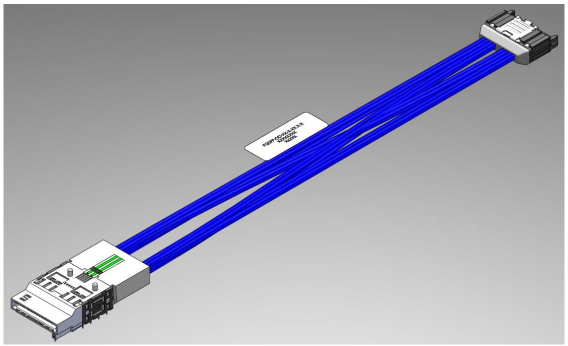
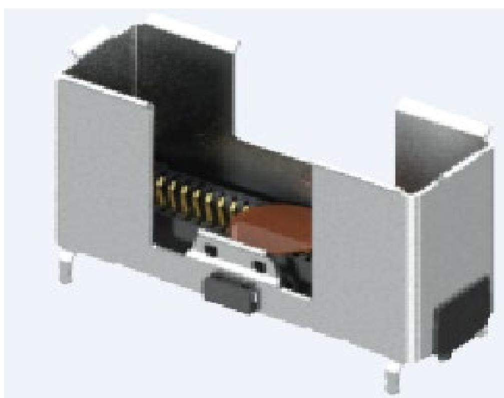
High Speed Characterization Report

FQSFP-DD-01-A-XX.X-3



Mated with:

ARF6-16-X-D-A-X



Description

Double Density Flyover® QSFP28 Cable System, 34 AWG Twinax, ARC6-16 End Option

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: 04/21/2020

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Table of Contents

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Cable Assembly Overview

The FQSFP-DD series, Double Density Flyover® QSFP28 Cable System, is constructed using 34 AWG, 100 Ohm twin-ax cable. The cable is terminated at both ends with connector on a printed circuit board. The cable assembly signal mapping is defined in the assembly print for both ends. FQSFP-DD series cable assemblies have 8 high-speed lanes (16 differential pairs). The data in this report is applicable only to 6 inch,12 inch, and 18 inch length cable assemblies. The FQSFP-DD miscellaneous I/O signal pins are not tested in this report.

Each FQSFP-DD cable assembly was tested by mating it to the QSFP-DD test card at end1 and ARF6 (vertical) socket connector at end2. One sample of each assembly was tested. The actual part numbers that were tested are shown in Table 1, which also identifies End 1 and End 2 of each assembly. A relative sample picture is shown in Figure1.

Length	Part Number	End 1	End 2
6 inches	FQSFP-DD-01-A-06.0-3	FQSFP-DD	ARC6
12 inches	FQSFP-DD-01-A-12.0-3	FQSFP-DD	ARC6
18 inches	FQSFP-DD-01-A-18.0-3	FQSFP-DD	ARC6

Table 1: Sample Description

Figure 1: Test Sample

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Frequency Domain Data Summary

