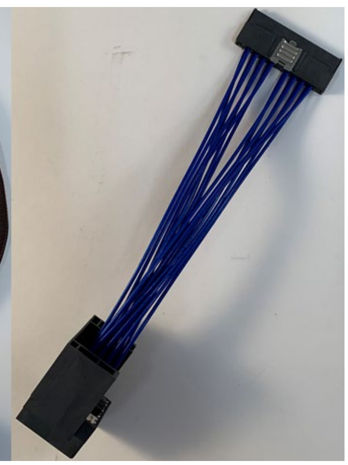
High Speed Characterization Report

"NVAC-EBCF_Flyover_10in-EBCM_40in"
(EBCM-2-4-04-1-x-x-40-1-x-x + NVAC-DP-1-02-2-10.0-EBCF End 2)



Mated with:

NVAM-DP-02-2-02.0-S-2-C

Description:
0.80 mm NovaRay® Extreme Density & Performance Cable Assembly and ExaMAX® 2.00 mm High-Speed Backplane Cable Assembly

Samtec Inc.
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Report Revision: 8/02/2023

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Cable Assembly Overview

The NVAC series 0.80 mm NovaRay® Extreme Density & Performance Cable Assembly is constructed using 34 AWG Eye Speed® twinax cable. It is available in 2, 3 or 4 rows, 1 or 2 banks with up to 16 pairs/bank, and 40% smaller than conventional cable solutions.

The EBCM series ExaMAX® 2.00 mm High-Speed Backplane Cable is constructed using Samtec's Eye Speed® ultra-low skew twinax cable, it provides increased flexibility and routability, also improves signal integrity and increases signal path length at higher data rates.

Figure 1: Test Sample

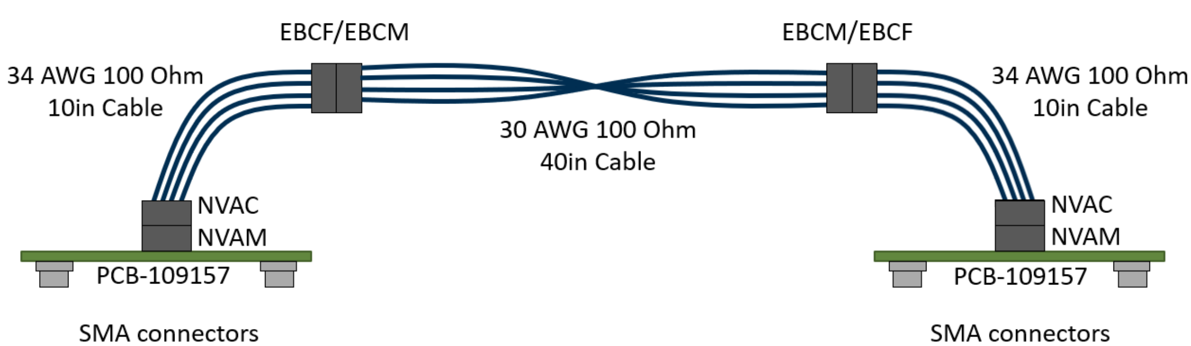

Figure 2: Diagram of the DUT

Series: NVAC-EBCF_Flyover_10in-EBCM_40in
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Frequency Domain Data Summary

Bandwidth Figures – Differential Insertion Loss

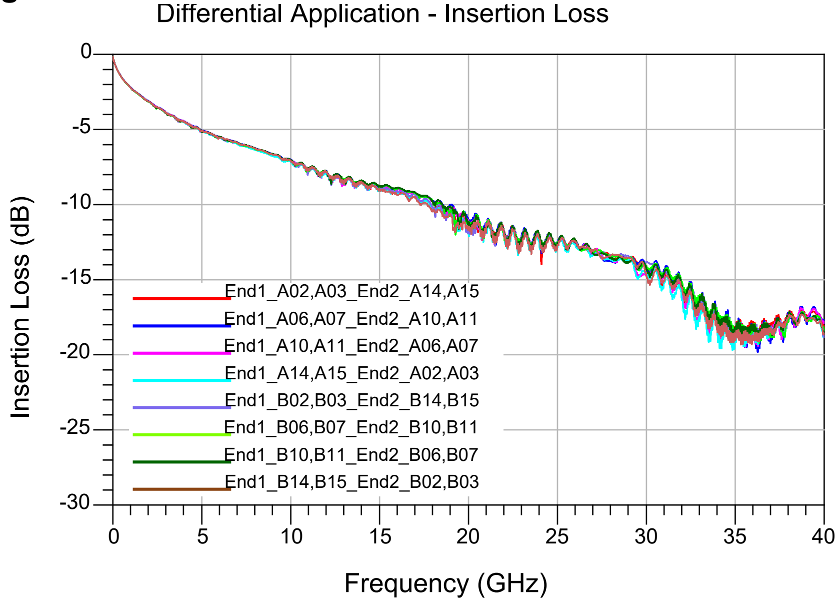

Figure 3

Time Domain Data Summary

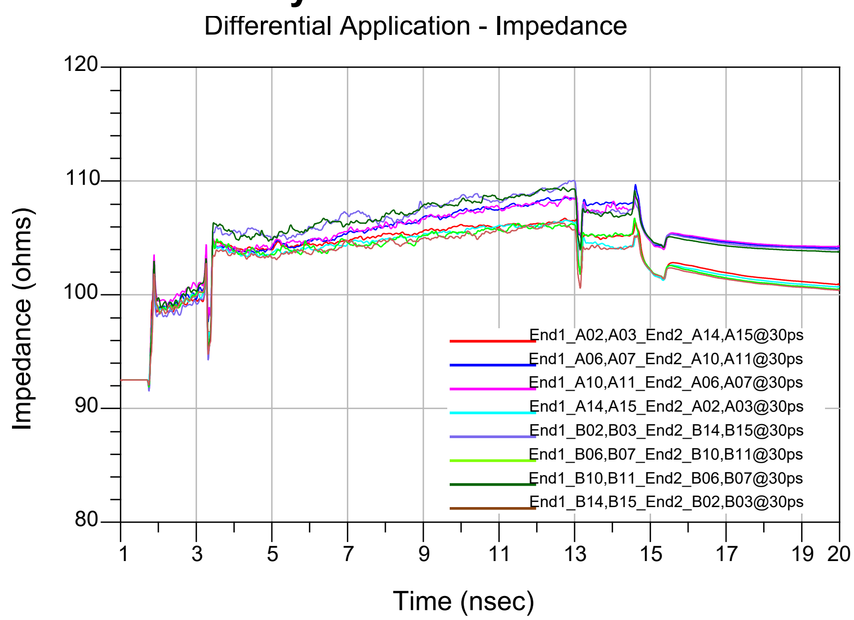

Figure 4

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Table 1 - Propagation Delay (Cable Assembly)

Driver	Receiver	60 Inches
End 1_A02, A03	End 2_A14, A15	6.513 ns
End 1_A06, A07	End 2_A10, A11	6.513 ns
End 1_A10, A11	End 2_A06, A07	6.511 ns
End 1_A14, A15	End 2_A02, A03	6.512 ns
End 1_B02, B03	End 2_B14, B15	6.501 ns
End 1_B06, B07	End 2_B10, B11	6.501 ns
End 1_B10, B11	End 2_B06, B07	6.502 ns
End 1_B14, B15	End 2_B02, B03	6.502 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 "GSSG" differential drive configuration only.

