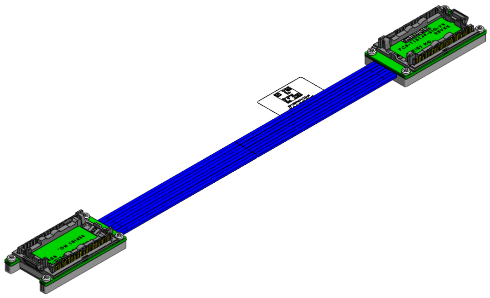
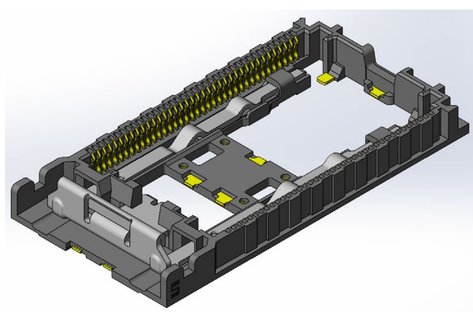
High Speed Characterization Report

HALO-PE-01-4-XXXX



Mated with:

HLF6-38-03.5-S-2-XR



Description:

Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

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Report Revision: 3/27/2025

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Cable Assembly Overview

The HALO Cable Assembly is constructed using 34 AWG, 92 Ω Eye Speed Thinax™ ultra-low skew twinax cable, High-density up to 76 pins in a single row around the perimeter (38 pins per side).The data in this report is applicable to 250 mm length cable assembly.

At each end of the cable there is a connector that is terminated to a small transition PCB. Each connector is mounted on its respective PCB. The HALO-PE-01-4-XXXX assembly is wired to facilitate a Pin A1 to Pin B1 mapping between the cable ends.

The HALO assemblies were tested by mating to HLF6-38-03.5-S-2-XR at both ends. One sample of HALO 250 mm cable length assembly was tested. The actual part number that was tested is shown in Table 1, a relative sample picture is shown in Figure 1.

Length	Part Number
250 mm	HALO-PE-01-4-0250

Table 1: Sample Description

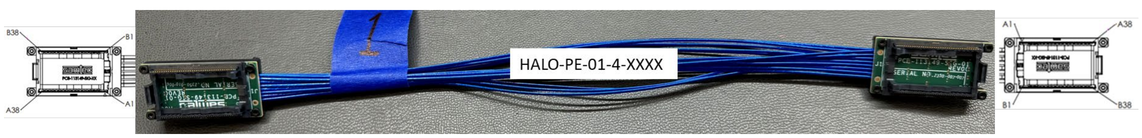

Figure 1: Test Sample

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Frequency Domain Data Summary

Bandwidth Figures – Differential Insertion Loss

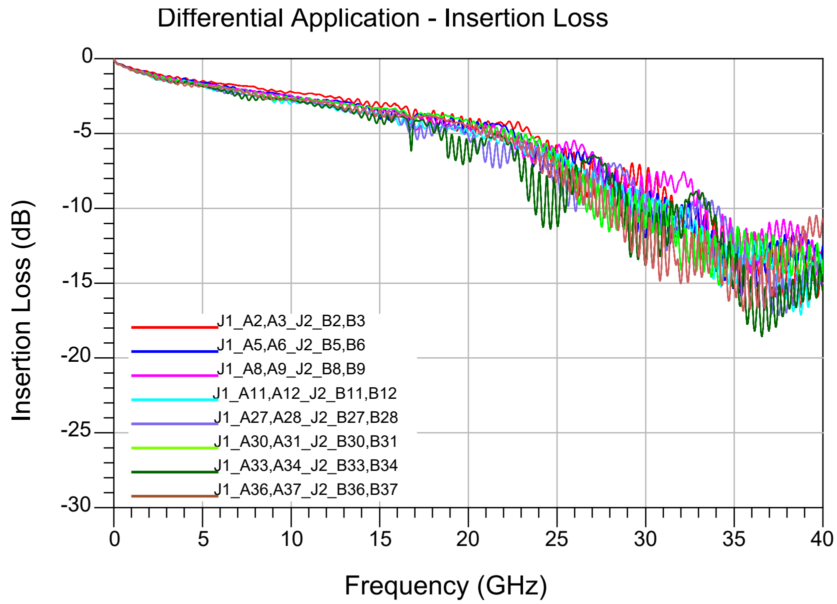

Figure 2

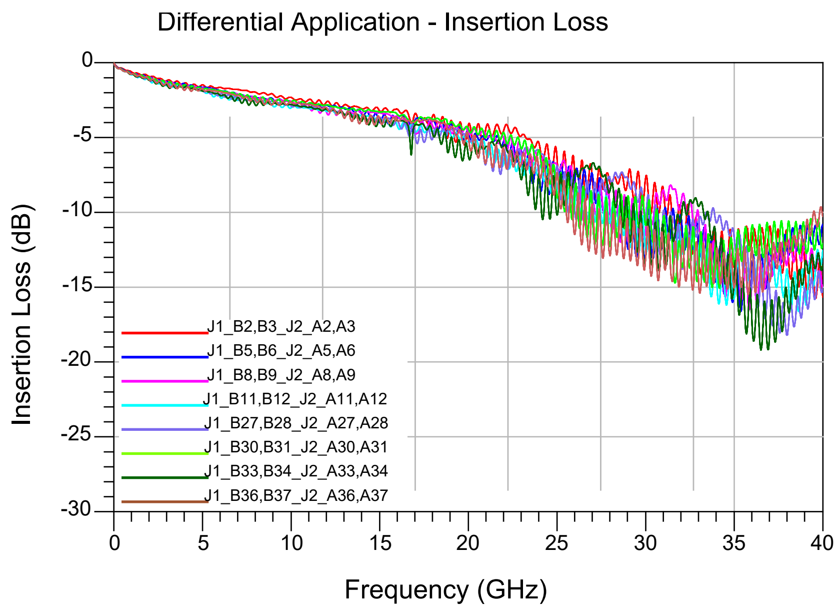

Figure 3

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

Bandwidth Figures – Differential Return Loss

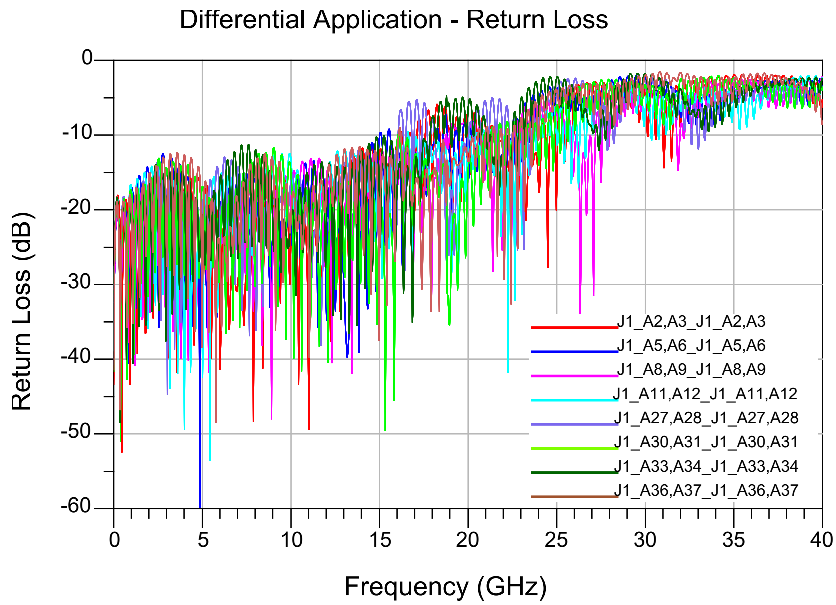

Figure 4

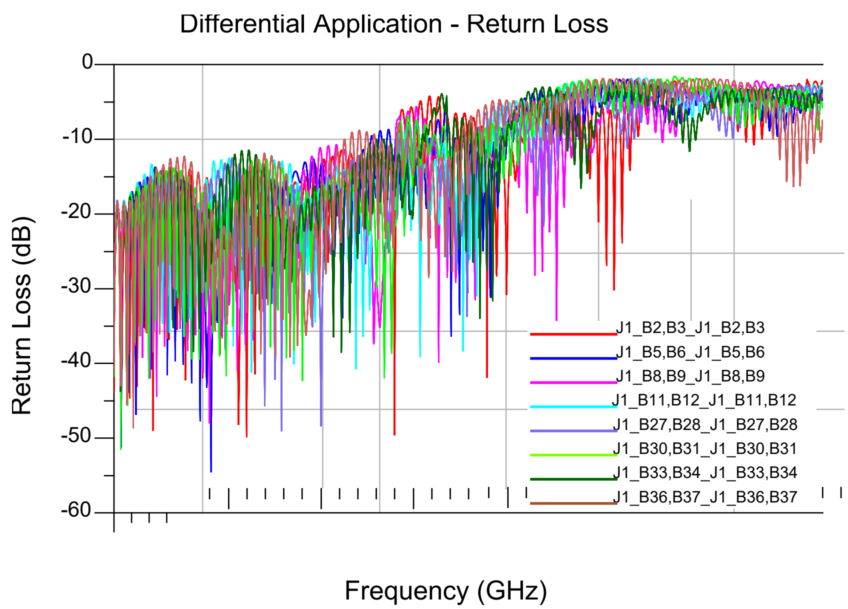

Figure 5

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Time Domain Data Summary

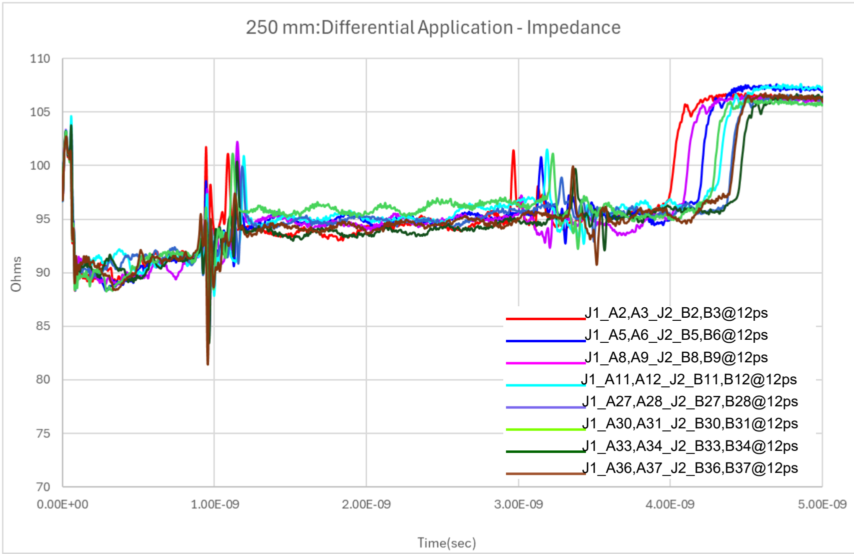

Figure 6

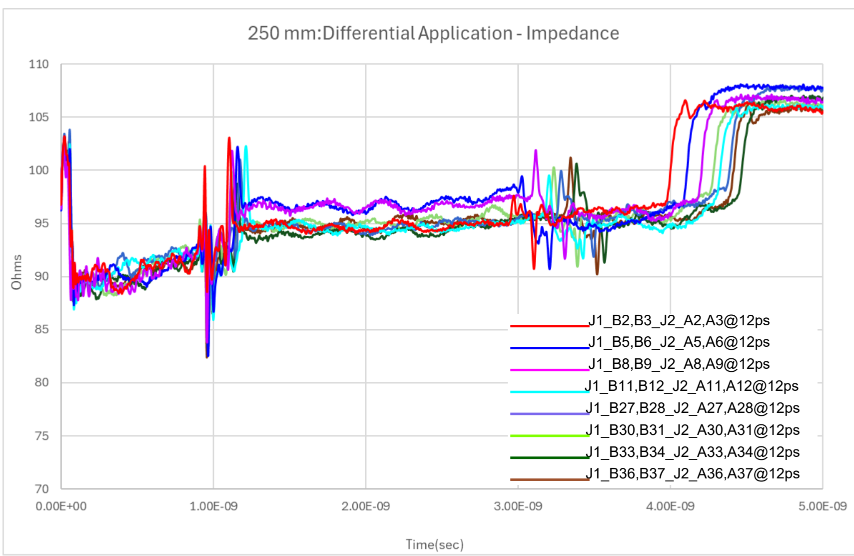

Figure 7

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Table 2 - Propagation Delay (Cable Assembly)		
Driver	**Receiver**	**250 mm**
J1_A2,A3	J2_B2,B3	1.124 ns
J1_A5,A6	J2_B5,B6	1.175 ns
J1_A8,A9	J2_B8,B9	1.227 ns
J1_A11,A12	J2_B11,B12	1.286 ns
J1_A27,A28	J2_B27,B28	1.324 ns
J1_A30,A31	J2_B30,B31	1.273 ns
J1_A33,A34	J2_B33,B34	1.358 ns
J1_A36,A37	J2_B36,B37	1.337 ns
J1_B2,B3	J2_A2,A3	1.126 ns
J1_B5,B6	J2_A5,A6	1.177 ns
J1_B8,B9	J2_A8,A9	1.229 ns
J1_B11,B12	J2_A11,A12	1.291 ns
J1_B27,B28	J2_A27,A28	1.322 ns
J1_B30,B31	J2_A30,A31	1.272 ns
J1_B33,B34	J2_A33,A34	1.360 ns
J1_B36,B37	J2_A36,A37	1.343 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.