Bandwidth Chart – Differential Insertion Loss

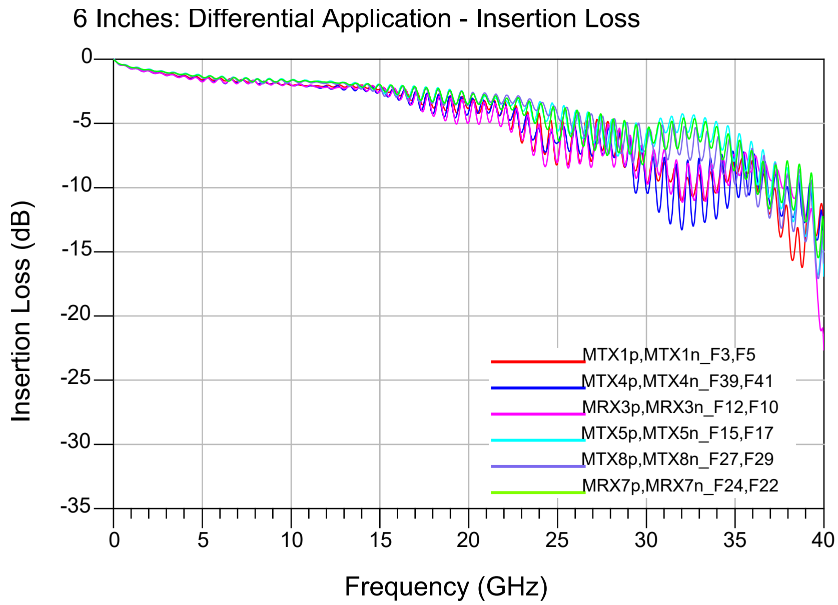


Figure 2

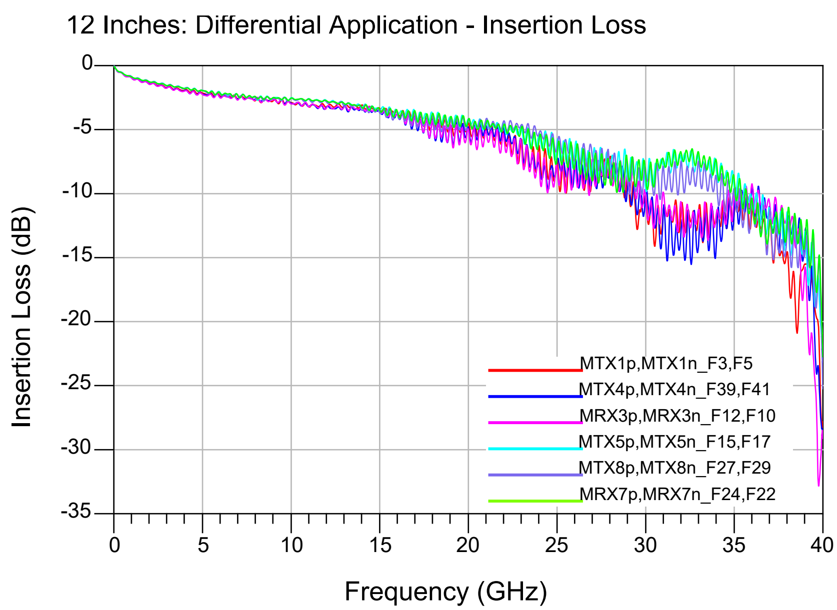


Figure 3

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

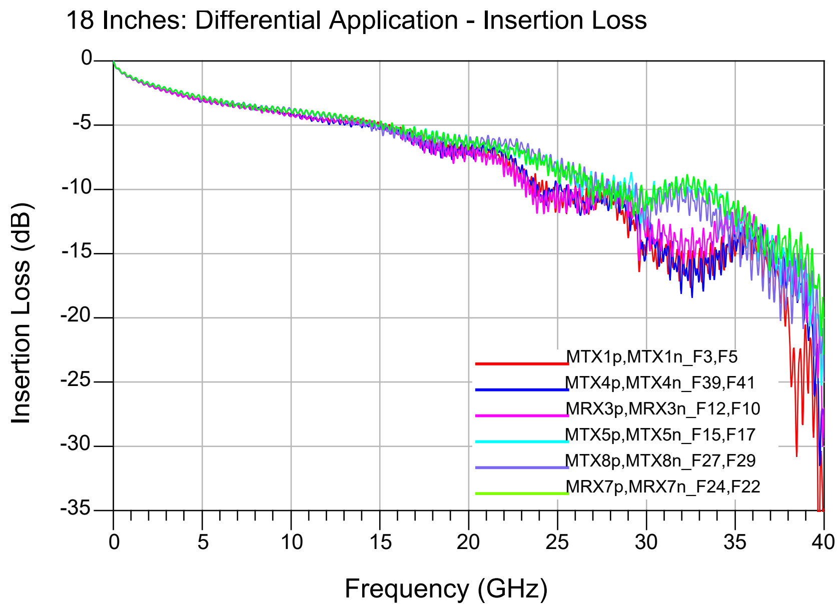


Figure 4

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Time Domain Data Summary

6 Inches: Differential Application - Impedance

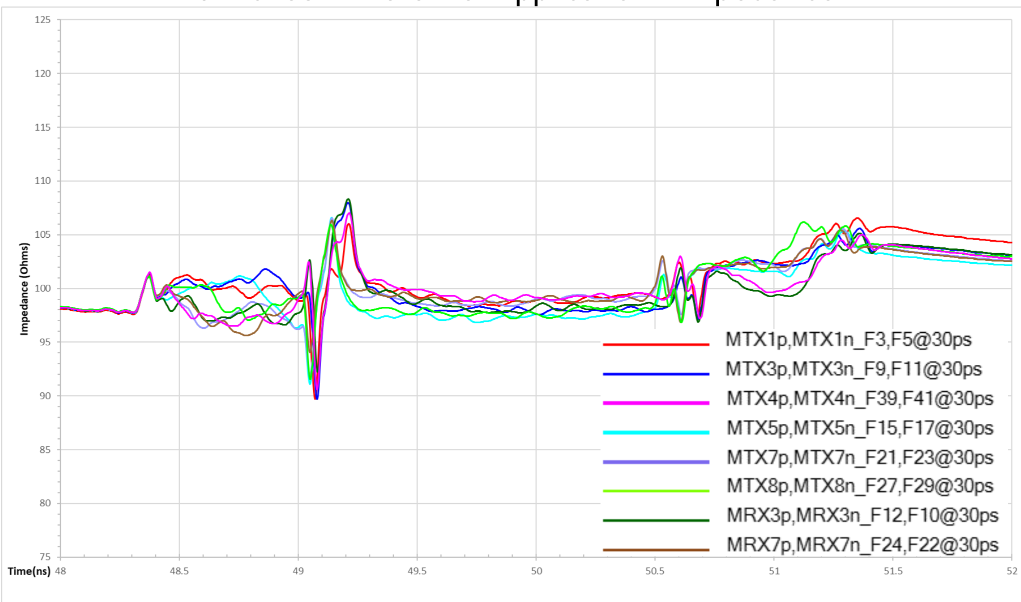


Figure 5

Because the same type cable is used in the cable assemblies with different lengths, only the impedance profile of the 6 Inch long cable assembly is reported.

Table 2 - Propagation Delay (Cable Assembly)				
Driver	**Receiver**	**6 inches**	**12 inches**	**18 inches**
J1_TX1p, TX1n	J2_3,5	0.837 ns	1.546 ns	2.492 ns
J1_TX4p, TX4n	J2_39,41	0.848 ns	1.558 ns	2.514 ns
J1_RX3p, RX3n	J2_12,10	0.842 ns	1.555 ns	2.499 ns
J1_TX5p, TX5n	J2_15,17	0.804 ns	1.515 ns	2.460 ns
J1_TX8p, TX8n	J2_27,29	0.809 ns	1.519 ns	2.466 ns
J1_RX7p, RX7n	J2_24,22	0.803 ns	1.513 ns	2.463 ns

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

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.