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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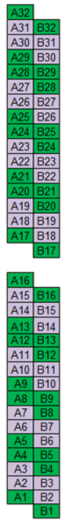
The NVAC-EBCF_Flyover_10in-EBCM_40in cable assembly pin mapping is shown below:

NVAx



NVAC to EBCF Cable Mapping

NVAC	EBCF
A2	C1
A3	D1
A6	F1
A7	G1
A10	I1
A11	J1
A14	L1
A15	M1
B2	B2
B3	C2
B6	E2
B7	F2
B10	H2
B11	I2
B14	K2
B15	L2
A18	C3
A19	D3
A22	F3
A23	G3
A26	I3
A27	J3
A30	L3
A31	M3
B18	B4
B19	C4
B22	E4
B23	F4
B26	H4
B27	I4
B30	K4
B31	L4

EBCM to EBCM Cable Mapping

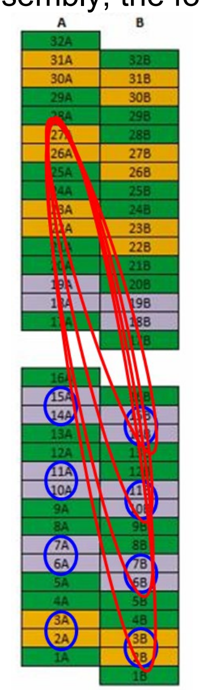
EBCM	EBCM
C1	M1
D1	L1
F1	J1
G1	I1
I1	G1
J1	F1
L1	D1
M1	C1
B2	L2
C2	K2
E2	I2
F2	H2
H2	F2
I2	E2
K2	C2
L2	B2
C3	M3
D3	L3
F3	J3
G3	I3
I3	G3
J3	F3
L3	D3
M3	C3
B4	L4
C4	K4
E4	I4
F4	H4
H4	F4
I4	E4
K4	C4
L4	B4

EBCx

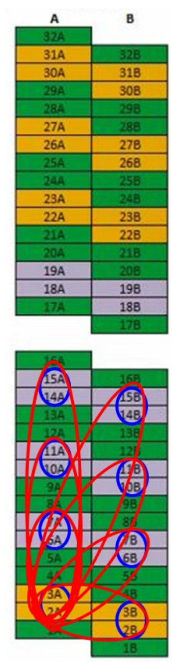
	1	2	3	4
N	N1	N2	N3	N4
M	M1	M2	M3	M4
L	L1	L2	L3	L4
K	K1	K2	K3	K4
J	J1	J2	J3	J4
I	I1	I2	I3	I4
H	H1	H2	H3	H4
G	G1	G2	G3	G4
F	F1	F2	F3	F4
E	E1	E2	E3	E4
D	D1	D2	D3	D4
C	C1	C2	C3	C4
B	B1	B2	B3	B4
A	A1	A2	A3	A4

x Ground pin
x x Routed Pair
x No Connect

For this cable assembly, the following configurations are evaluated:



Potential NEXT aggressors, depending on pinout



Potential FEXT aggressors, depending on pinout

Differential Impedance (denoted by blue circles):

- GSSG (Ground-positive signal-negative signal-Ground)

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.

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

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.

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Time Domain Data

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 update 1. This tool has a transient convolution simulator, which can generate a Time Domain response directly from measured S-Parameters. An example of a similar methodology is provided in the Samtec Technical Note on domain transformation.
http://suddendocs.samtec.com/notesandwhitepapers/tech-note_using-plts-for-time-domain-data_web.pdf

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 also includes 2.937 mm of PCB trace on each connector side. 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.

Data for other configurations may be available. Please contact our Signal Integrity Group at sig@samtec.com for further information.

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

Differential Application – Insertion Loss

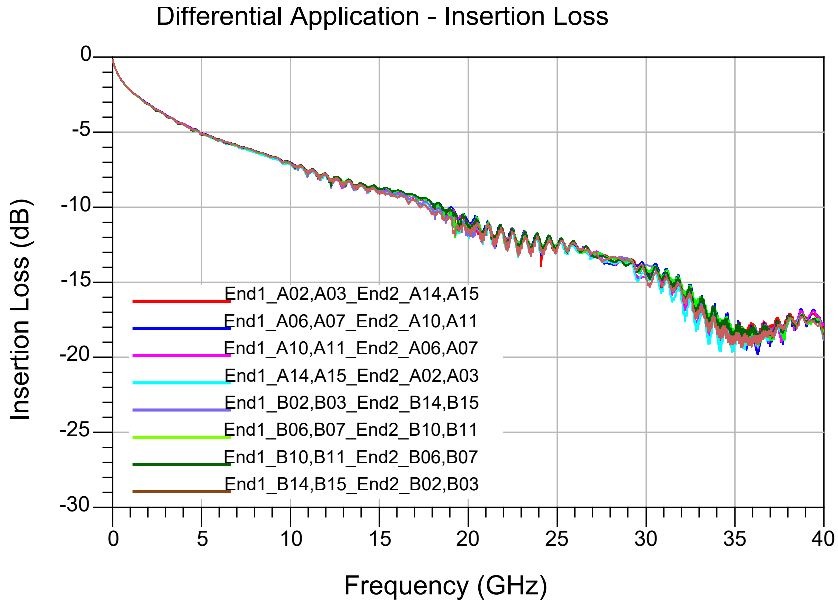

Figure 5

Differential Application – Return Loss

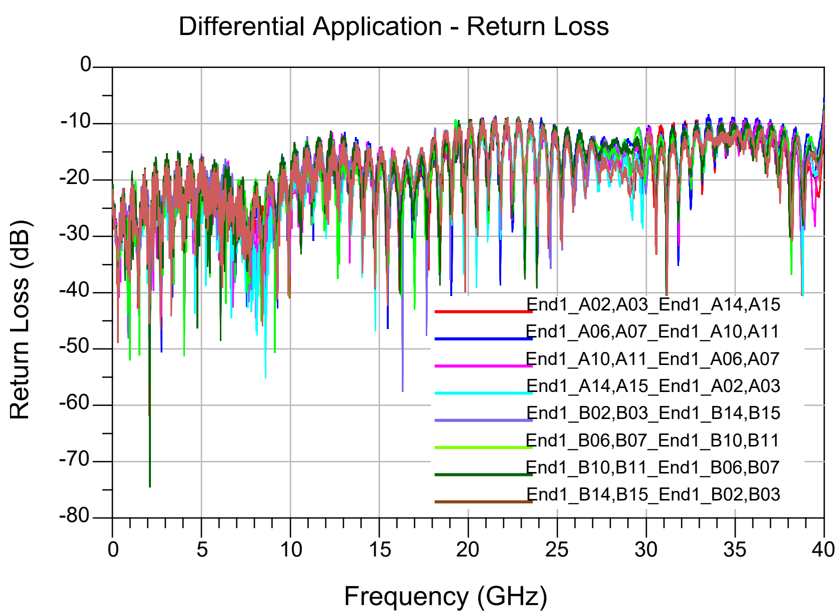

Figure 6

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Differential Application – NEXT Configurations

