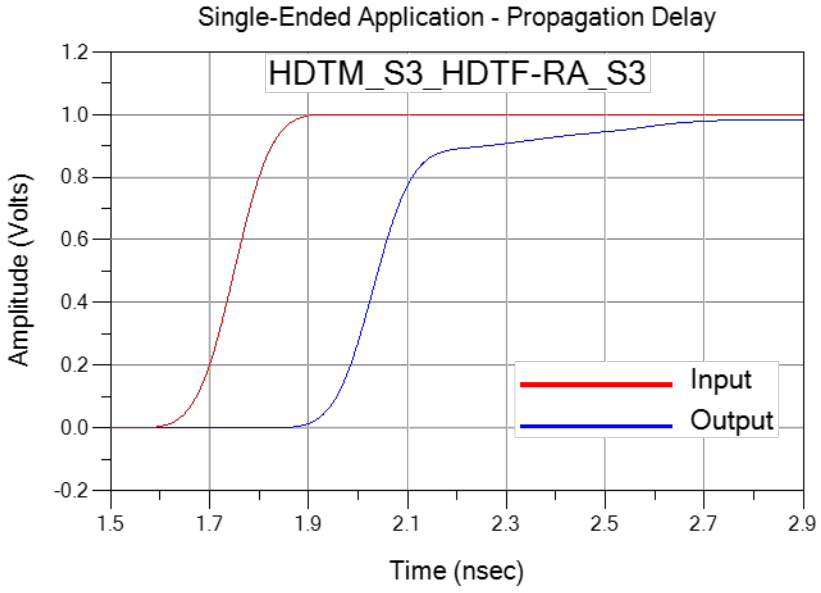

Figure 45

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

Differential Application – Propagation Delay

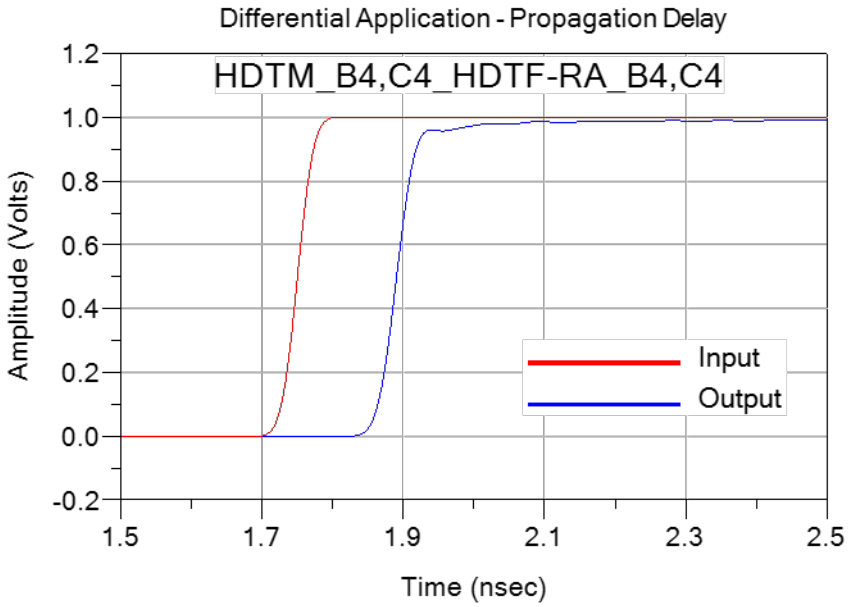

Figure 46

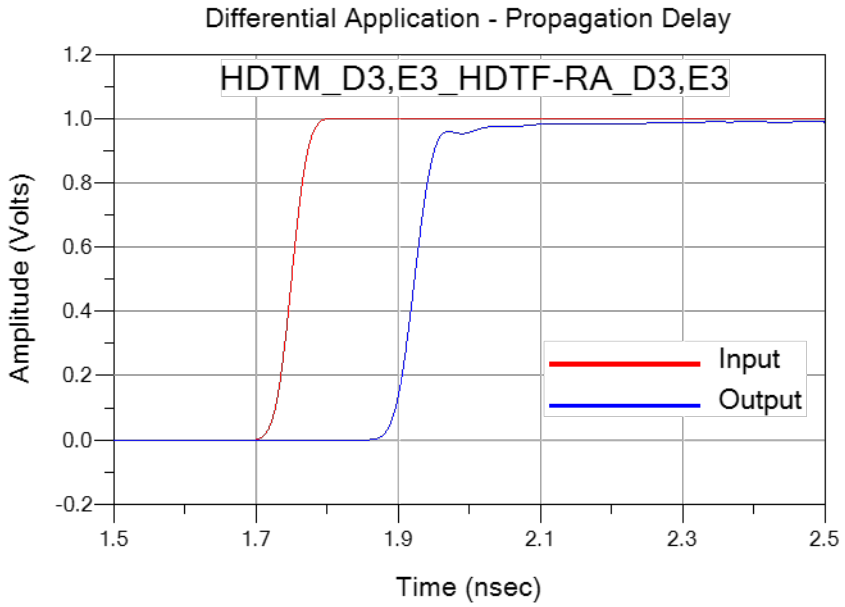

Figure 47

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

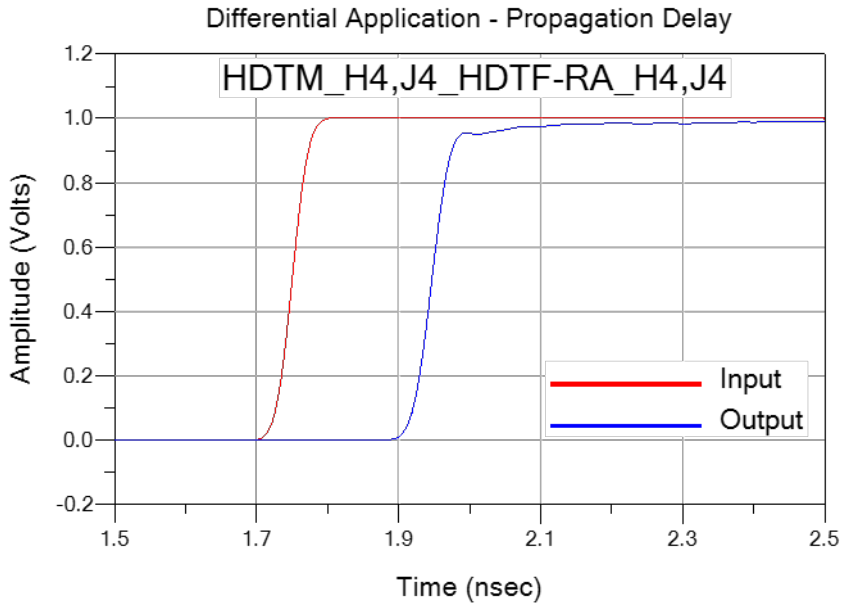

Figure 48

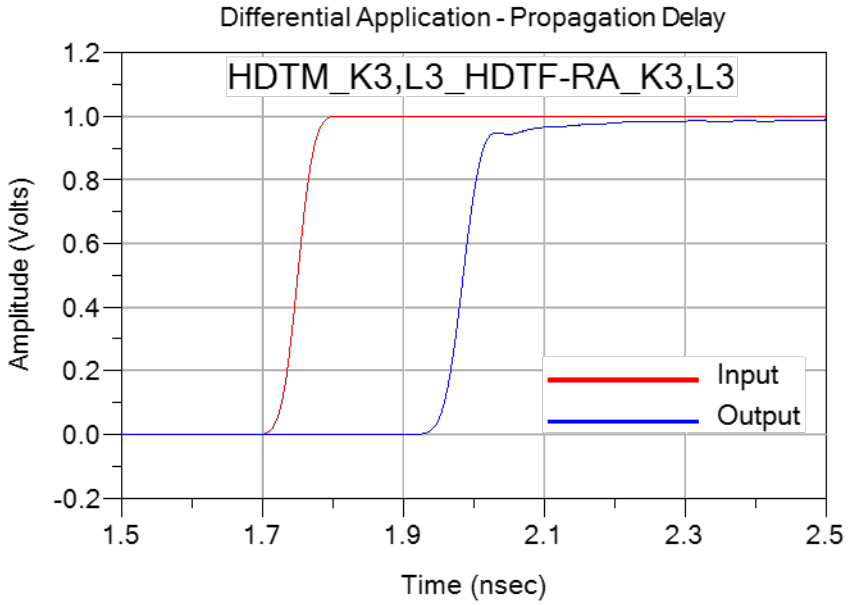