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:

TABLE 1																											
HALO-XX-01-X-XXXX-X-X (A1 TO B1) SIGNAL MAPPING																											
J1	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14~A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	A37	A38
NAME	G	S	S	G	S	S	G	S	S	G	S	S	G	NC	G	S	S	G	S	S	G	S	S	G	S	S	G
J2	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14~B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38
J1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14~B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38
NAME	G	S	S	G	S	S	G	S	S	G	S	S	G	NC	G	S	S	G	S	S	G	S	S	G	S	S	G
J2	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14~A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	A37	A38
ALL GROUNDS ARE COMMON AND TIED TO CABLE SHIELD																											

NEXT

TABLE 1																											
HALO-XX-01-X-XXXX-X-X (A1 TO B1) SIGNAL MAPPING																											
J1	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14~A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	A37	A38
NAME	G	S	S	G	S	S	G	S	S	G	S	S	G	NC	G	S	S	G	S	S	G	S	S	G	S	S	G
J2	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14~B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38
J1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14~B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38
NAME	G	S	S	G	S	S	G	S	S	G	S	S	G	NC	G	S	S	G	S	S	G	S	S	G	S	S	G
J2	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14~A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	A37	A38
ALL GROUNDS ARE COMMON AND TIED TO CABLE SHIELD																											

FEXT

Differential Impedance (denoted by blue circles)**:**

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

Differential Crosstalk (denoted by red circles)**:**

- NEXT: from the terminals to the other terminals on the same end.
- FEXT: from one end of terminals to the other end 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.

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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 12 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 12 ps and 100 ps.

Unless otherwise stated, 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.

Time Domain Data

Time Domain parameters indicate Impedance mismatch versus length and signal propagation time in a pulsed signal environment.

Impedance mismatch versus length is measured by DCA-X86100D Digital Serial Analyzer. Board-related effects, such as pad-to-ground capacitance and trace loss, are included in the data presented in this report. The impedance data is provided in Appendix B of this report.

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.

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In this report, propagation delay is defined as the signal propagation time through the cable assembly, mating connectors, and connector footprint. It includes 1.3 mm PCB trace on each 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.

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

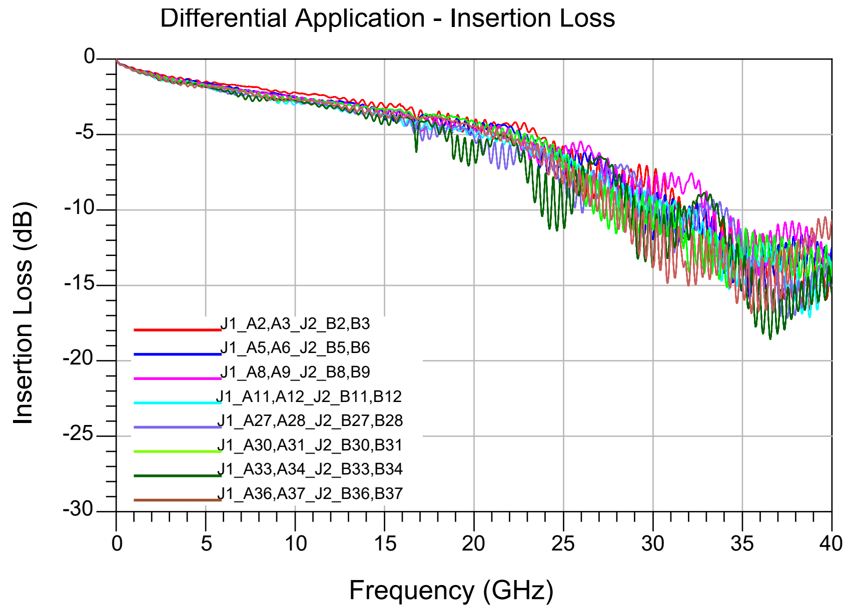


Figure 8

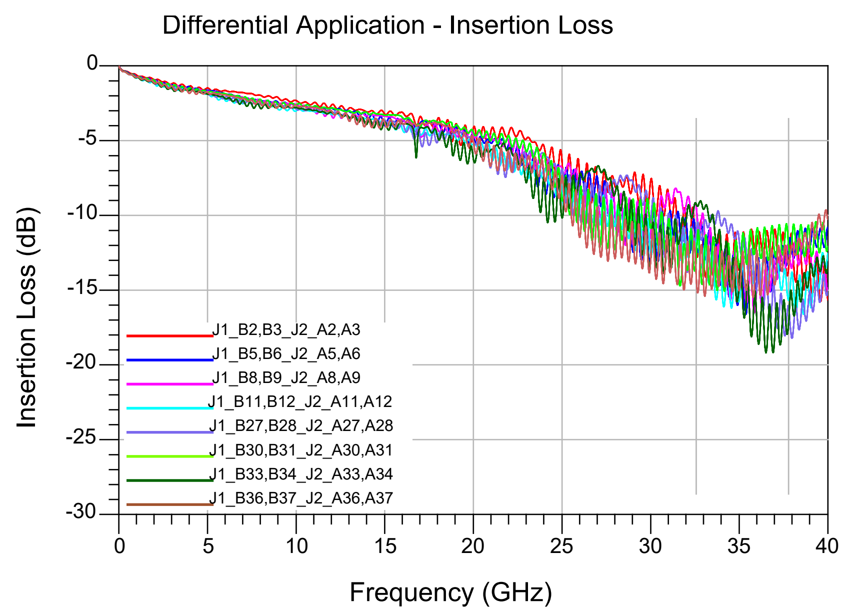


Figure 9

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

Differential Application – Return Loss

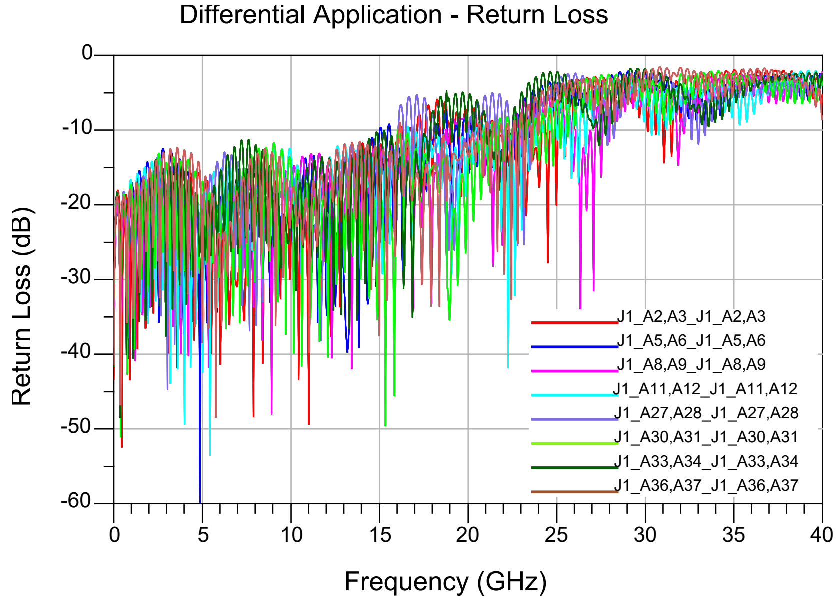


Figure 10

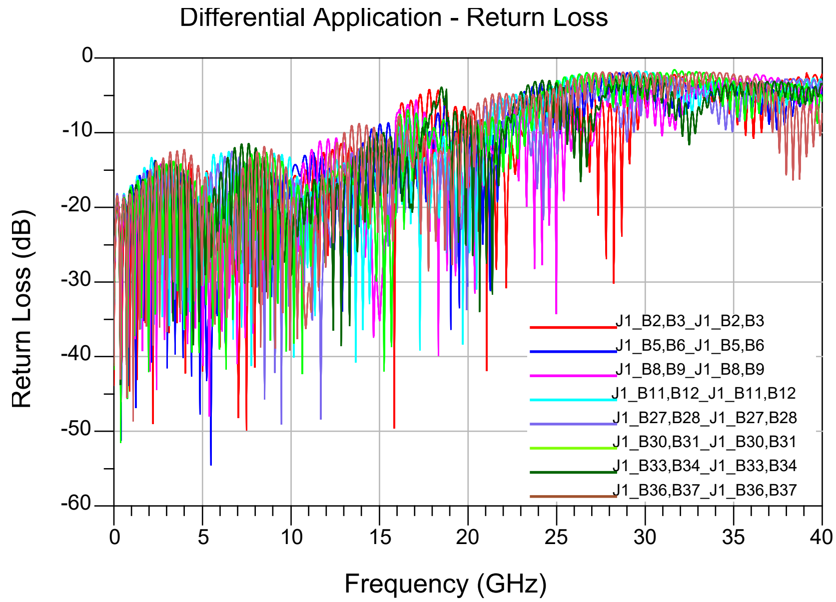
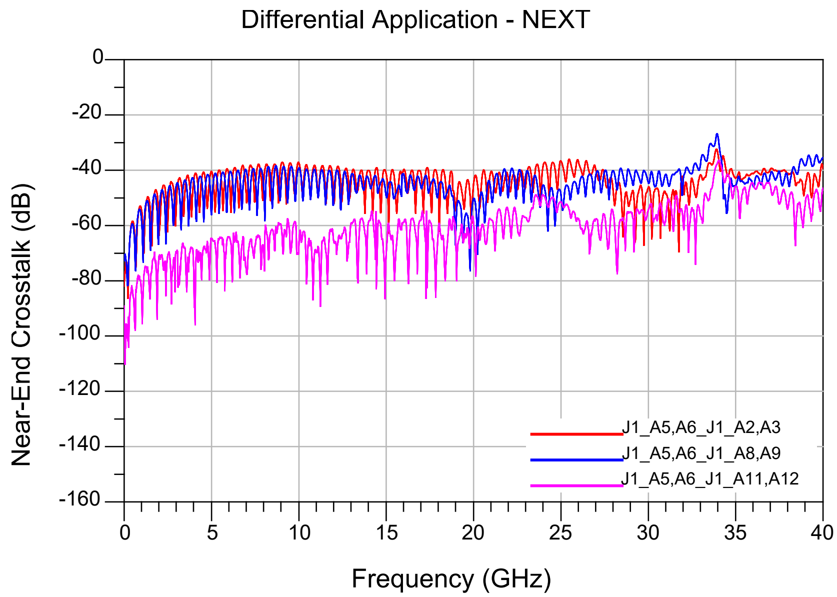


Figure 11

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

Differential Application – NEXT Configurations



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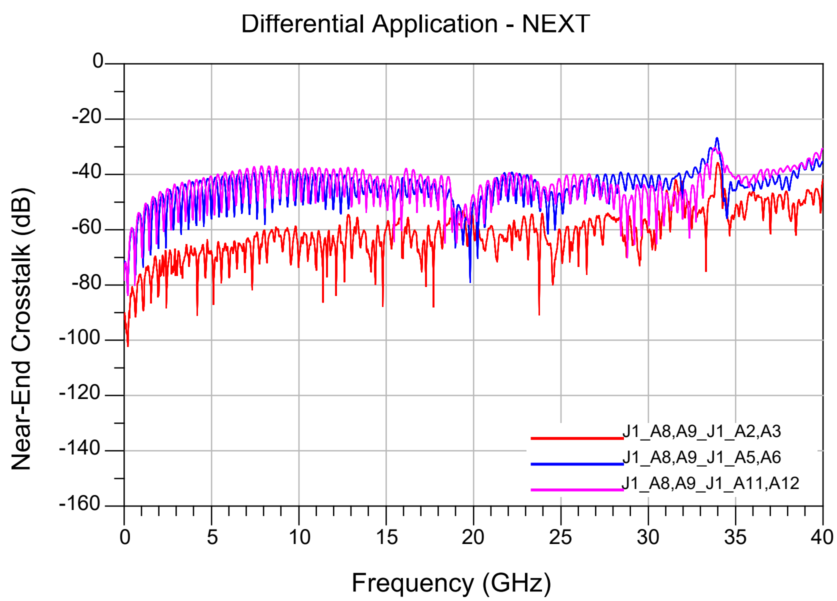