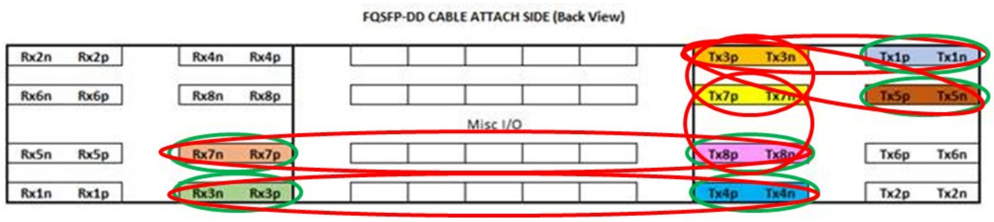
Cable assembly Signal to Ground Ratio

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.

For this cable assembly, signal and ground definitions are defined by the QSFP-DD MSA and cannot be altered.

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option



Respective signal line numbers as viewed from End 1

Differential Impedance (denoted by green 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

Other configurations can be evaluated upon request. Please contact sig@samtec.com for more information.

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.

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 from network analyzer measurements.

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

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 DSA8300 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.

In this report, propagation delay is defined as the signal propagation time through the cable assembly, mating connectors, and connector footprint. It also includes 4 mm of PCB trace on PCB-108922 side and 1.27 mm of PCB trace on PCB-109926 side. Delay is measured at 50 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.

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Appendix A – Frequency Domain Response Graphs