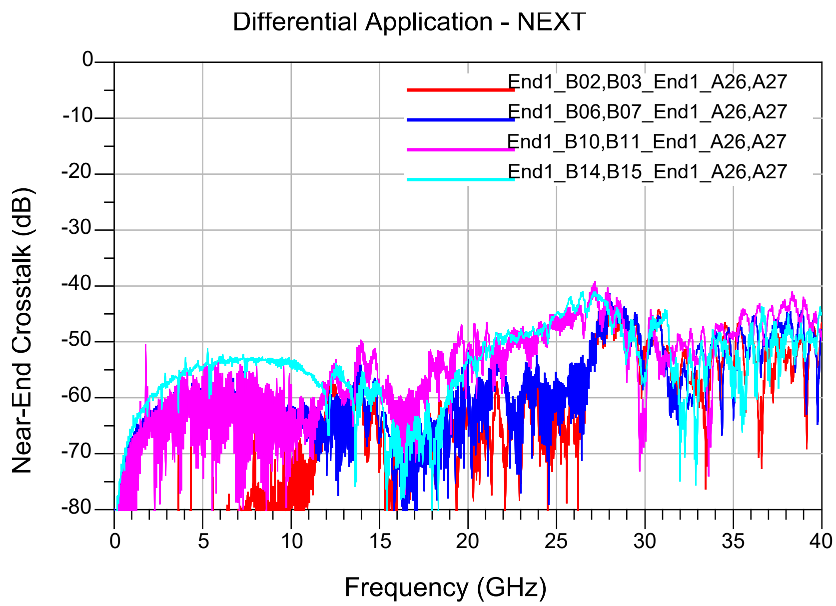

Figure 7

Differential Application – FEXT Configurations

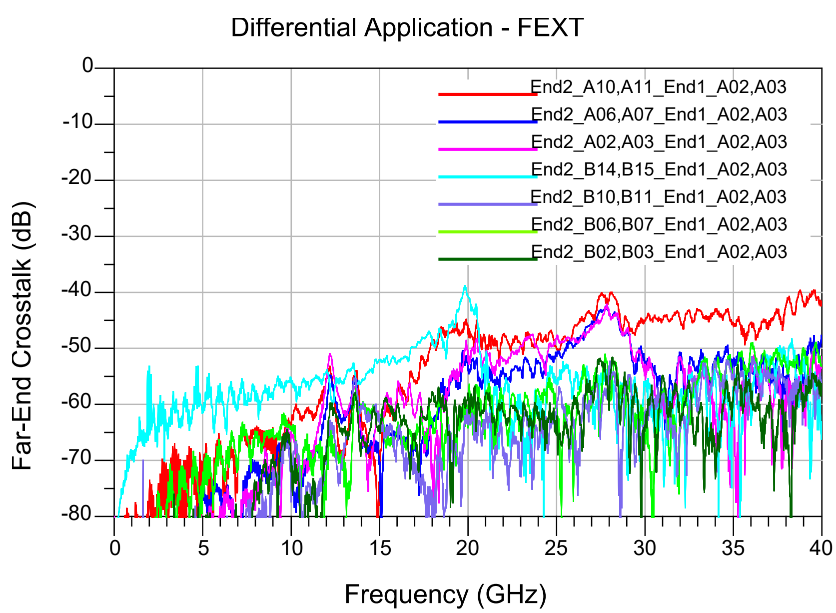

Figure 8

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Differential Application – Differential to Common Mode Conversion

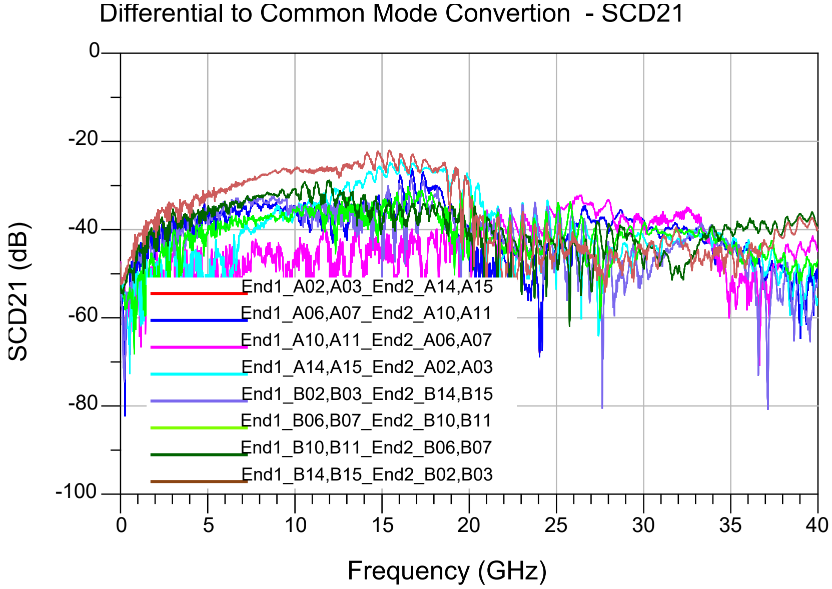

Figure 9

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Appendix B – Time Domain Responses