Figure 13

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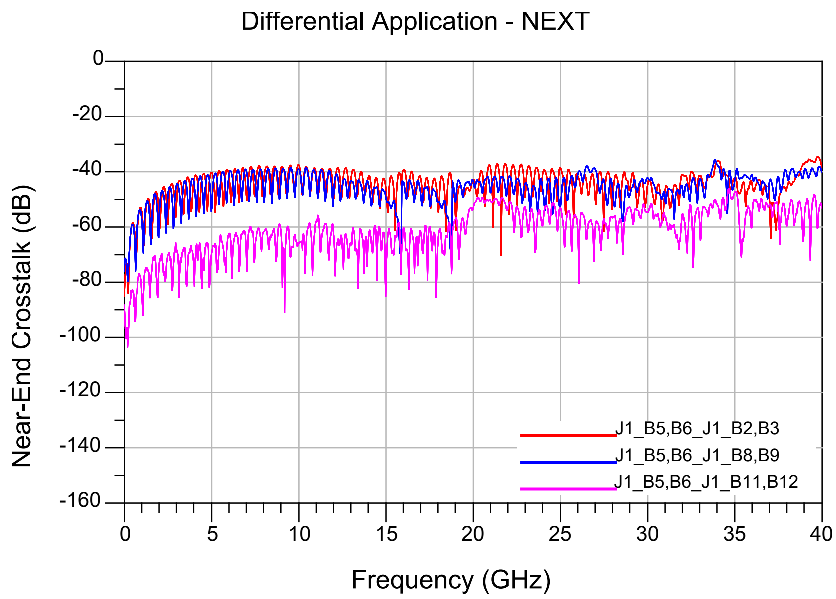

Figure 14

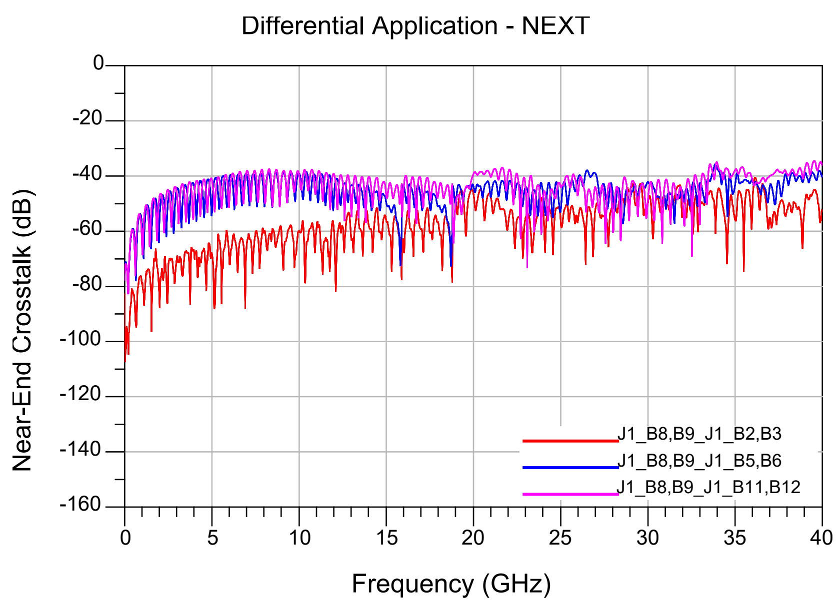

Figure 15

Series: HALO-PE
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Differential Application – FEXT Configurations

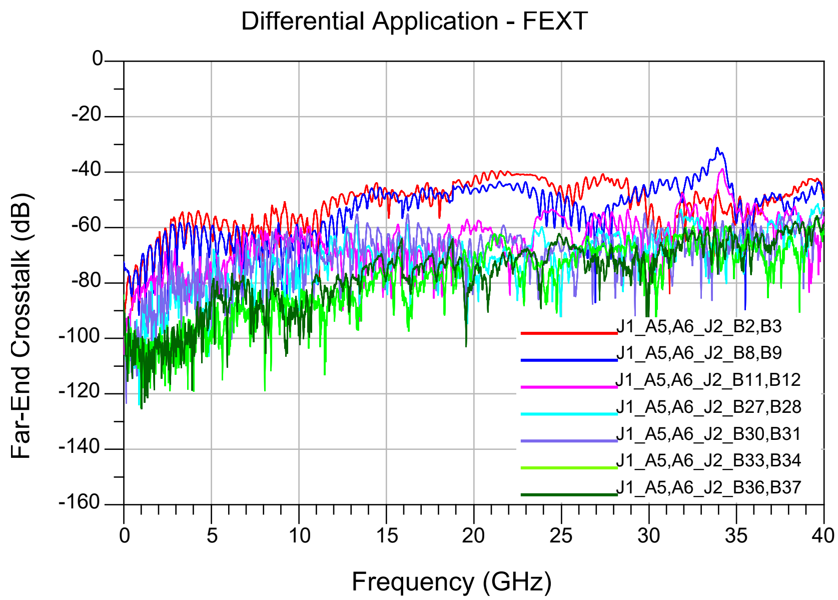


Figure 16

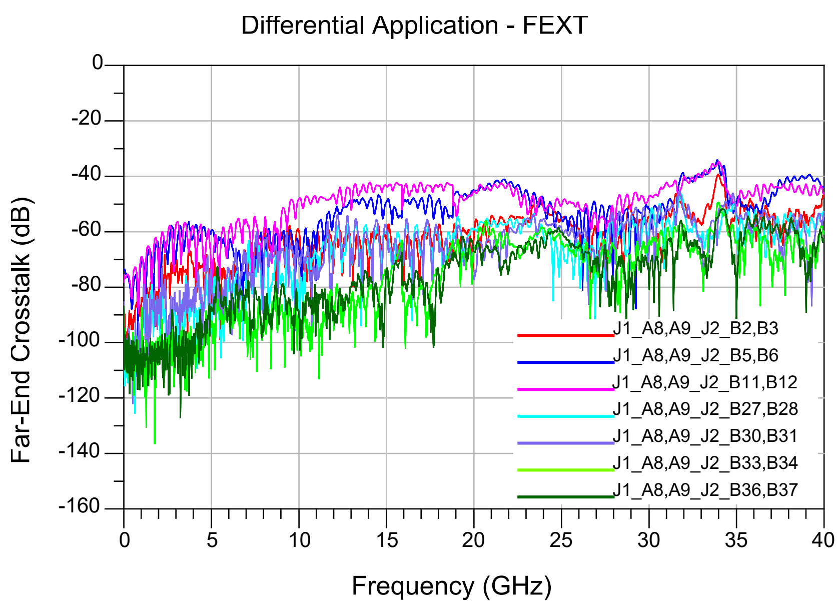
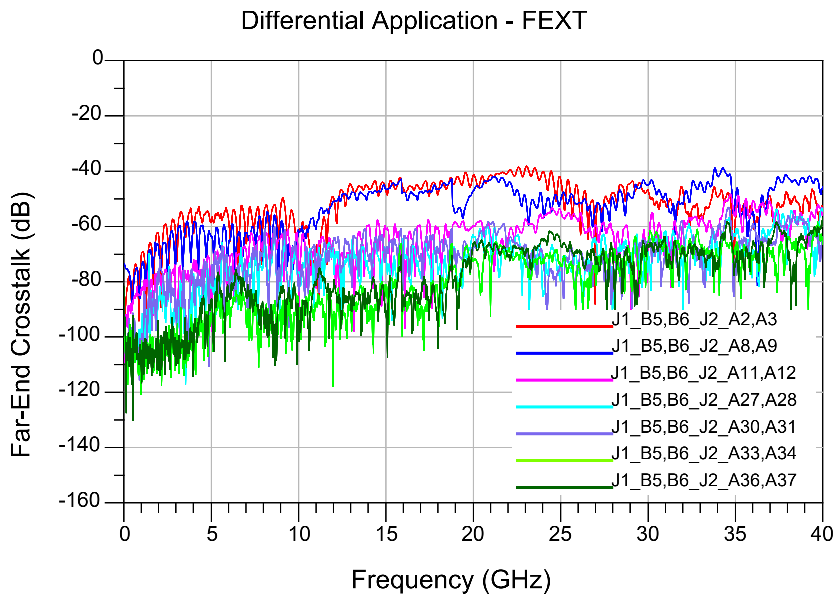


Figure 17

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1



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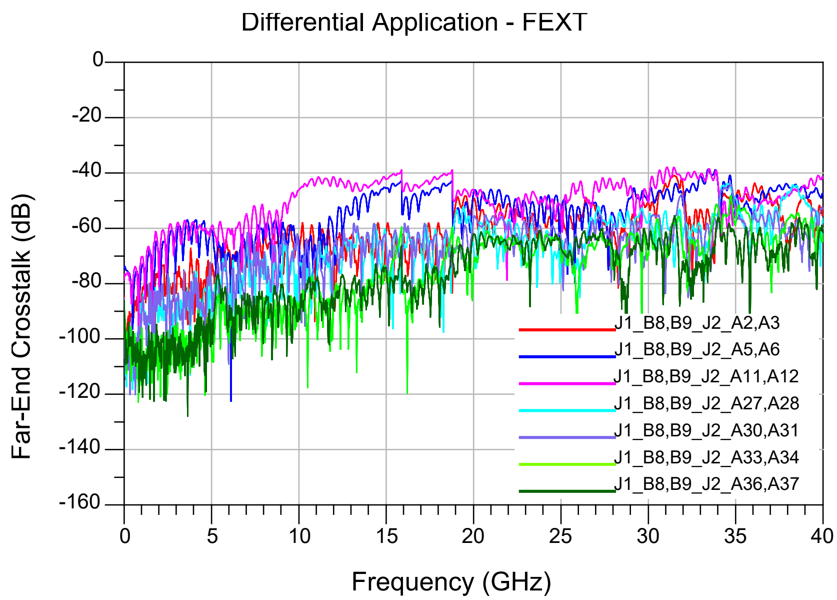

Figure 19

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Differential Application – Differential to Common Mode Conversion

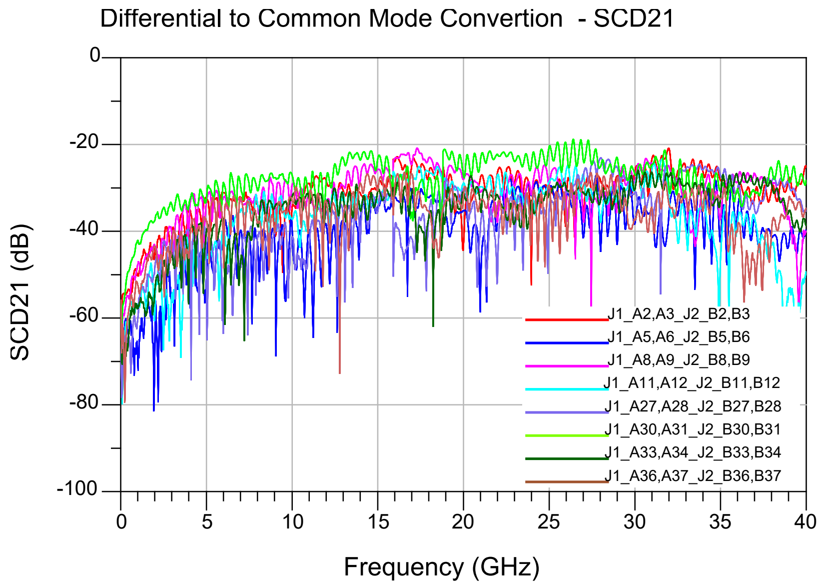

Figure 20

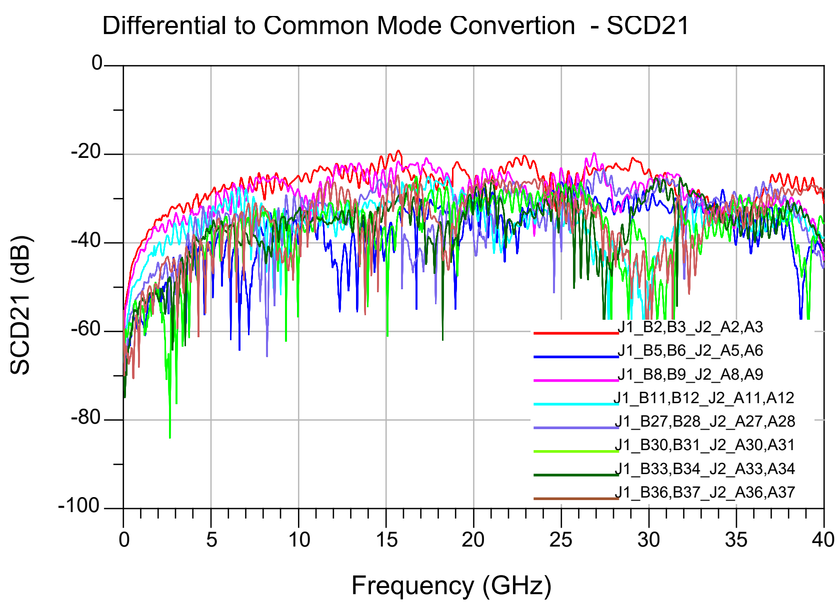

Figure 21

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Appendix B – Time Domain Responses