Differential Application – Insertion Loss

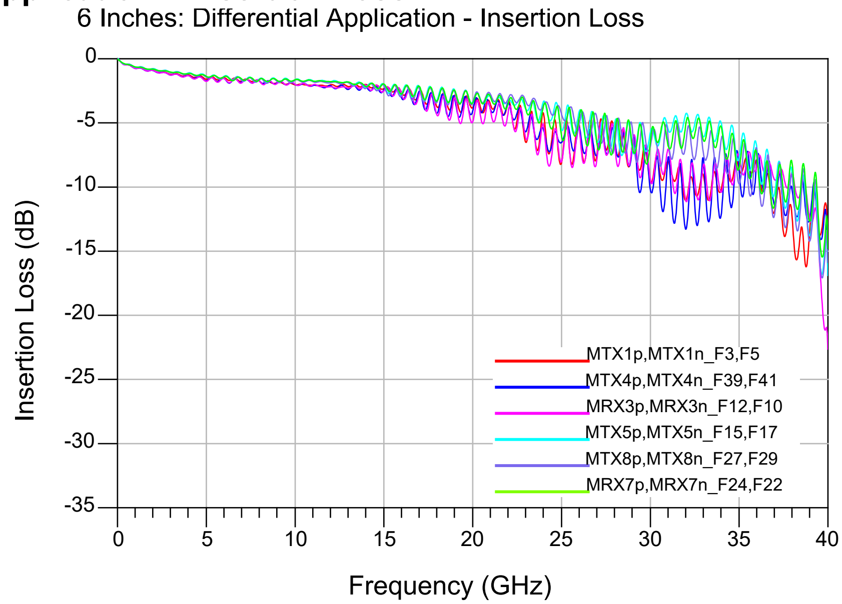


Figure 6

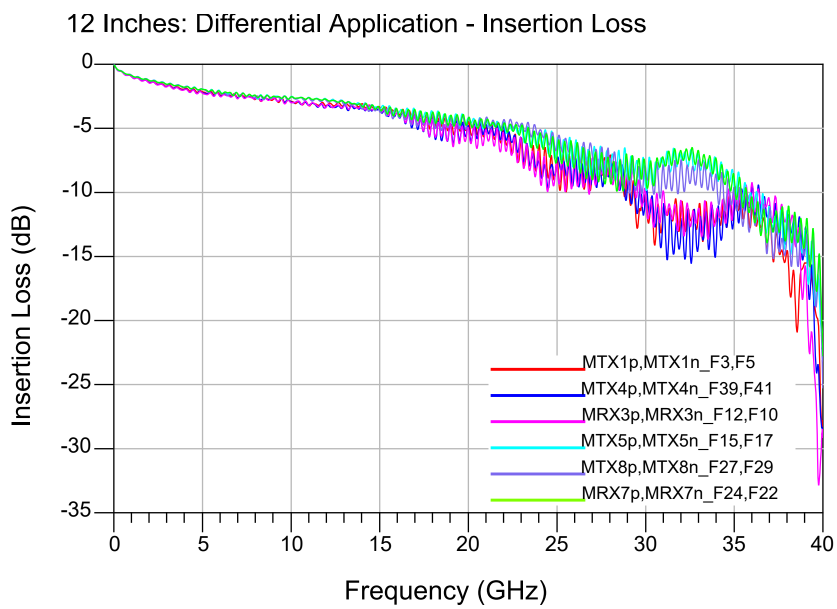


Figure 7

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

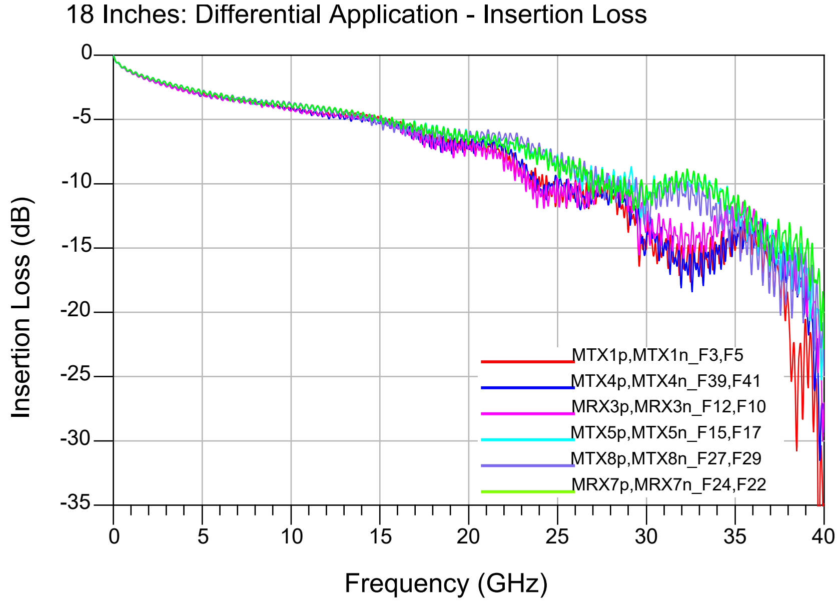


Figure 8

Differential Application – Return Loss

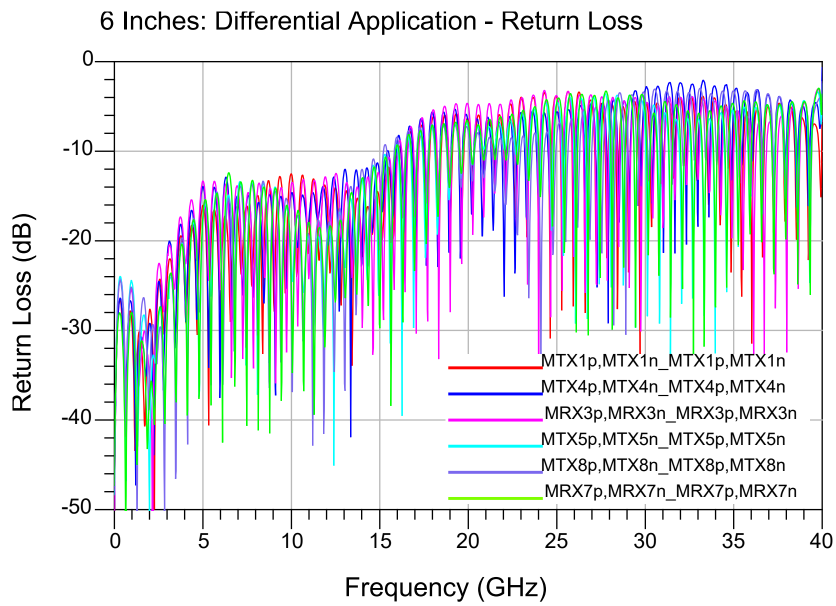


Figure 9

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