Differential Application – Input Pulse

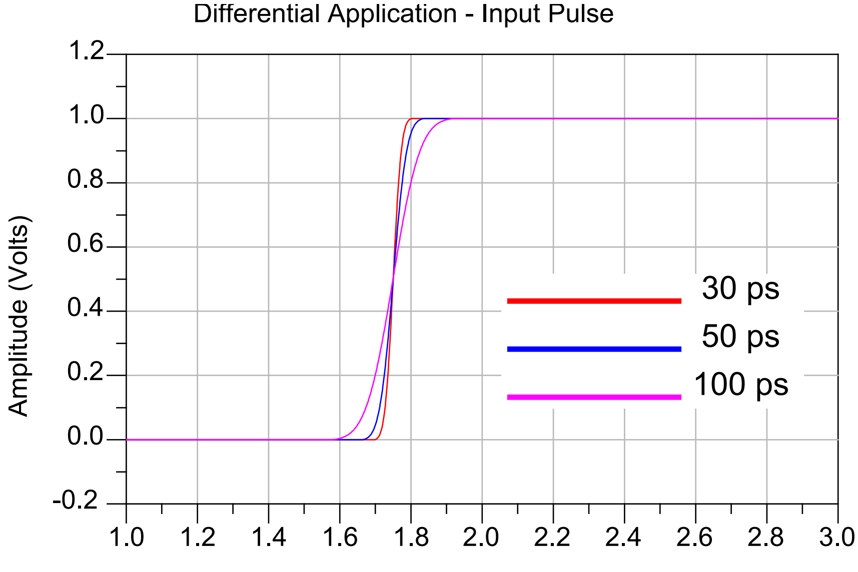

Figure 10

Differential Application – Cable assembly Impedance

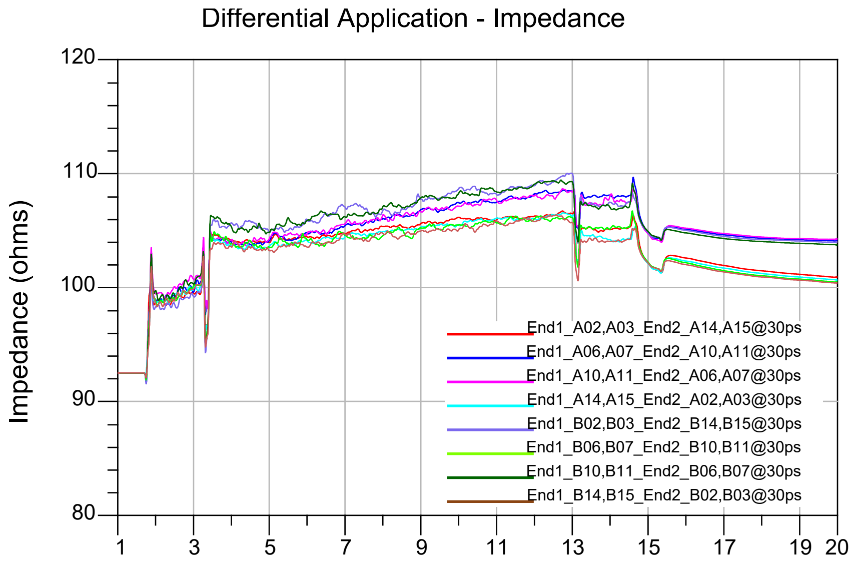

Figure 11

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Differential Application – Cable assembly Impedance

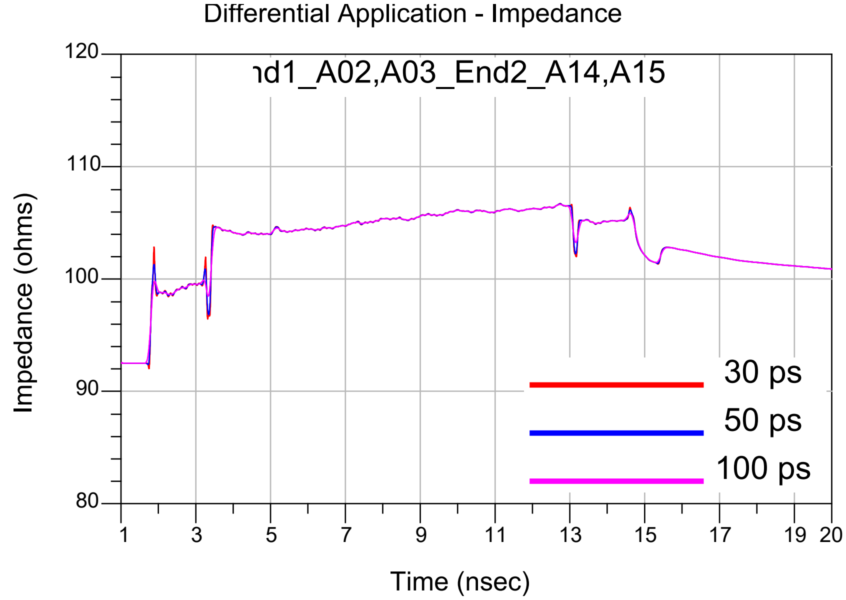

Figure 12

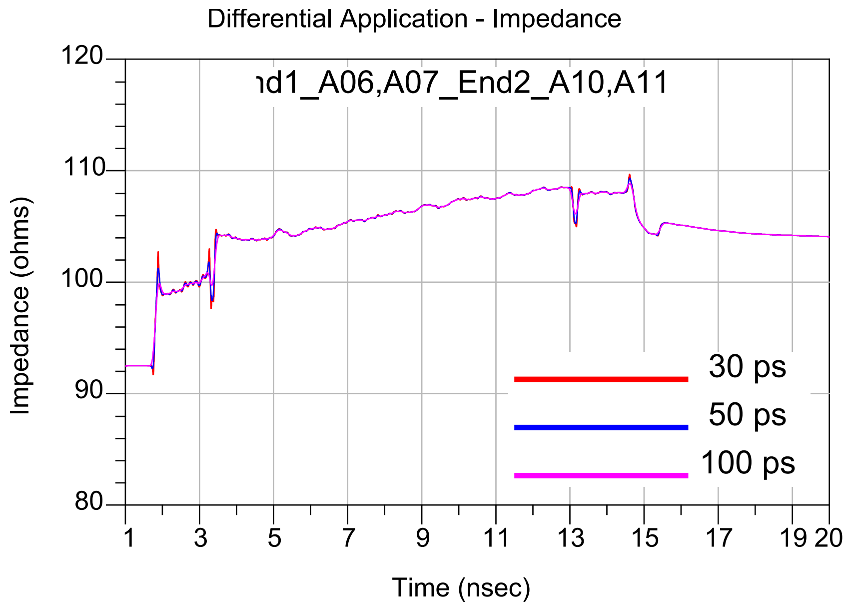

Figure 13

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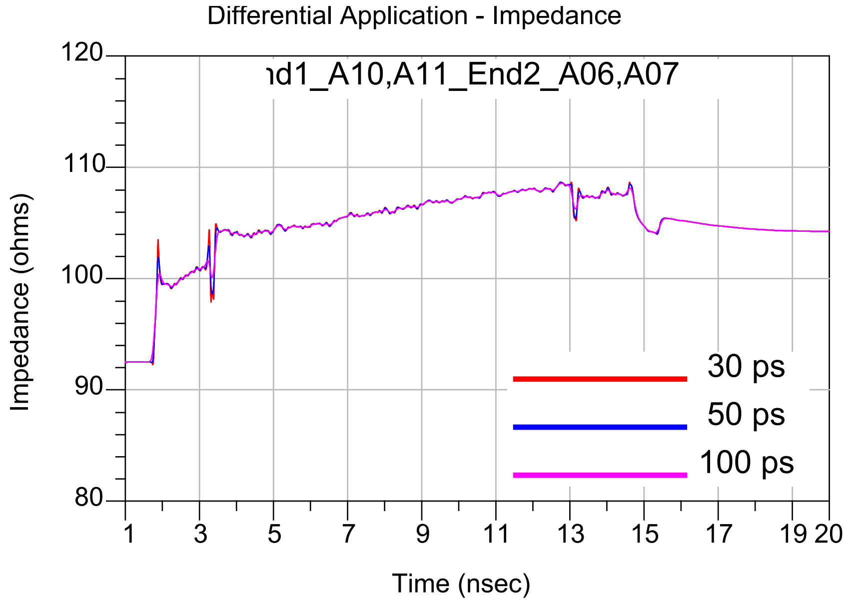