Differential Application – Input Pulse

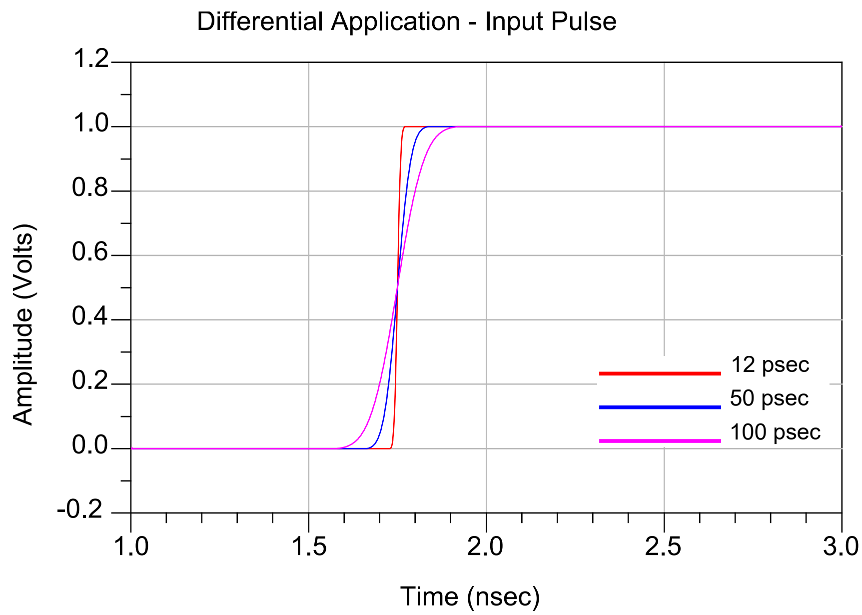

Figure 22

Series: HALO-PE
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Differential Application – Cable assembly Impedance