12 Inches: Differential Application - Return Loss

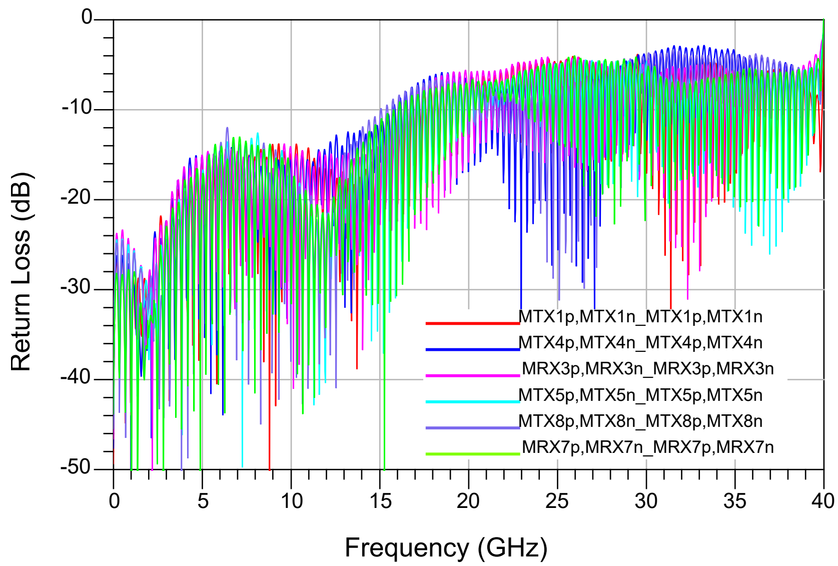


Figure 10

18 Inches: Differential Application - Return Loss

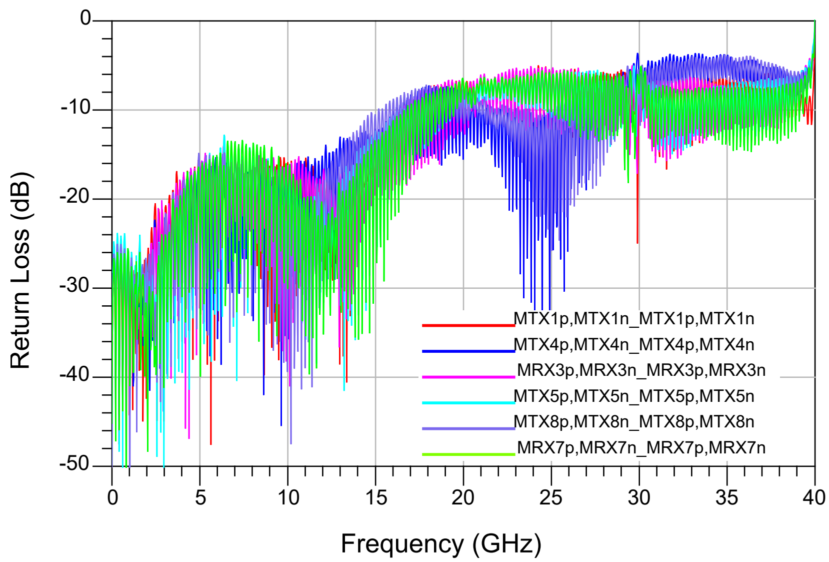


Figure 11

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: 04/21/2020

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Differential Application – NEXT Configurations