Figure 14

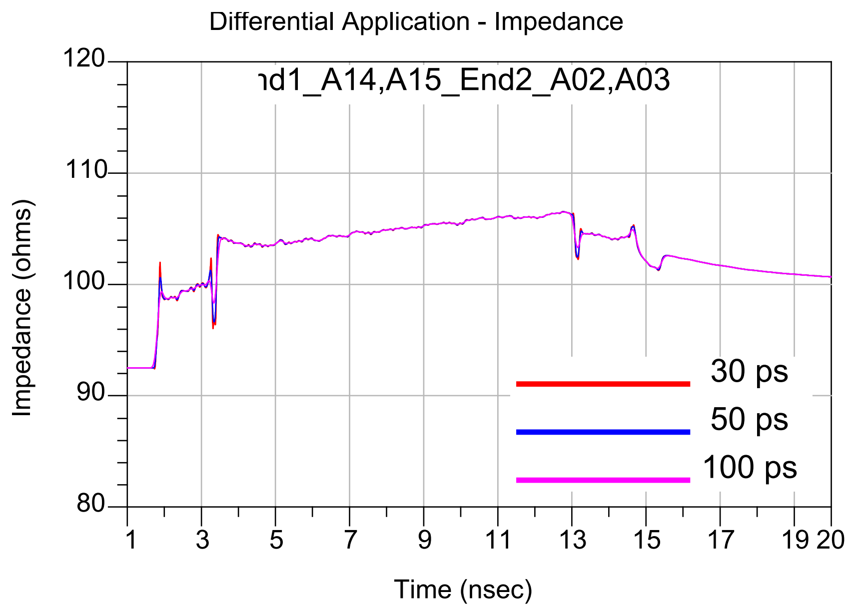

Figure 15

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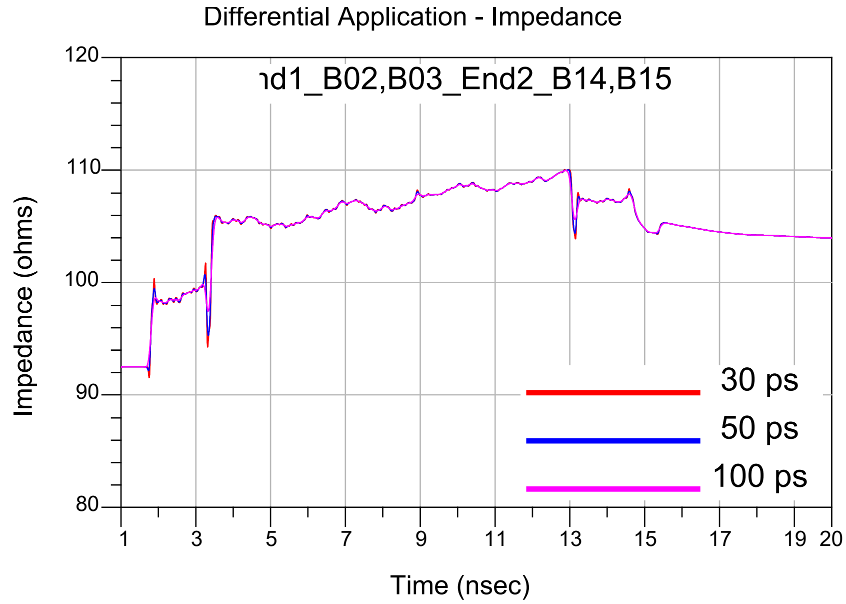

Figure 16

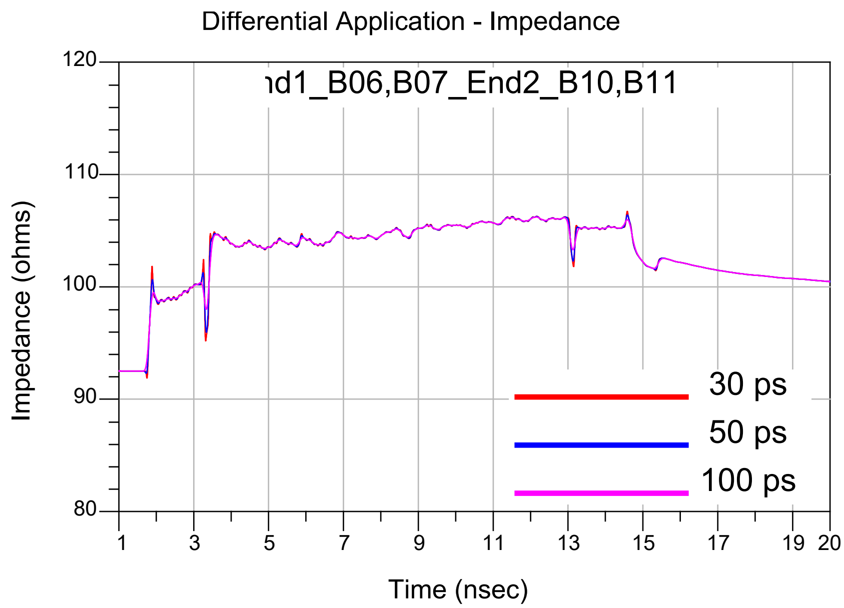

Figure 17

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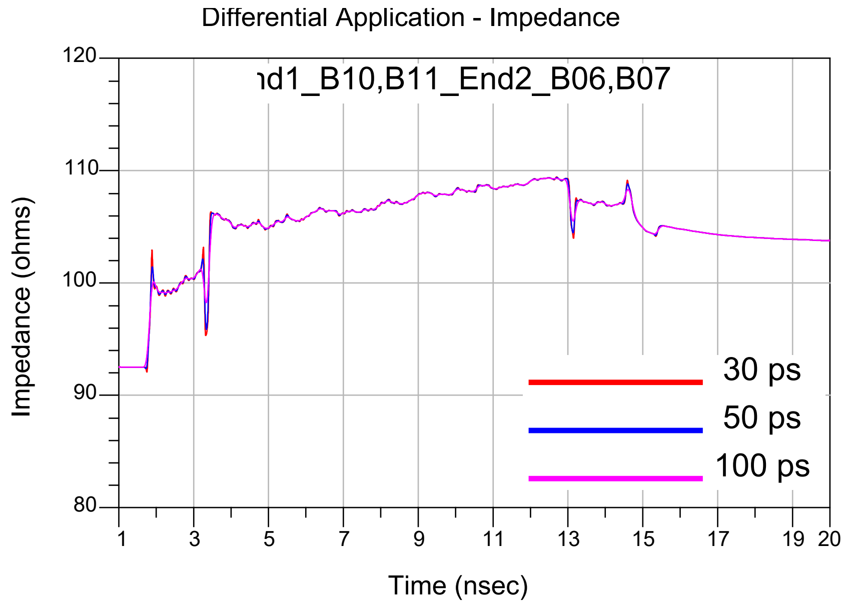

Figure 18

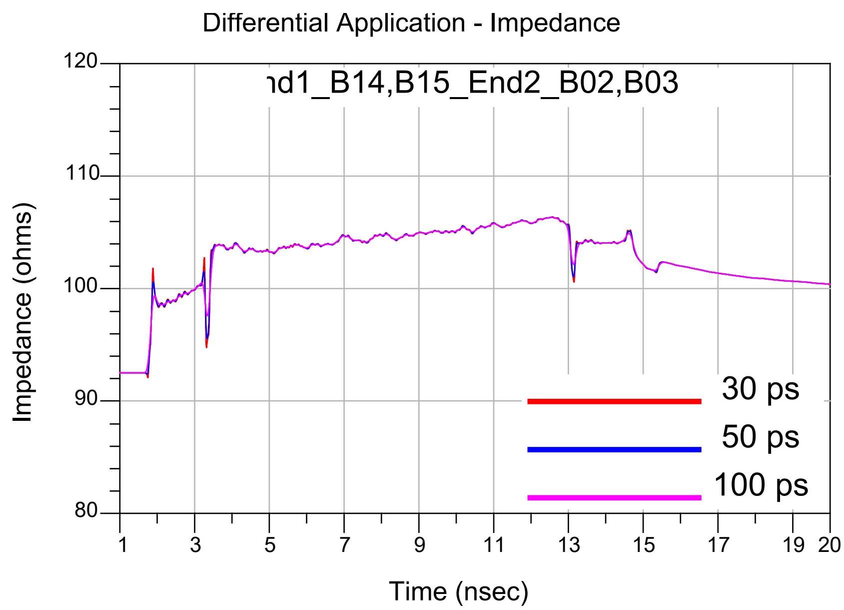

Figure 19

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Differential Application – Propagation Delay