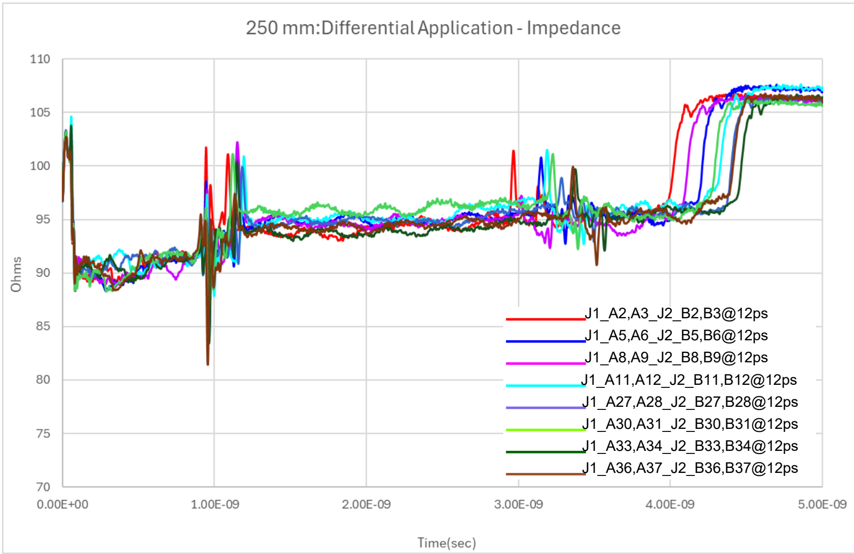

Figure 23

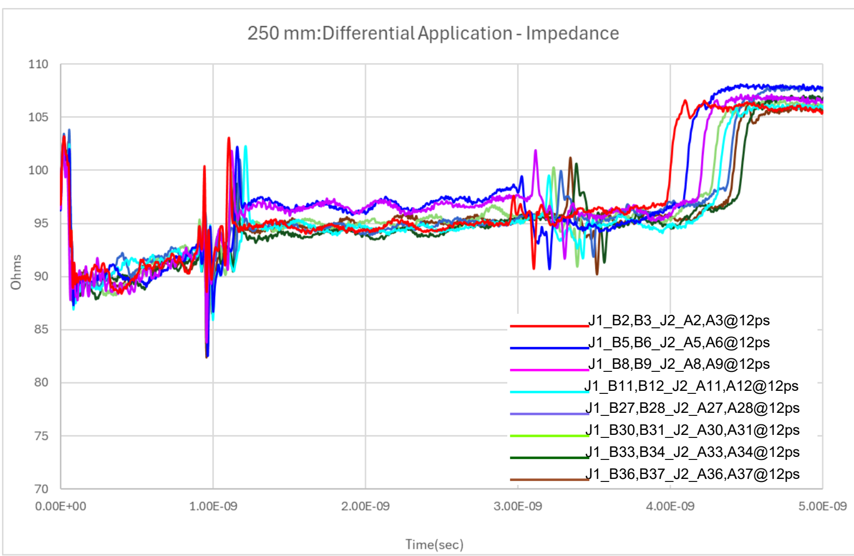

Figure 24

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

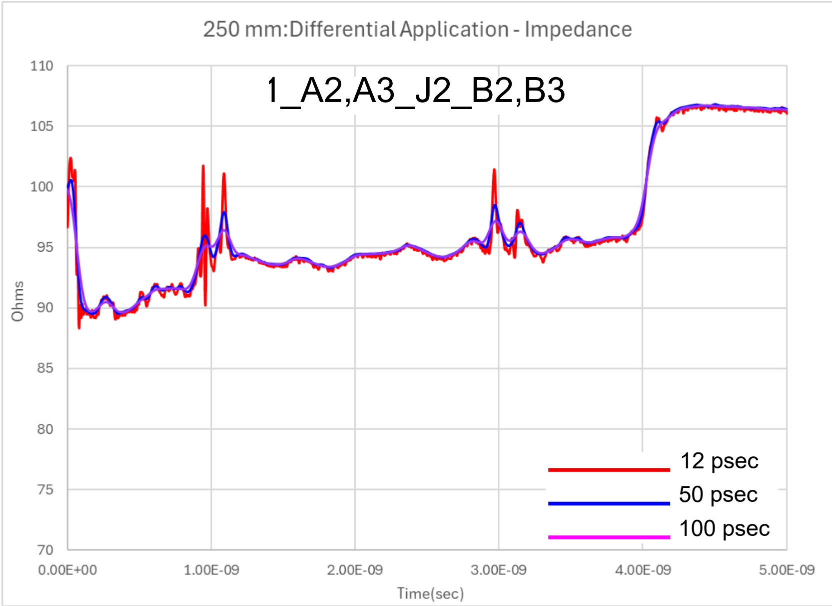

Figure 25

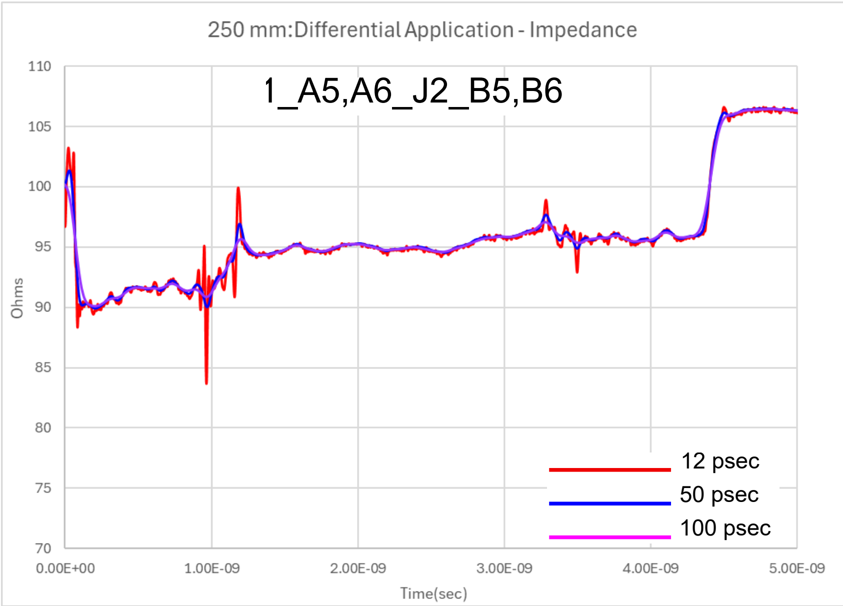

Figure 26

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

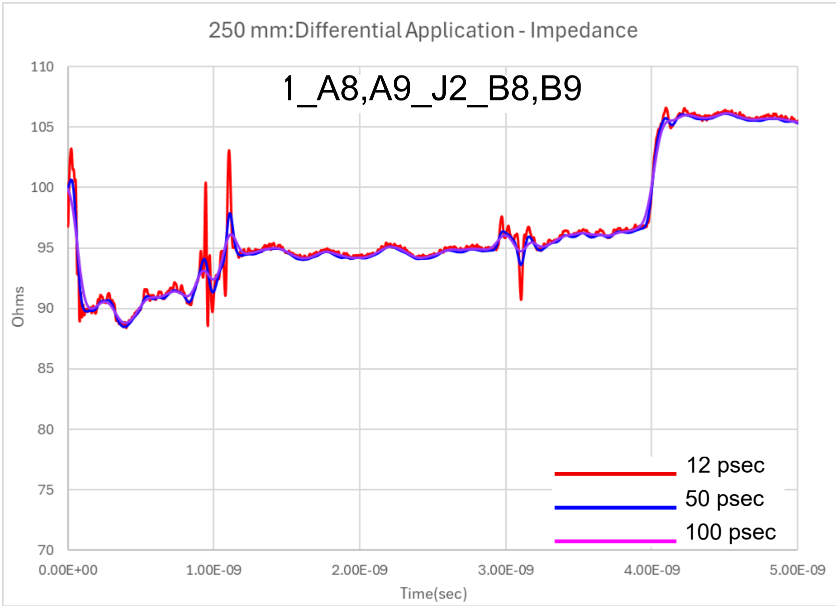

Figure 27

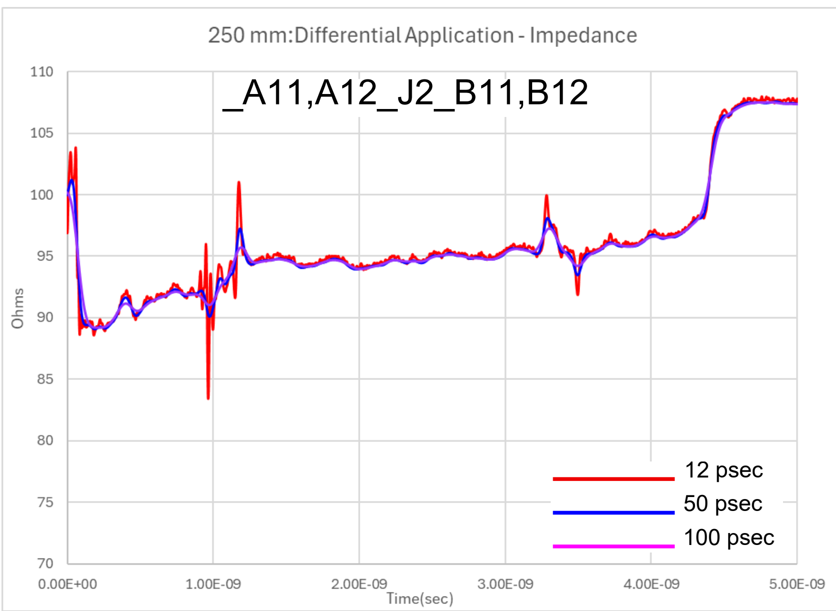

Figure 28

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

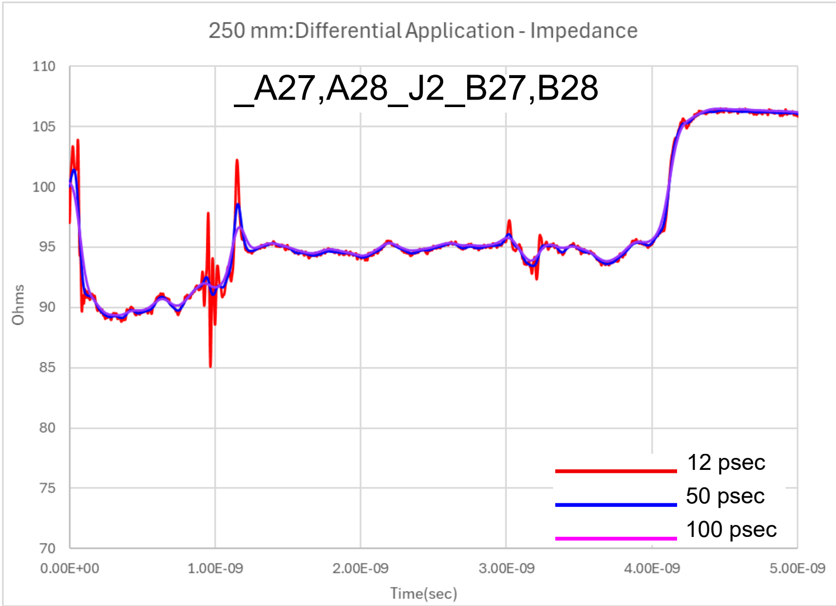

Figure 29

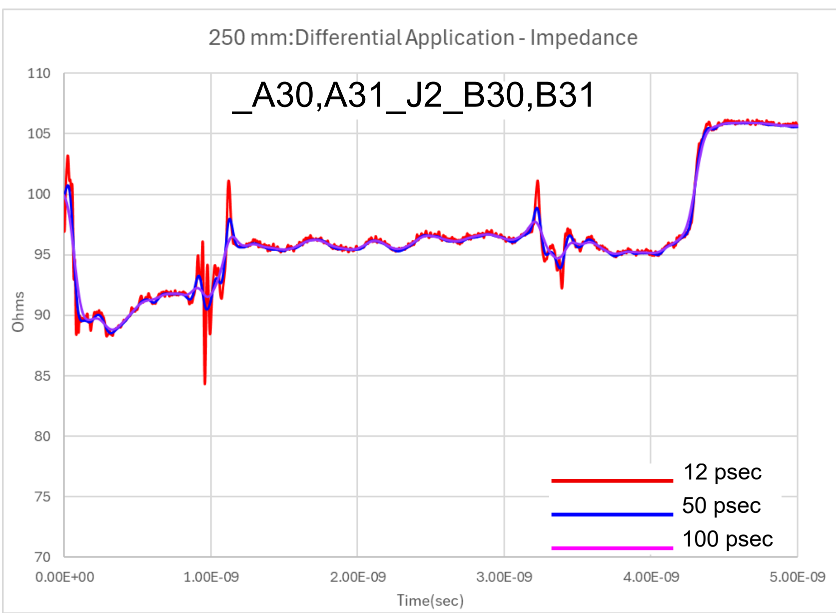

Figure 30

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

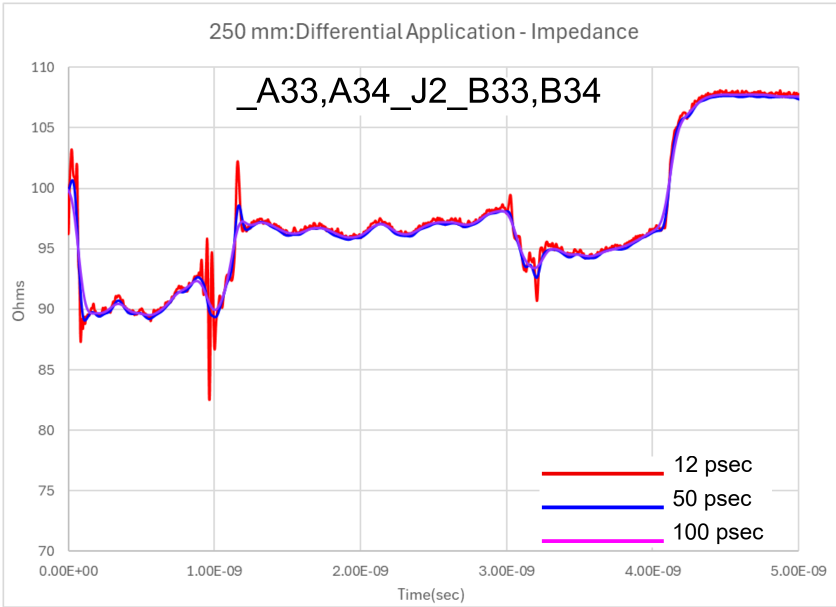

Figure 31

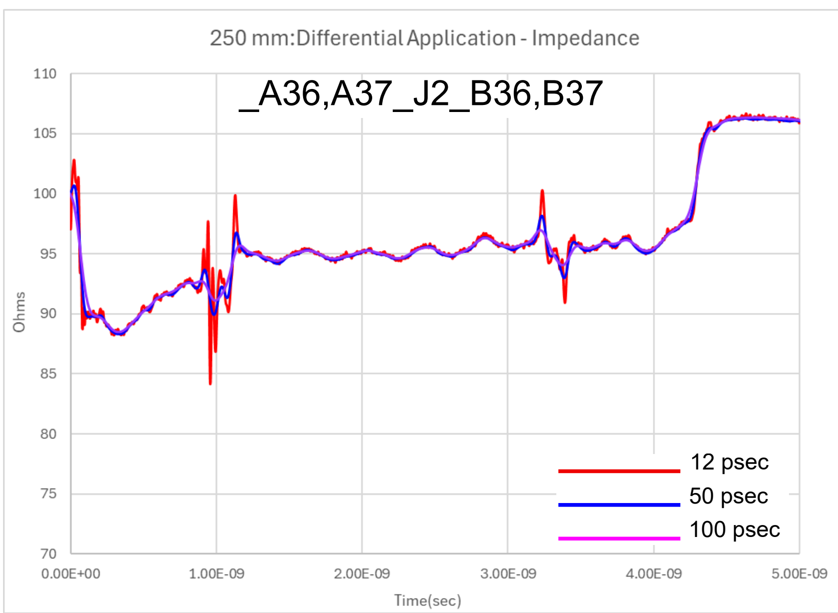

Figure 32

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

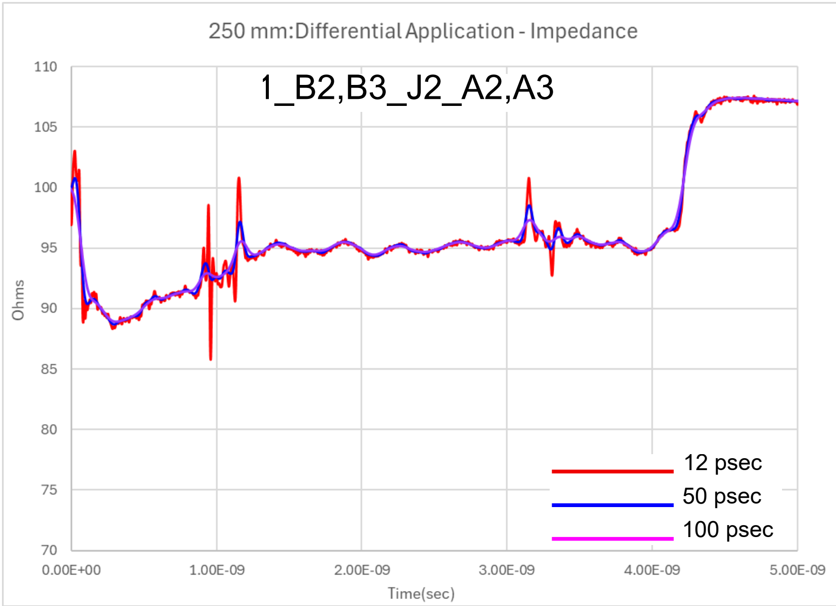

Figure 33

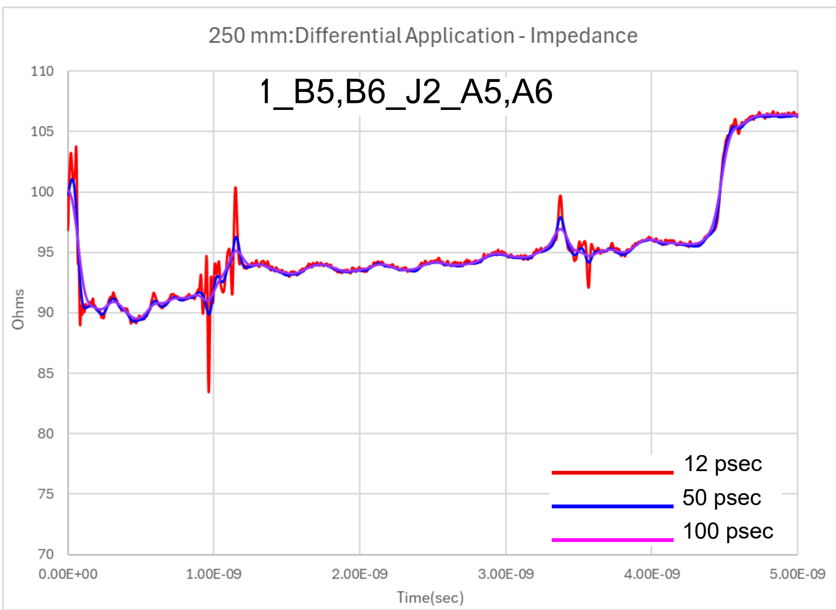

Figure 34

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

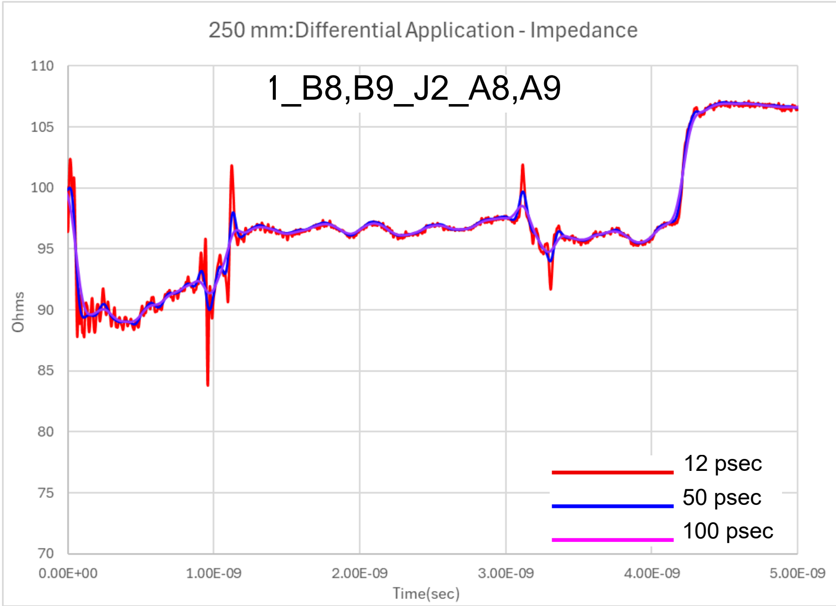

Figure 35

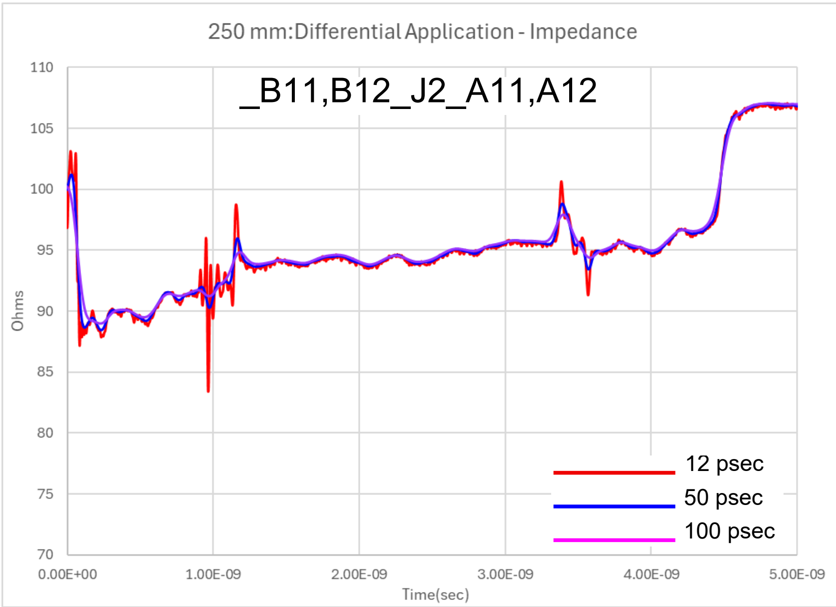

Figure 36

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

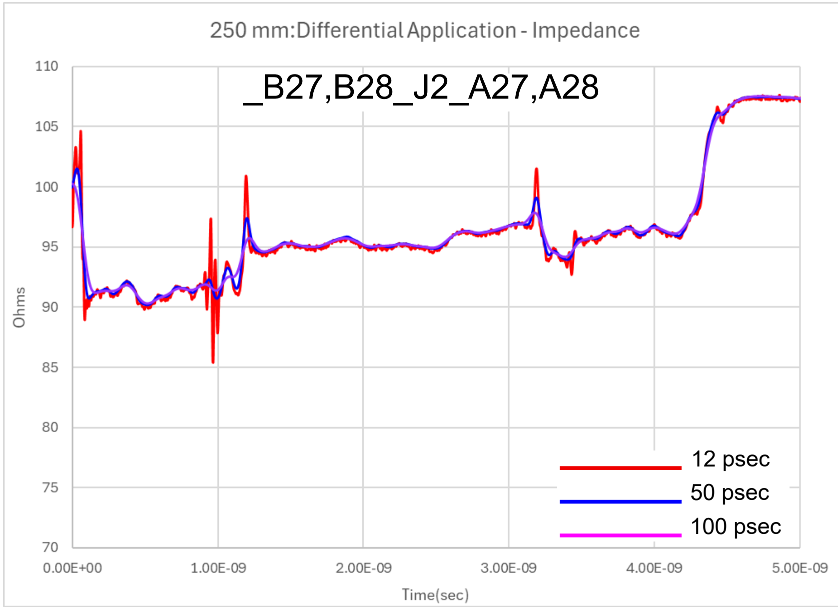

Figure 37

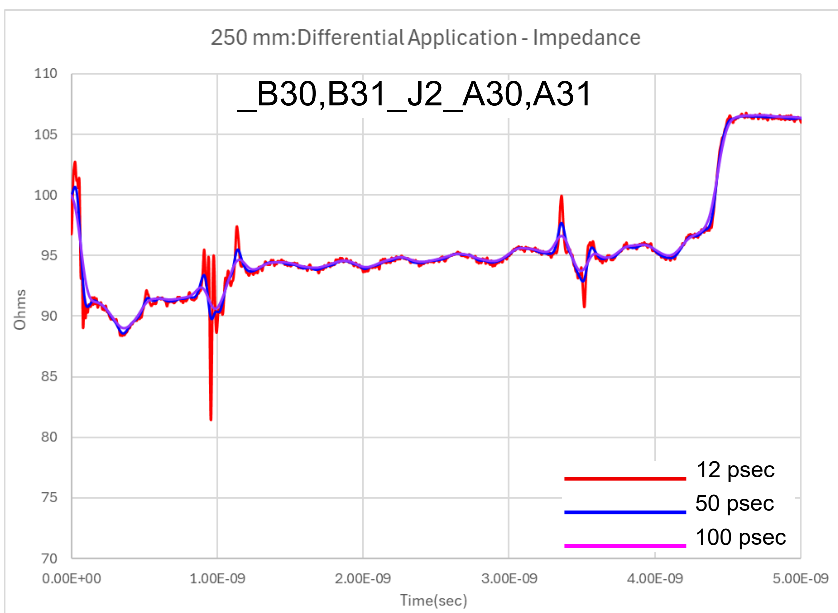

Figure 38

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

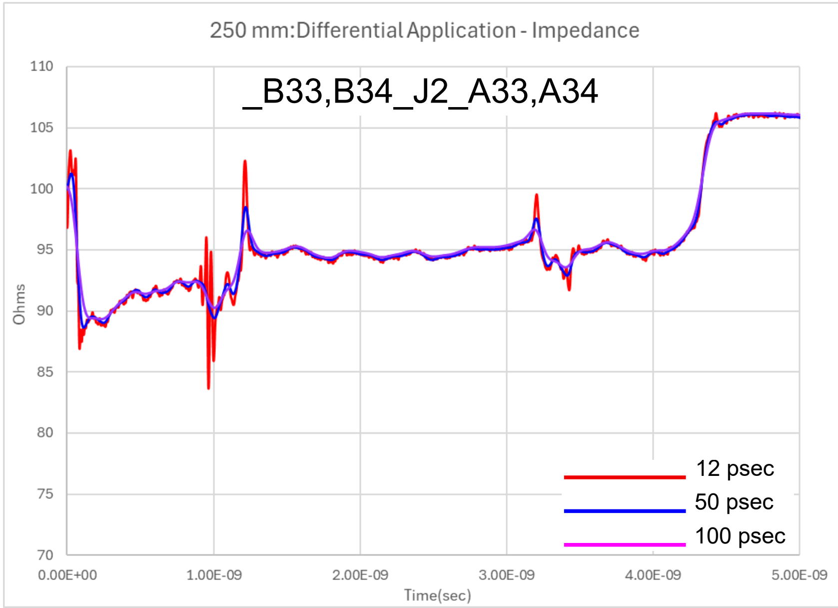

Figure 39

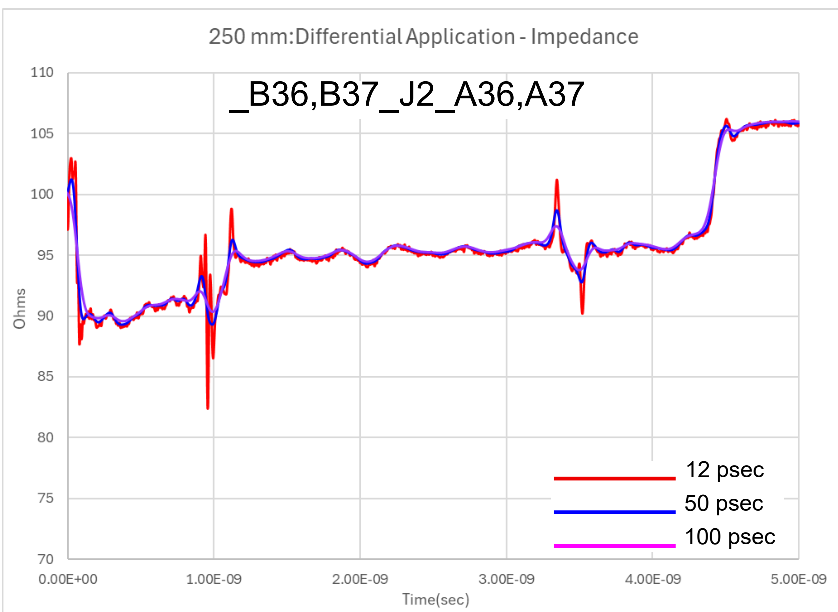

Figure 40

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