Figure 49

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

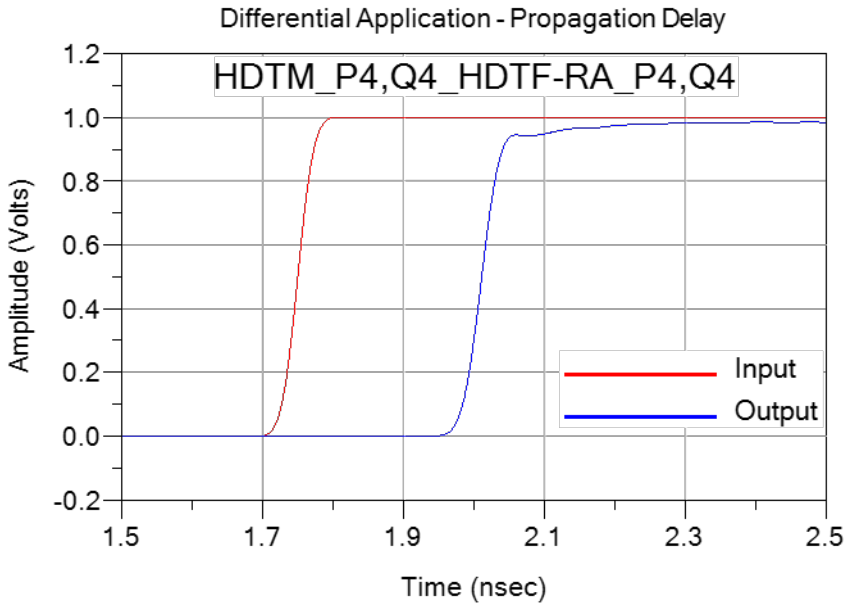

Figure 50

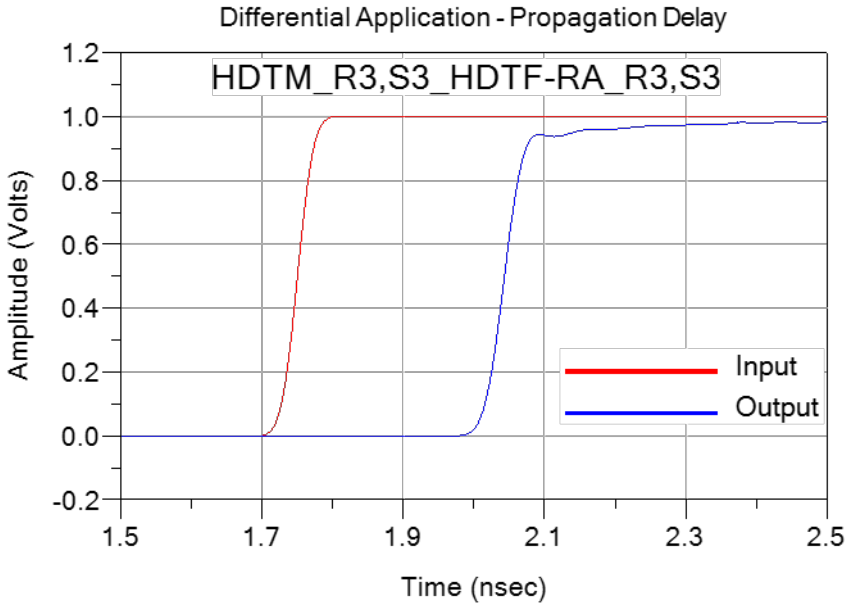

Figure 51

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

Appendix C – Product and Test System Descriptions

Product Description

Product test samples are press-fit HDTx Series connectors. The part numbers are HDTF-6-06-S-RA-LC-100 and