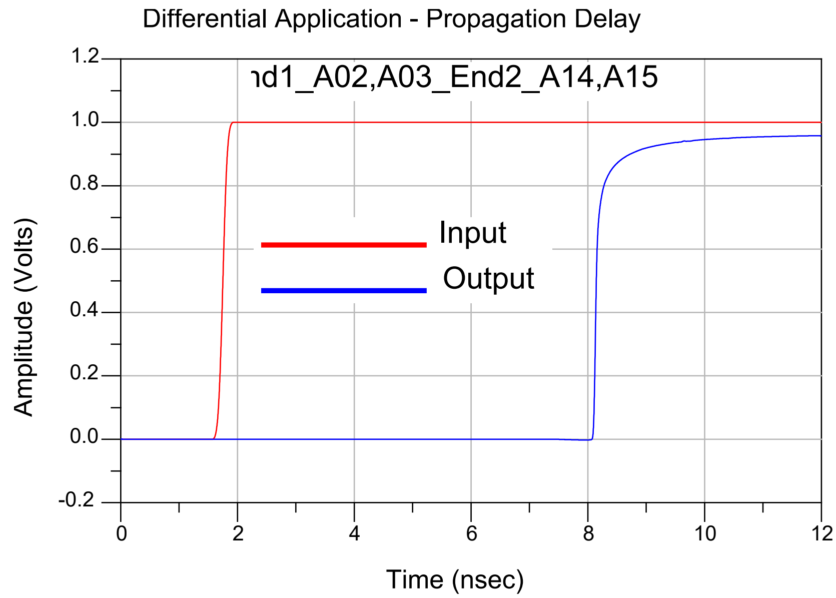

Figure 20

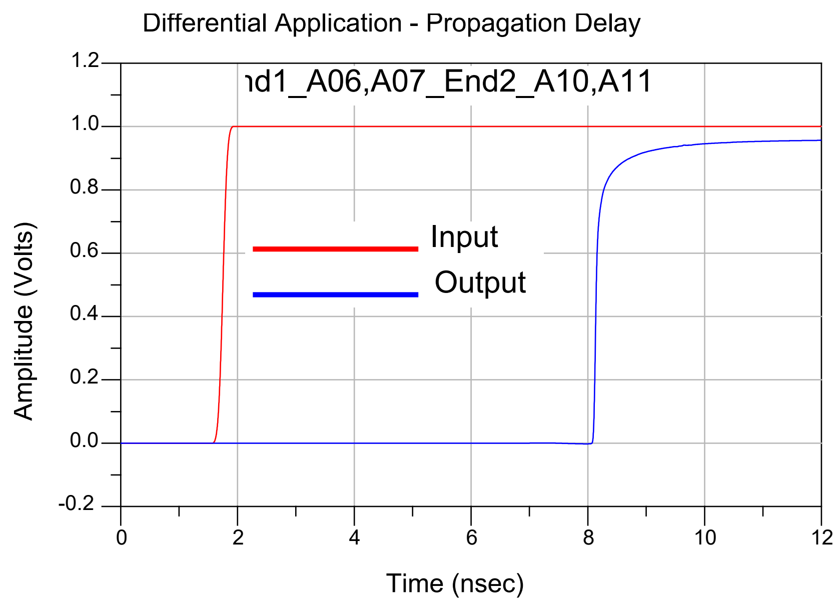

Figure 21

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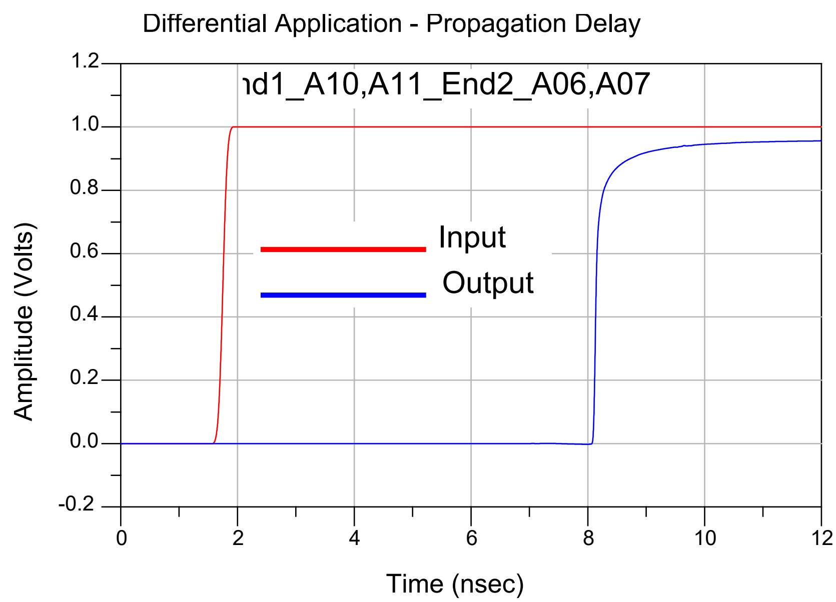