Differential Application – Propagation Delay

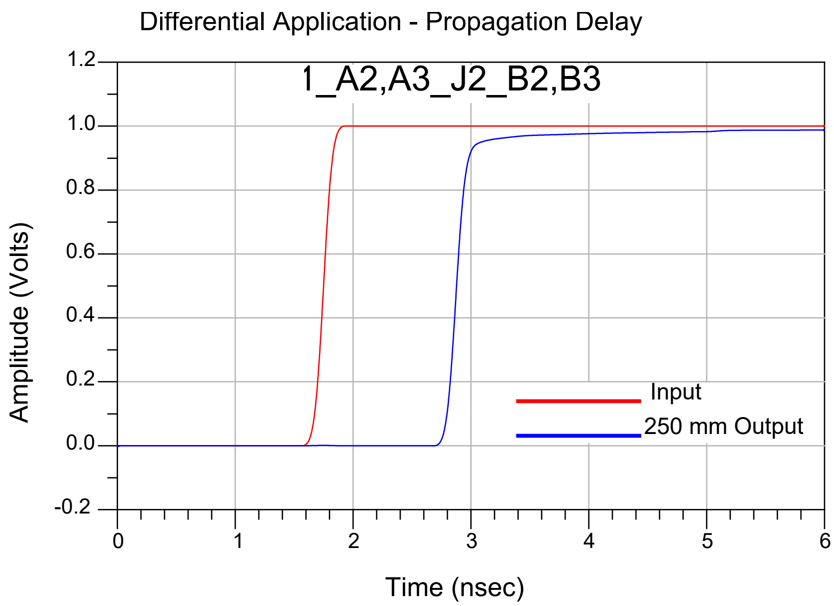

Figure 41

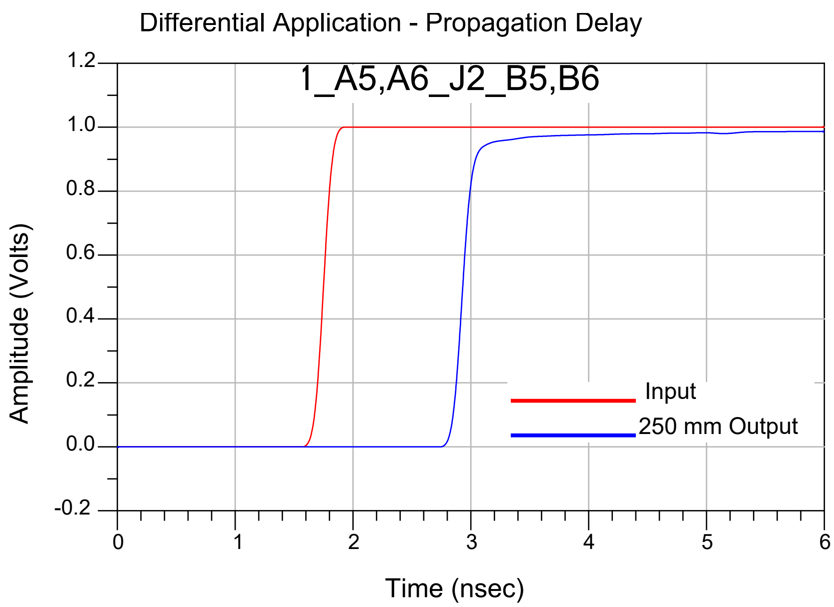

Figure 42

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: 3/27/2025

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

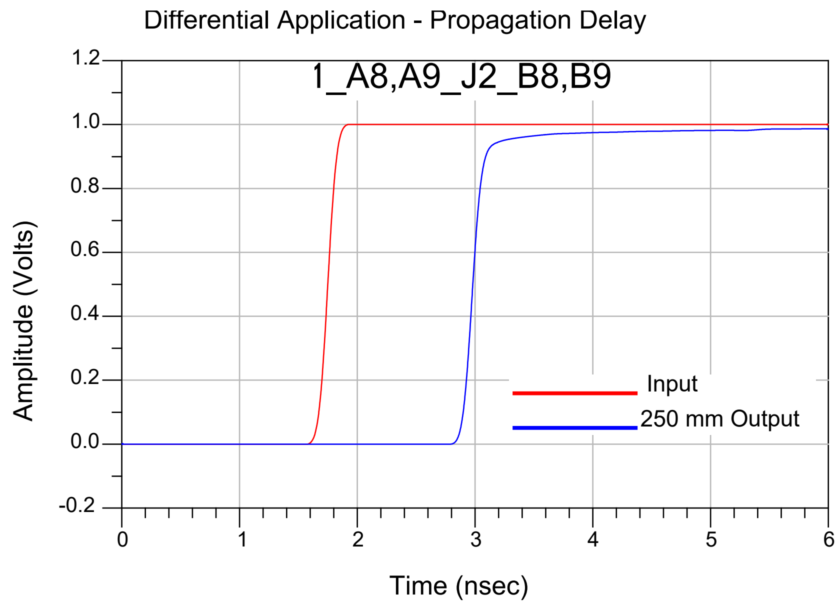

Figure 43

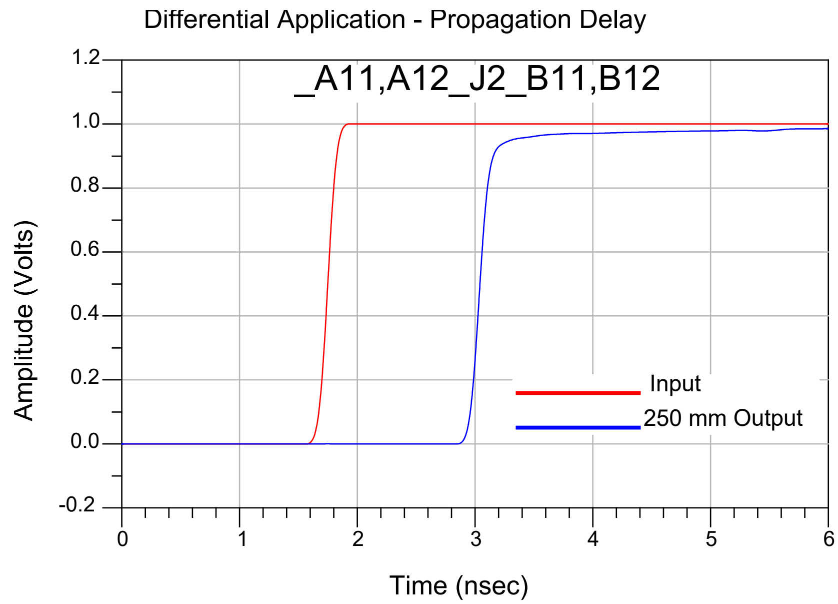

Figure 44

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

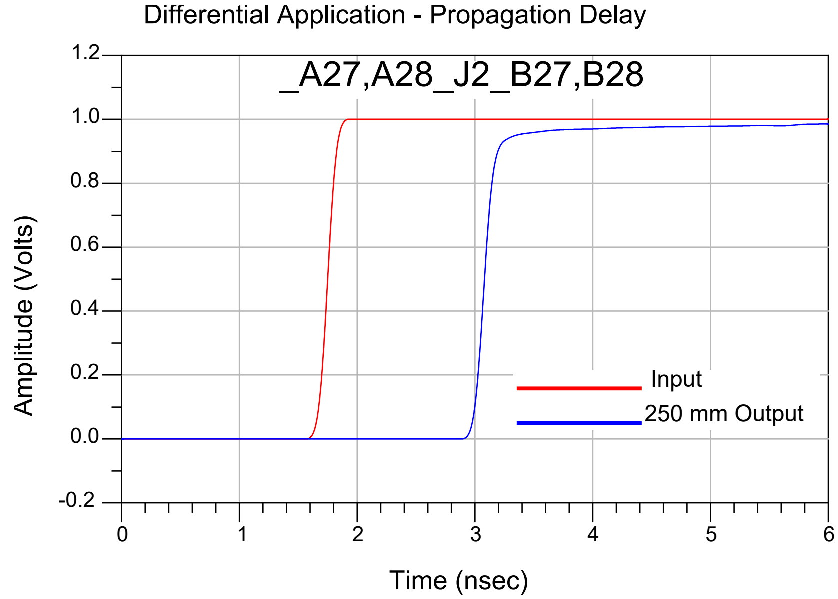

Figure 45

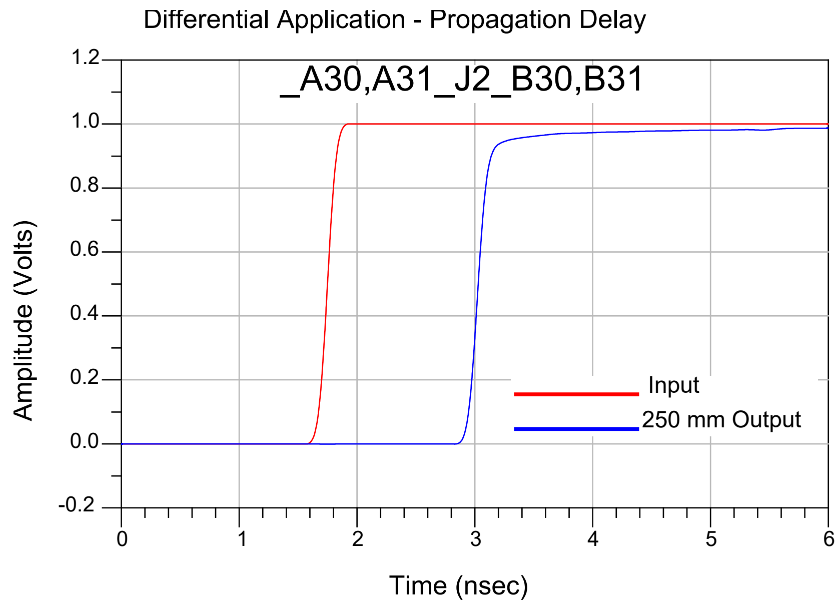

Figure 46

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

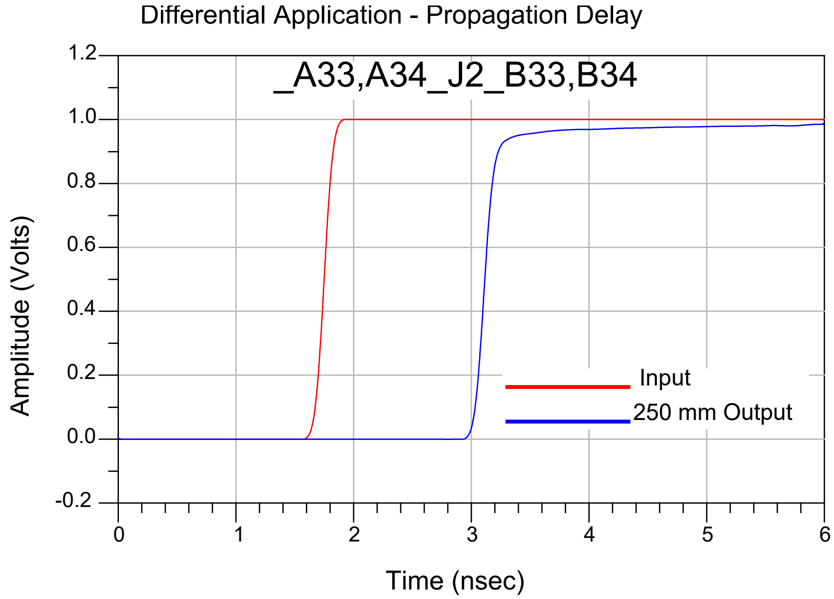

Figure 47

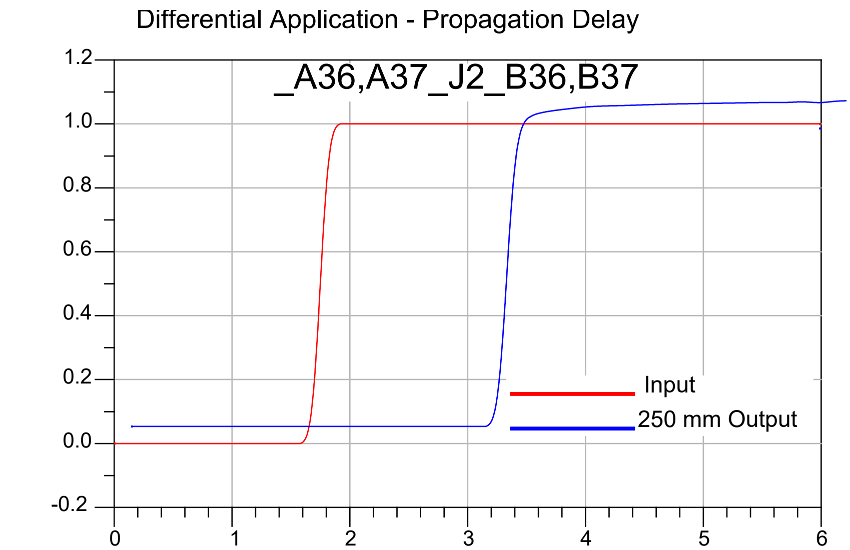

Figure 48

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

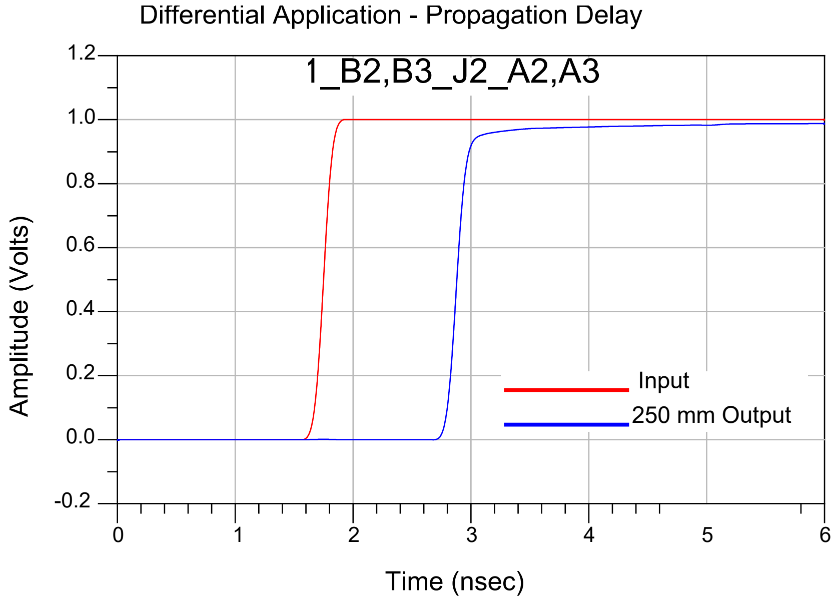

Figure 49

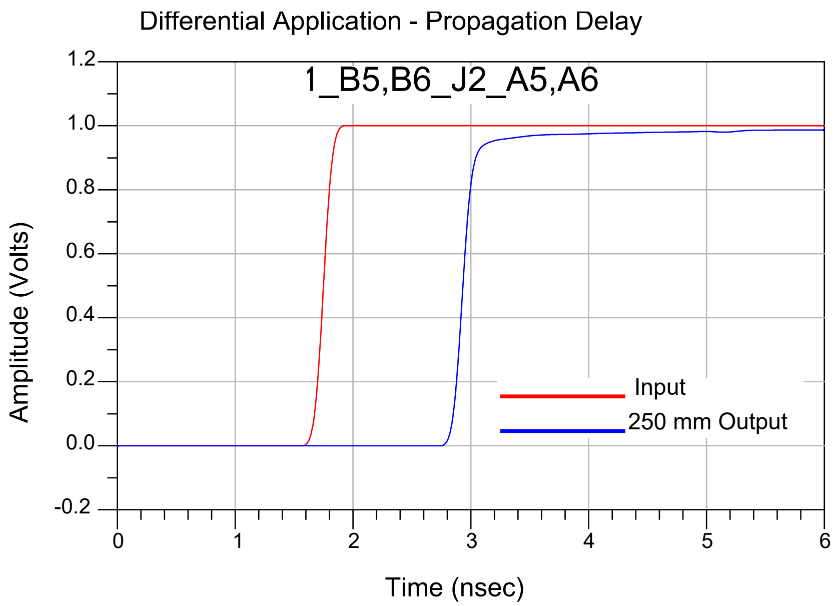

Figure 50

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

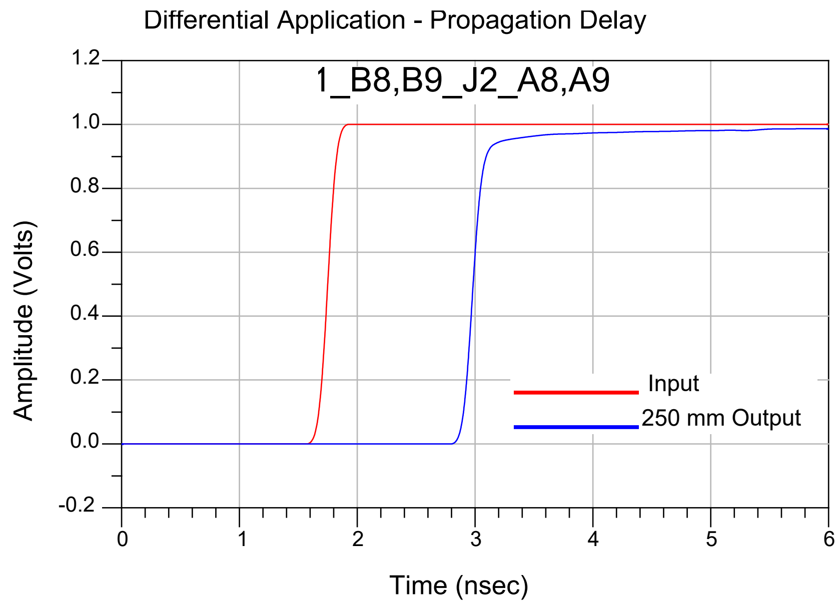

Figure 51

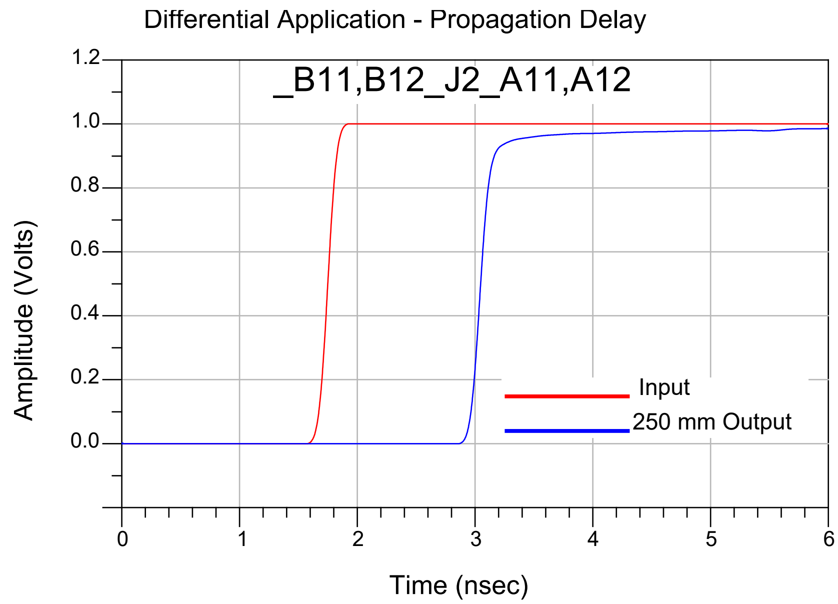

Figure 52

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

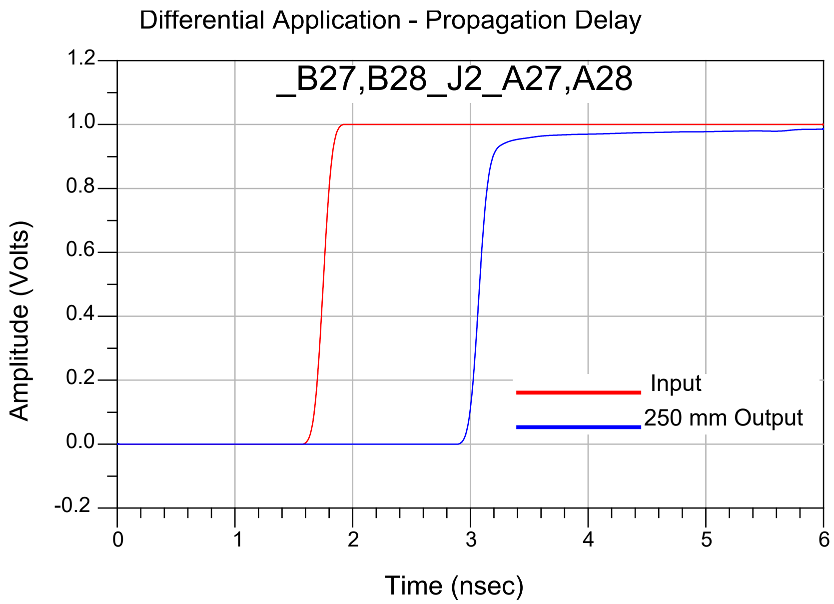

Figure 53

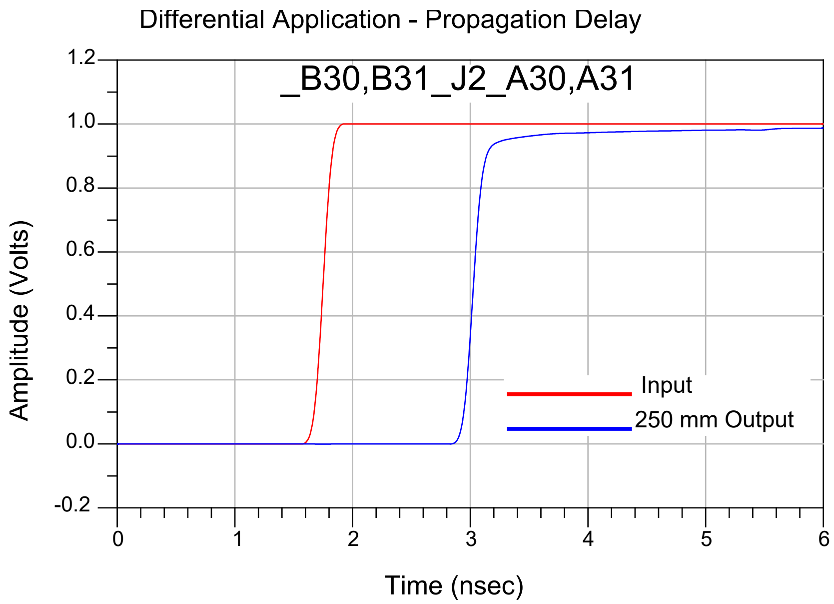

Figure 54

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

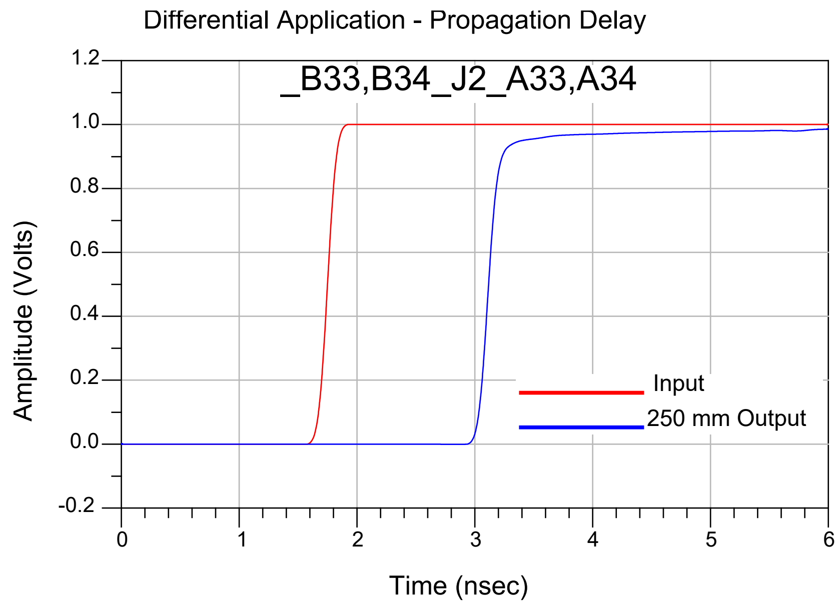

Figure 55

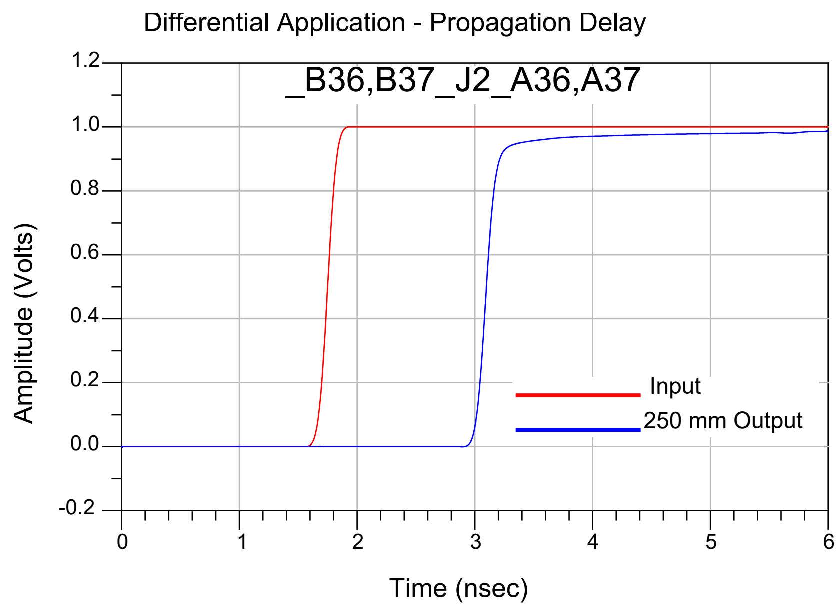

Figure 56

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

Appendix C – Product and Test System Descriptions

Product Description