HDTM-6-06-1-S-VT-0-1. The HDTx Series connectors are available for standard or high-speed wafers. The modular design provides flexibility in applications. A photo of the test articles mounted to SI test boards is shown below.

Test System Description

The test fixtures are composed of eight-layer FR-4 material with 50Ω signal trace and pad configurations designed for the electrical characterization of Samtec high speed connector products. A PCB mount 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 HDTx series connector set and identified by part number PCB-109191-SIG.

PCB-109191-SIG-XX Test Fixtures

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

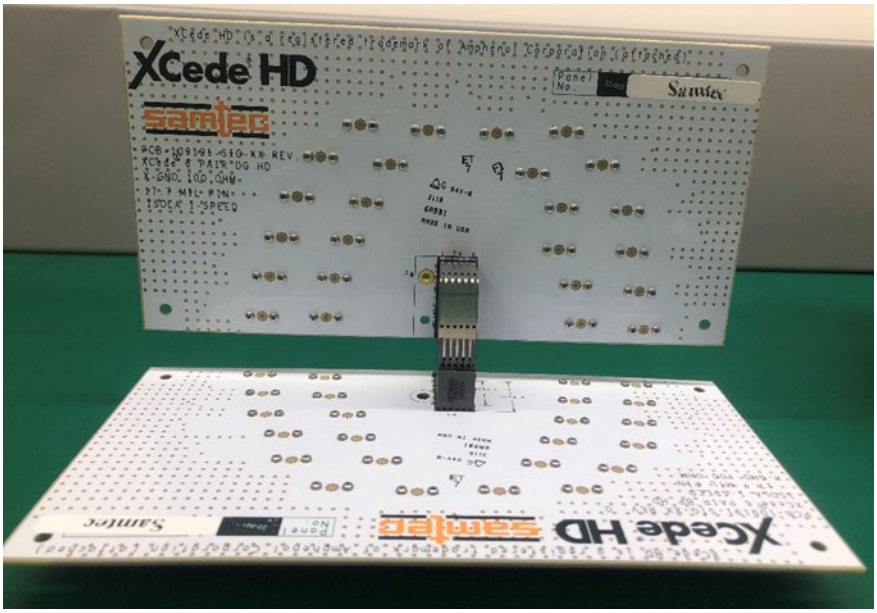

Figure 52

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

PCB Fixtures

The test fixtures used are as follows:

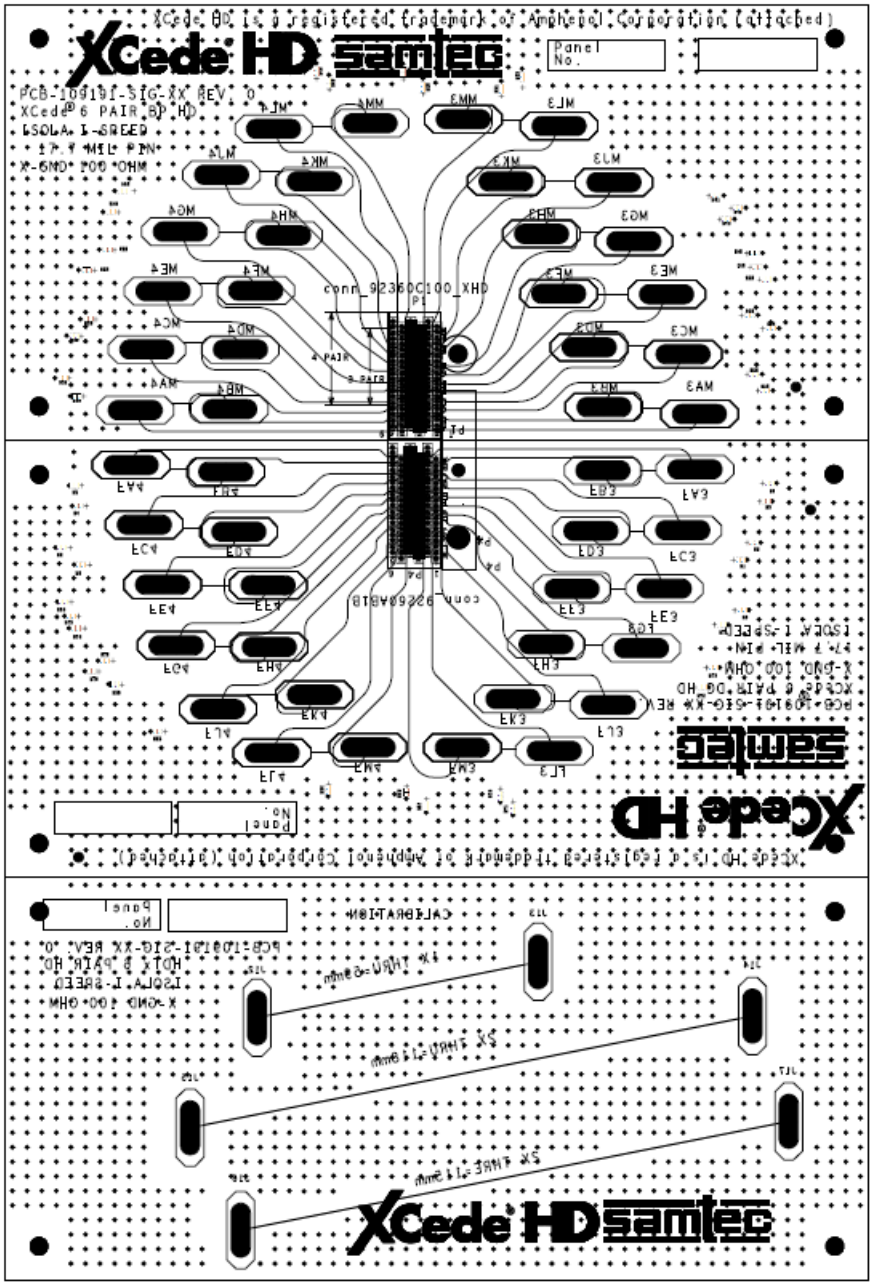

Figure 53

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

All traces on the test boards are length matched to 2345 mils measured from the edge of the pad to the 2.4mm connector. The AFR calibration effectively removes 2265 mils of test board trace effects. This means that 80 mils of test board trace length effects are included on both sides of test boards in the measurement. The S-Parameter measurement includes:

A- The HDTx Series connector set
B- Test board vias, pads (footprint effects) for the HDTM connector side.
C- 80 mils of 4.5 mil wide microstrip trace.
D- Test board vias, pads (footprint effects) for the HDTF-RA side.
E- 80 mils of 4.5 mil wide microstrip trace.