Figure 22

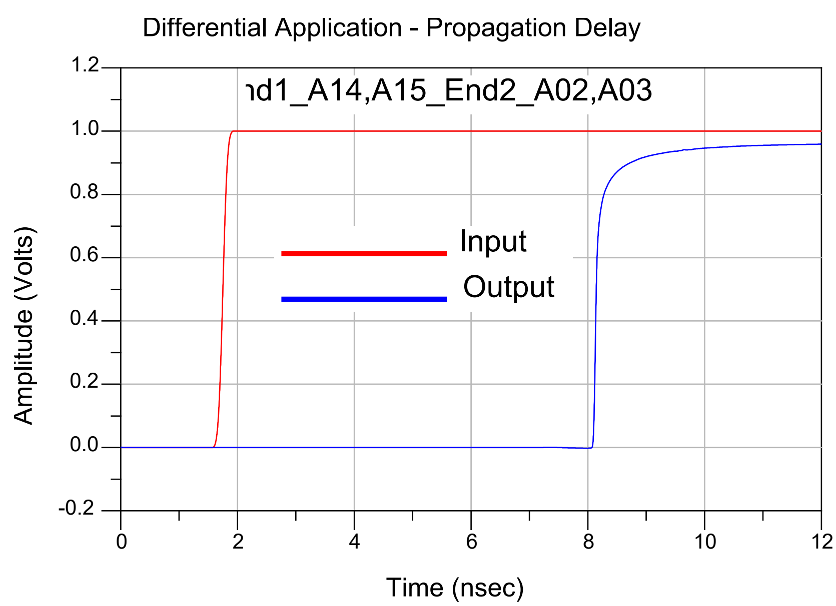

Figure 23

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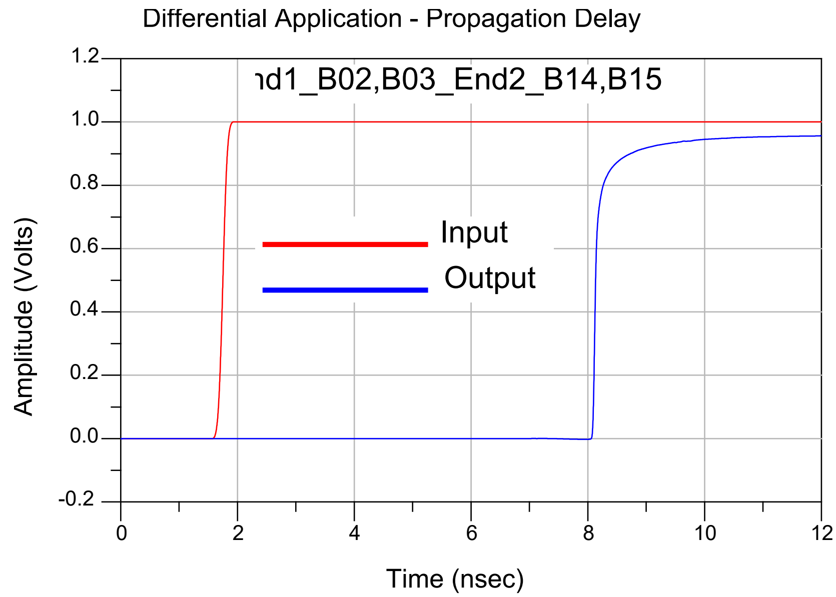

Figure 24

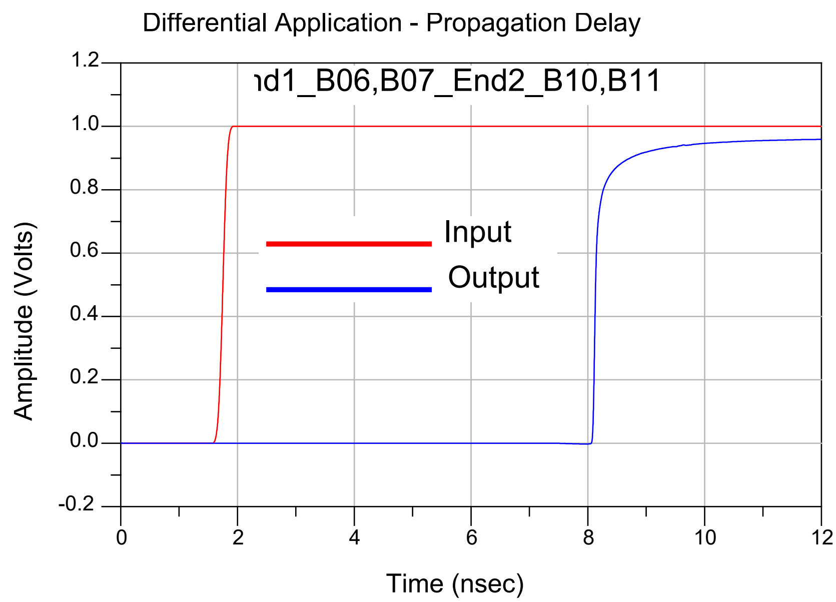

Figure 25

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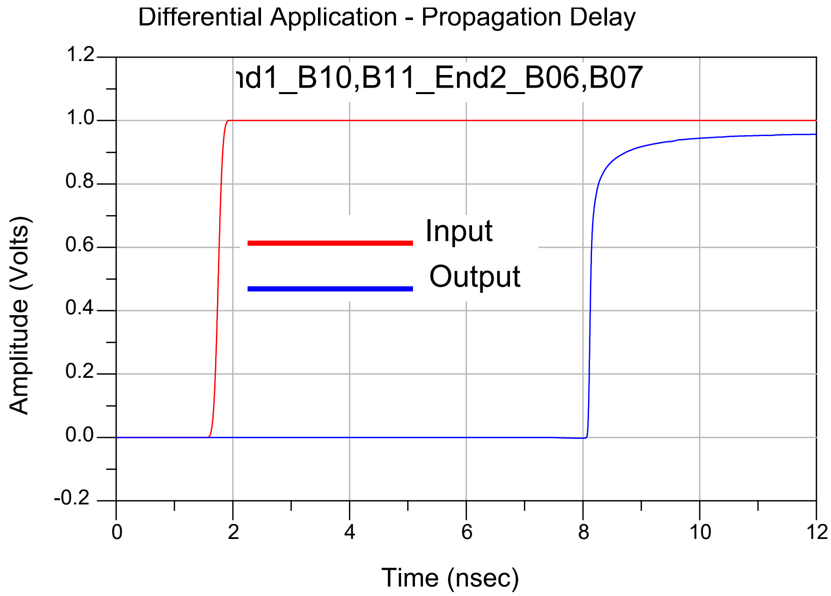

Figure 26

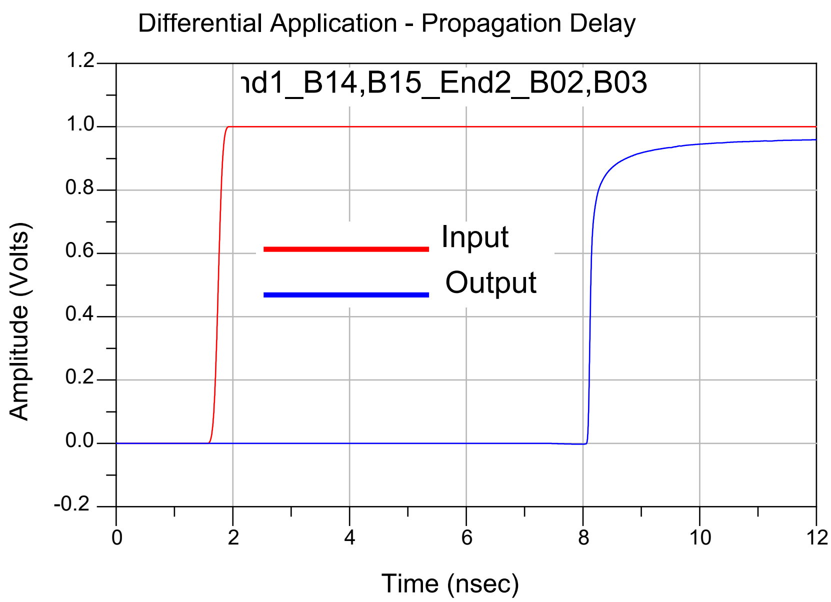

Figure 27

Series: NVAC-EBCF_Flyover_10in-EBCM_40in
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Appendix C – Product and Test System Descriptions

Product Description

Product test samples are 0.80 mm NovaRay® Extreme Density & Performance Cable Assembly and ExaMAX® 2.00 mm High-Speed Backplane Cable Assembly. A photo of the mated test article mounted to SI test boards is shown below.

Test System Description

The test fixtures are composed of six-layer TACHYON 100G material with 46.25Ω 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 NVAx series connector set and identified by part number PCB-109157-SIG-XX.