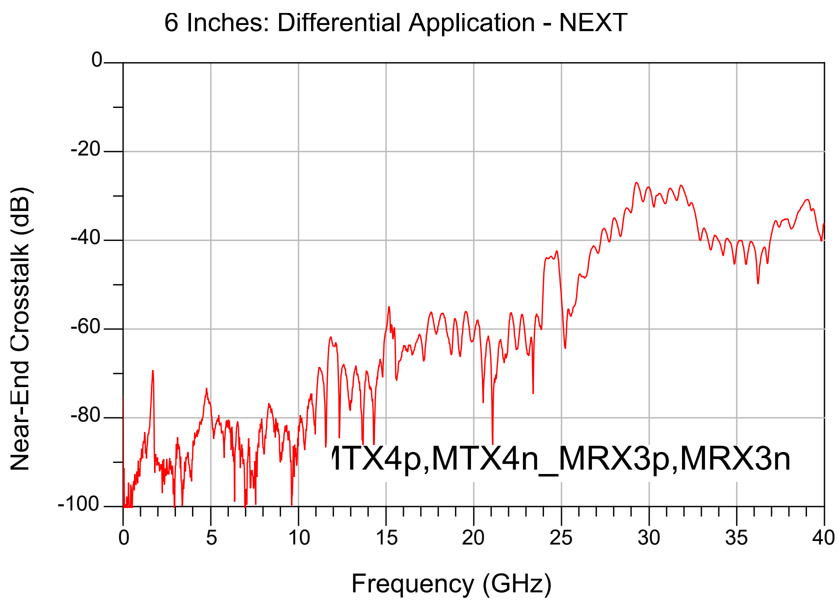


Figure 12

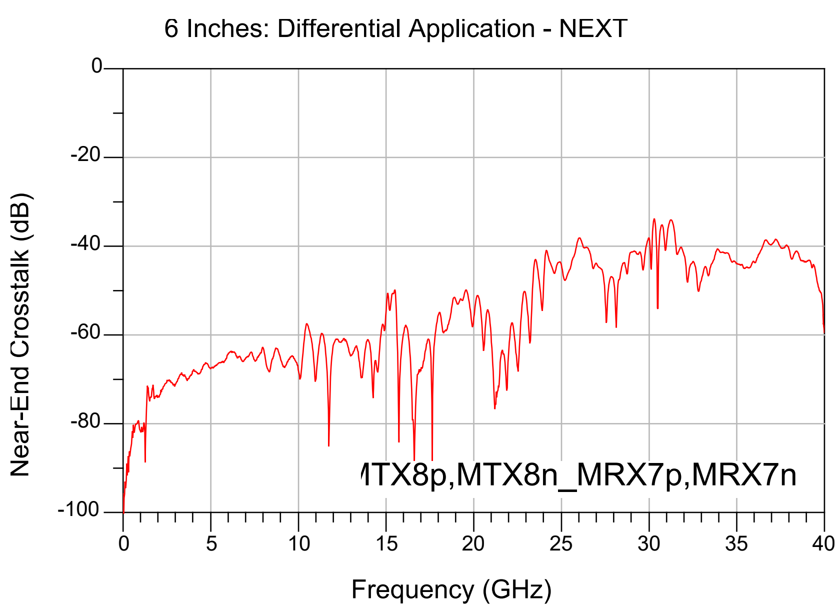


Figure 13

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

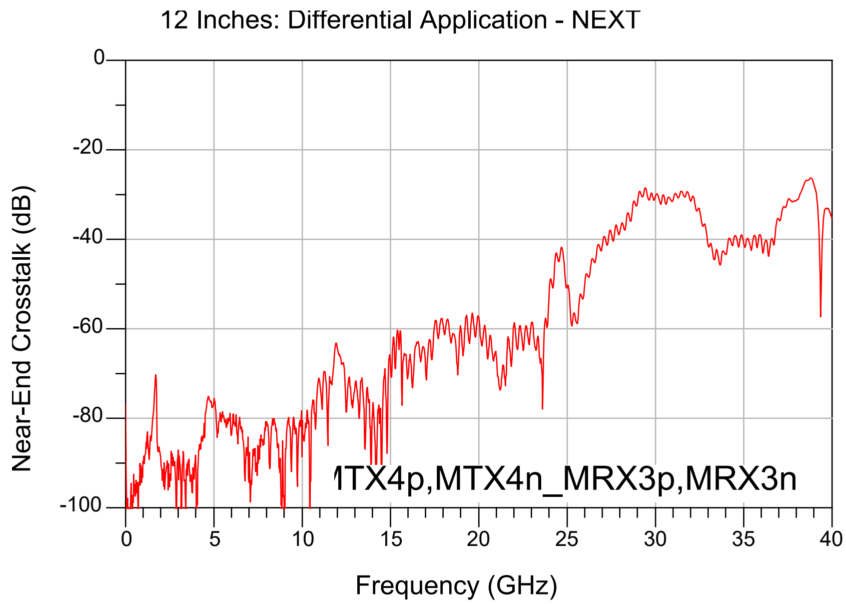


Figure 14

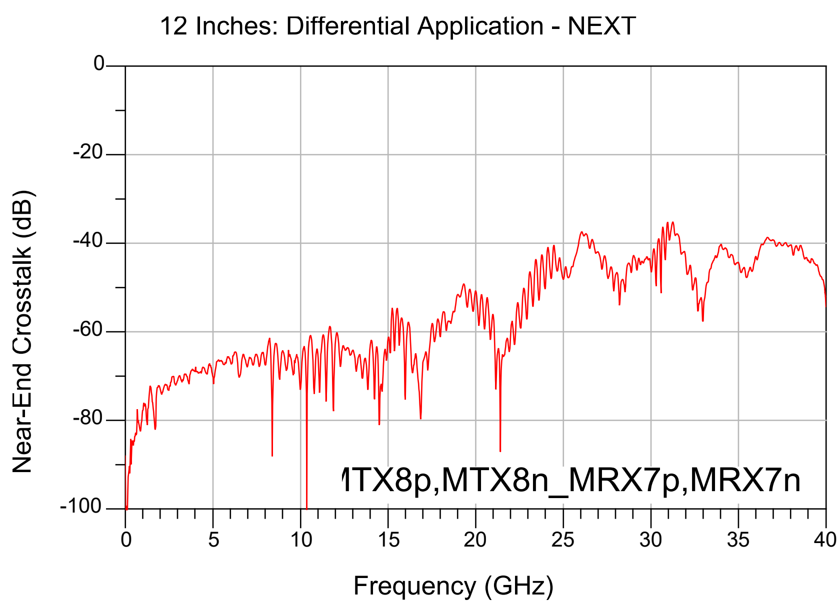


Figure 15