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

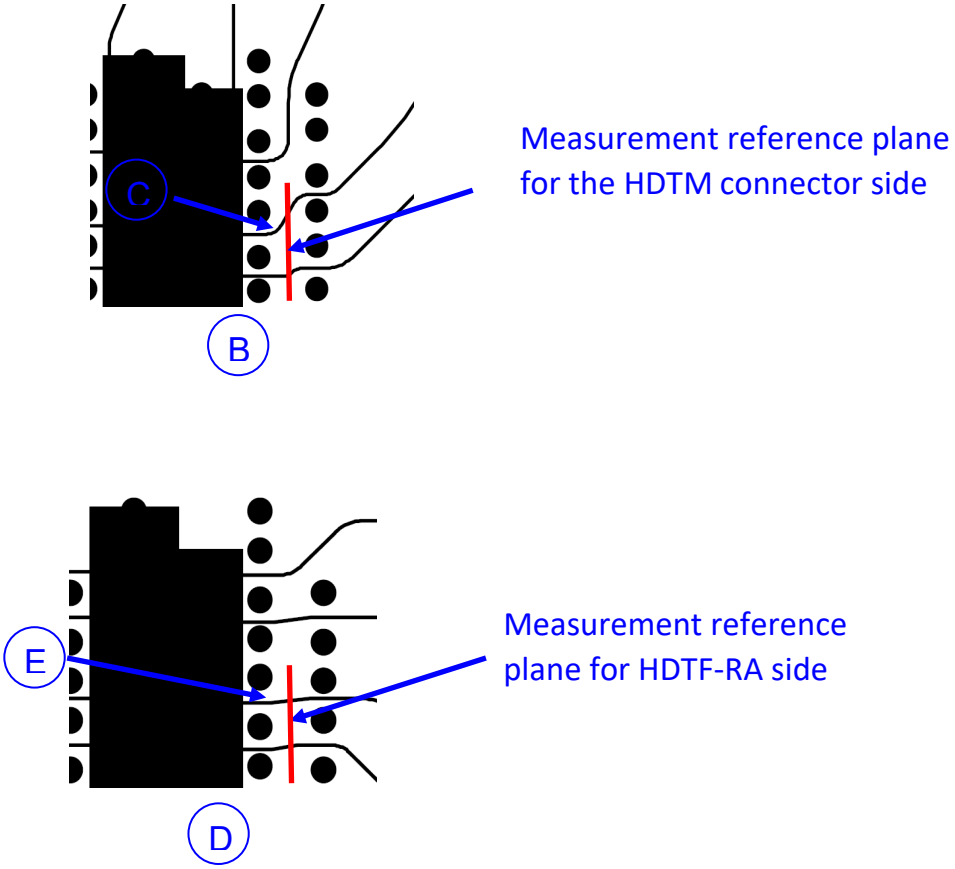

Figure 54

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

Appendix D – Test and Measurement Setup

For frequency domain measurements, the test instrument is the Keysight N5227A 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 – 50 GHz
Number of points – 5000
IFBW – 700 Hz

N5227A Measurement Setup

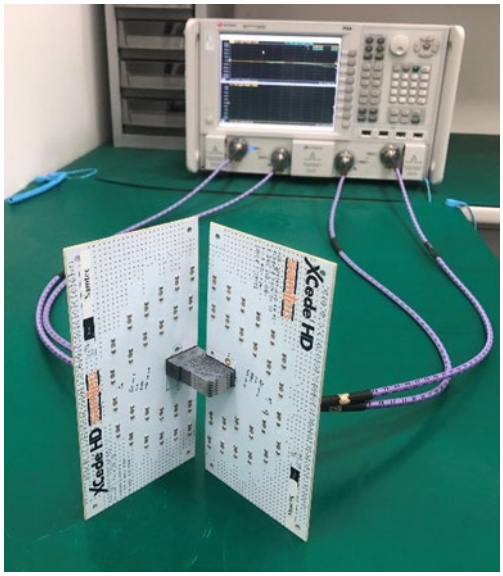

Figure 55

Test Instruments

QTY	Description
1	Keysight N5227A PNA-L Network Analyzer (10 MHz to 67 GHz)
1	Keysight N4694-60003 ECAL Module (10 MHz to 67 GHz)

Test Cables & Adapters

QTY	Description
4	Gore 0F0CACB036.0-LF (DC to 67 GHz)

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

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 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 2017. 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.

Series: HDTF-RA / HDTM
Description: XCede® HD 1.80 mm Backplane Connector

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)