PCB-109157-SIG Test Fixtures

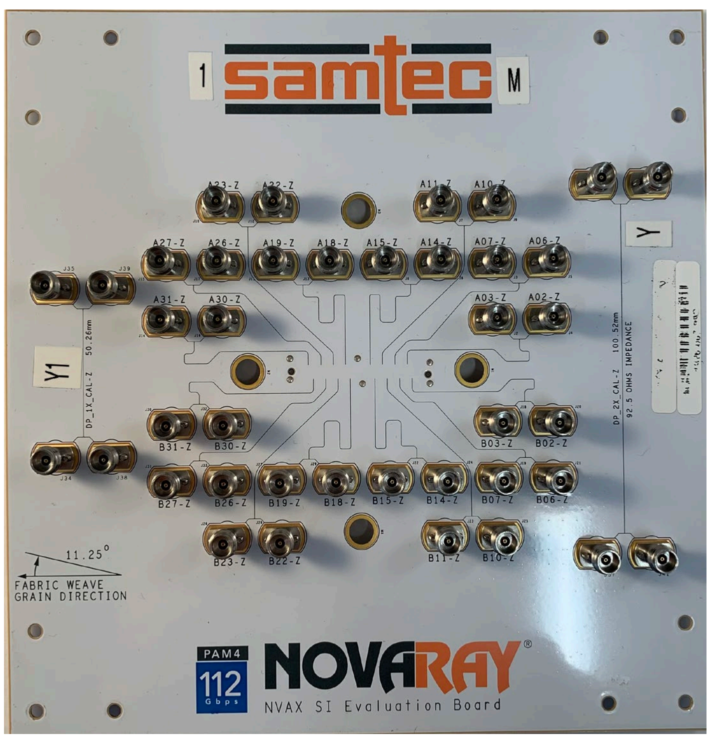

Figure 28

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PCB Fixtures

The test fixtures used are as follows:

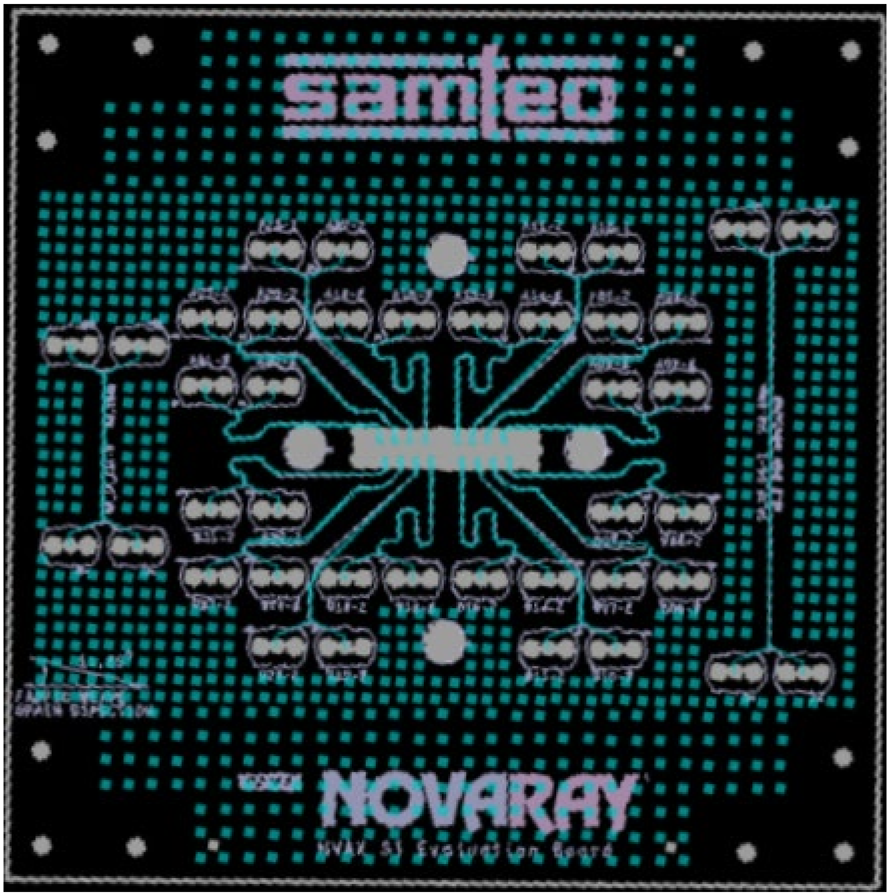

Figure 29

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Appendix D – Test and Measurement Setup

For frequency domain measurements, the test instrument is the Agilent N5227B PNA-L network analyzer. Frequency domain data and graphs are extracted from the instrument by AFR application. The network analyzer is configured as follows:

Start Frequency – 10 MHz
Stop Frequency – 40 GHz
IFBW – 1 KHz

N5227B Measurement Setup

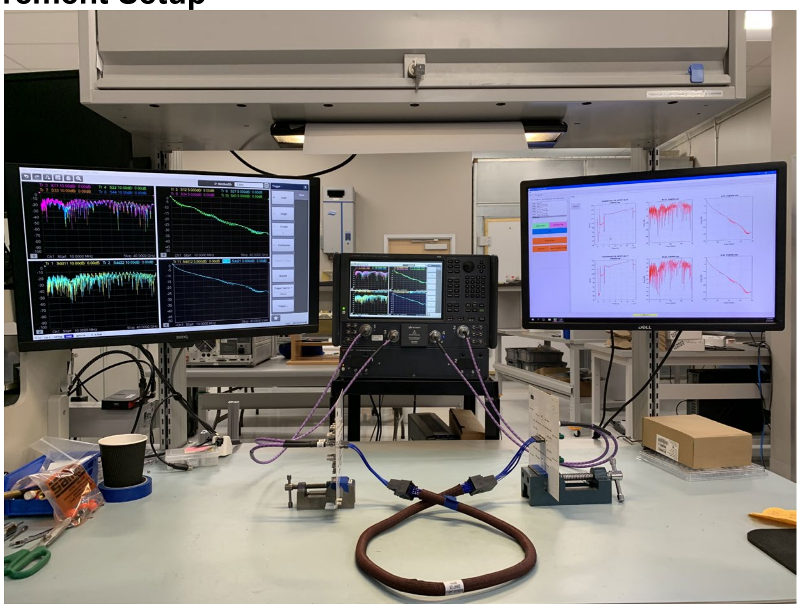

Figure 30

Test Instruments

QTY	Description
1	Agilent N5227B PNA-L Network Analyzer (10 MHz to 67 GHz)
1	Agilent N4694-60003 ECAL Module (10 MHz to 67 GHz)

Test Cables & Adapters

QTY	Description
4	1 m Junkosha 2.4mm male to female cables

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Appendix E - Frequency and Time Domain Measurements

Frequency (S-Parameter) Domain Procedures

The quality of any data taken with a network analyzer is directly related to the quality of the calibration standards and the use of proper test procedures. For this reason, extreme care is taken in the design of the 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 update 1. This tool has a transient convolution simulator, which can generate a Time Domain response directly from measured S-Parameters. An example of a similar methodology is provided in the Samtec Technical Note on domain transformation.
http://suddendocs.samtec.com/notesandwhitepapers/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: NVAC-EBCF_Flyover_10in-EBCM_40in
Description: 0.80 mm NovaRay® Extreme Density & Performance Cable Assembly
and ExaMAX® 2.00 mm High-Speed Backplane Cable Assembly

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 the 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.

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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