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

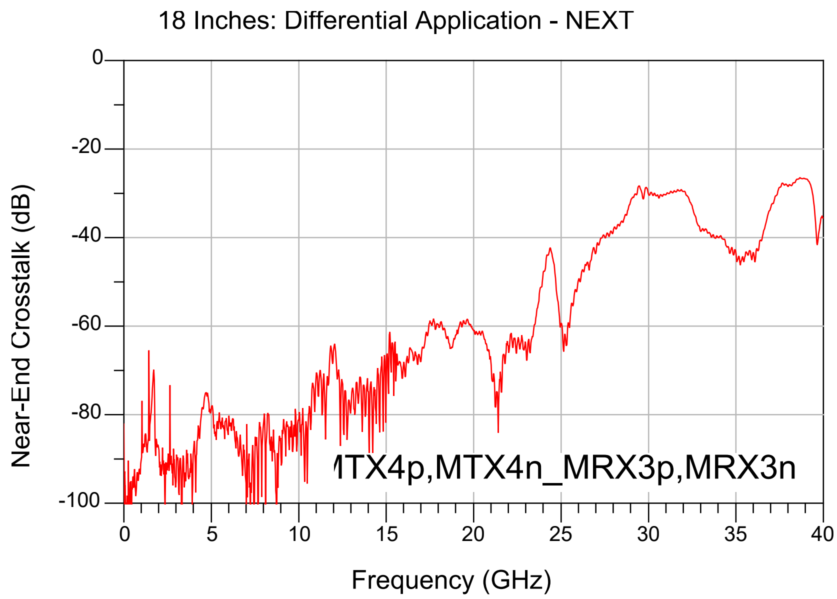


Figure 16

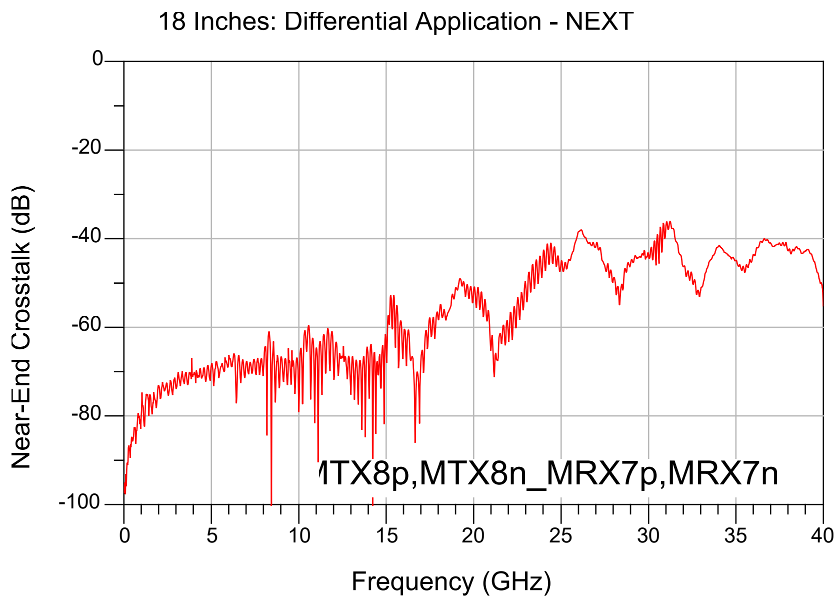


Figure 17

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Differential Application – FEXT Configurations