The product sample is HALO Cable Assembly. The part number is HALO-PE-01-4-0250 mating with HLF6-38-03.5-S-2-XR. A photo of the mated test article mounted to SI test boards is shown below.

The cable assembly terminations had a particular signal line configuration. The respective signal line numbers are shown in table 3 below.

HALO-XX-01-X-XXXX-X-X (A1 TO B1) SIGNAL MAPPING																											
J1	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14~A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	A37	A38
NAME	G	S	S	G	S	S	G	S	S	G	S	S	G	NC	G	S	S	G	S	S	G	S	S	G	S	S	G
J2	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14~B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38
J1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14~B25	B26	B27	B28	B29	B30	B31	B32	B33	B34	B35	B36	B37	B38
NAME	G	S	S	G	S	S	G	S	S	G	S	S	G	NC	G	S	S	G	S	S	G	S	S	G	S	S	G
J2	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14~A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	A37	A38
ALL GROUNDS ARE COMMON AND TIED TO CABLE SHIELD																											

Table 3: Respective signal line numbers

Test System Description

The test fixtures are composed of twelve-layer Tachyon 100G material with 92.5Ω differential 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 HLF6 series connector set and identified by part number PCB-113931-SIG-01. Displayed on the following pages is information for the HALO/AFR calibration structure and directives for mating HALO fixtures.

PCB-113931-SIG-01 Test Fixtures

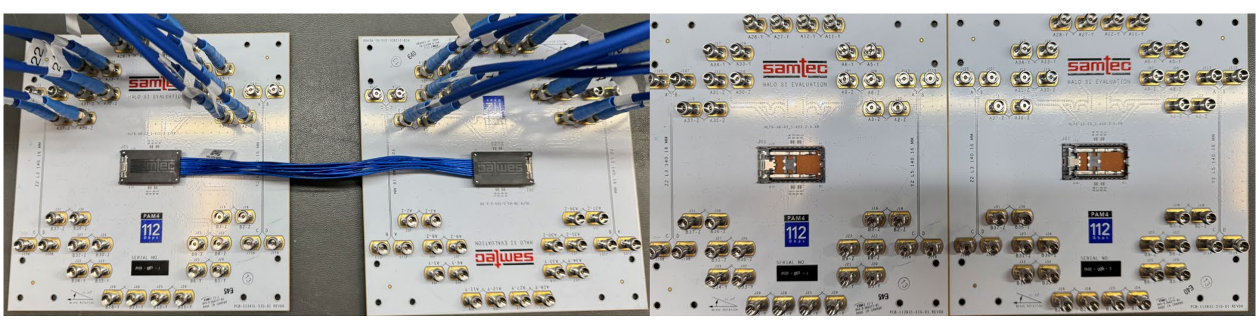

Figure 57

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

PCB Fixtures

The test fixtures used are as follows:

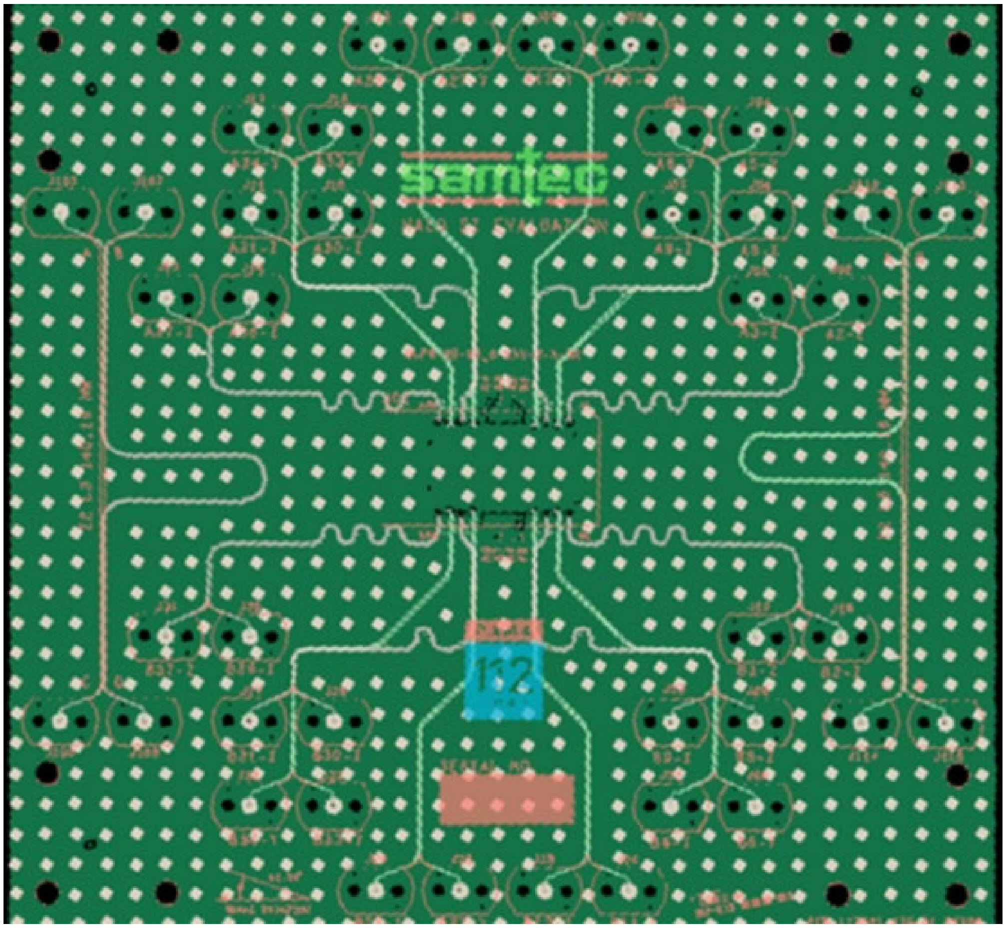

Figure 58

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

Appendix D – Test and Measurement Setup

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

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

N5225B Measurement Setup

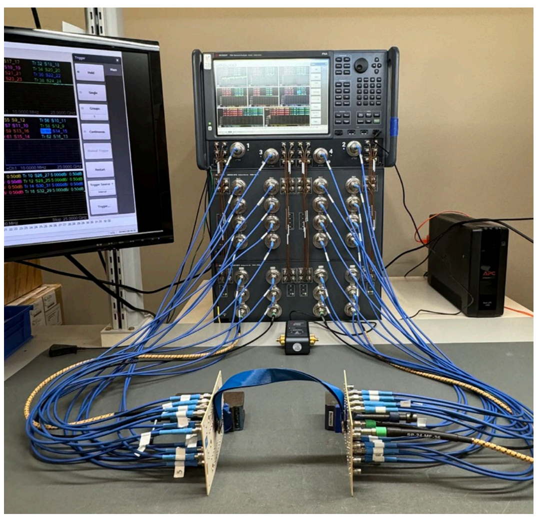

Figure 59

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: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

For impedance measurements, the test instrument is the Keysight DCA-X86100D Wide-Bandwidth Oscilloscope Mainframe. The impedance data and profiles are obtained directly from the instrument. The Digital Analyzer is configured as follows:

Vertical Scale: 5 ohm / Div
Horizontal Resolution: 2.5ps
Averages: 128

DCA-X86100D Measurement Setup

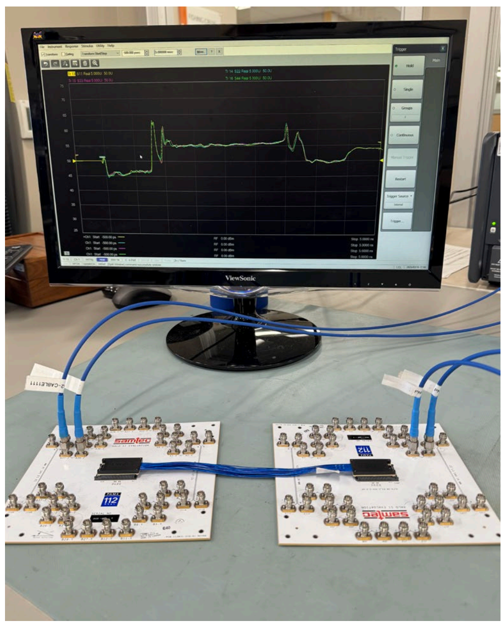

Figure 60

Test Instruments

QTY	Description
1	Keysight DCA-X86100D Wide-Bandwidth Oscilloscope Mainframe

Test Cables & Adapters

QTY	Description
4	Junkosha J12J103834-00

Series: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

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: HALO-PE
Description: Halo Cu™ Copper Mid-Board Cable System, 112G Data Rate, Pin A1 to B1

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