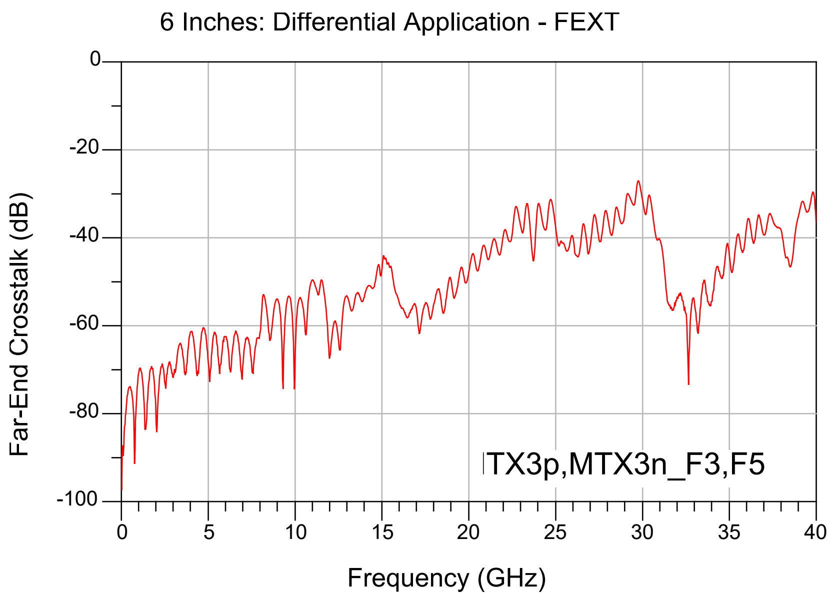


Figure 18

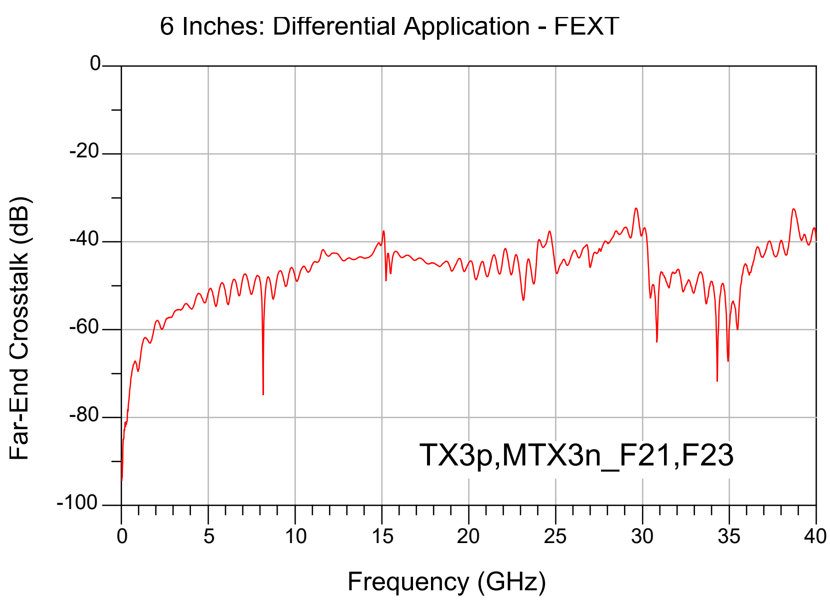


Figure 19

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

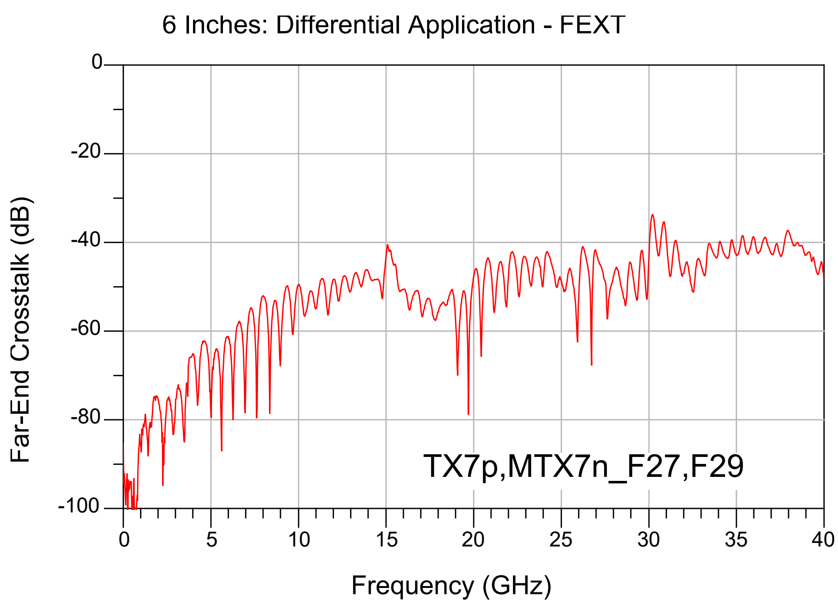


Figure 20

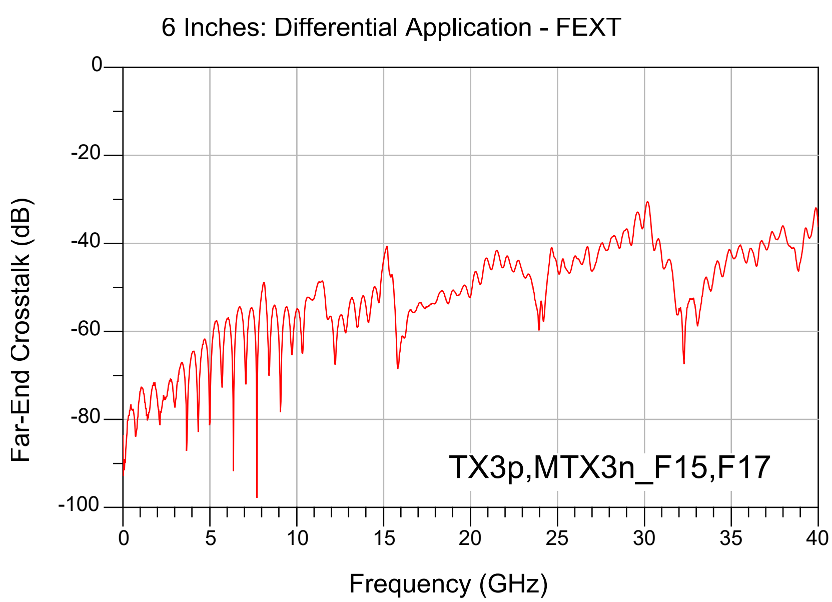


Figure 21

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

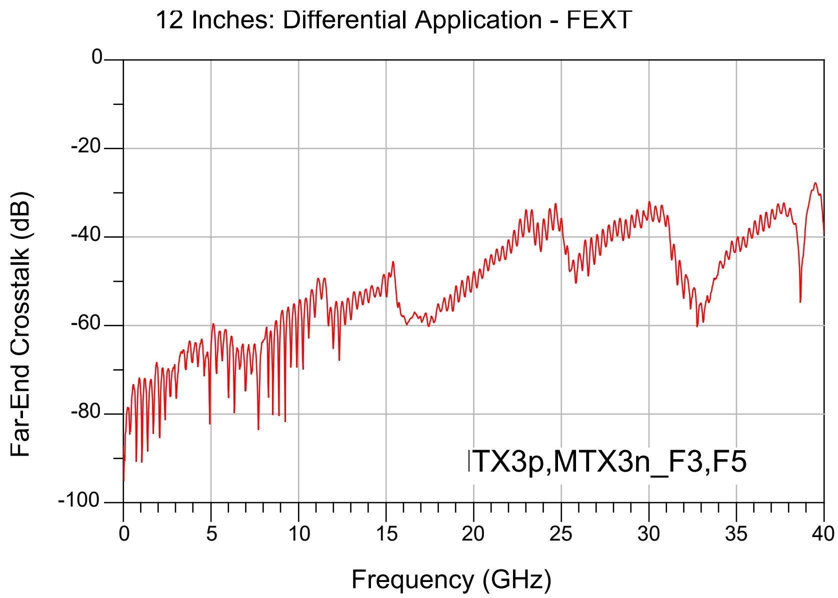


Figure 22

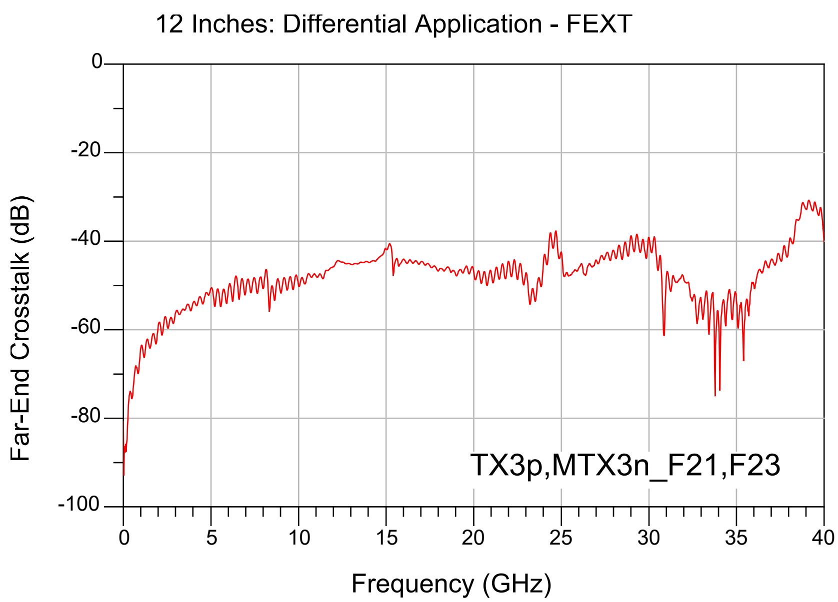


Figure 23

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

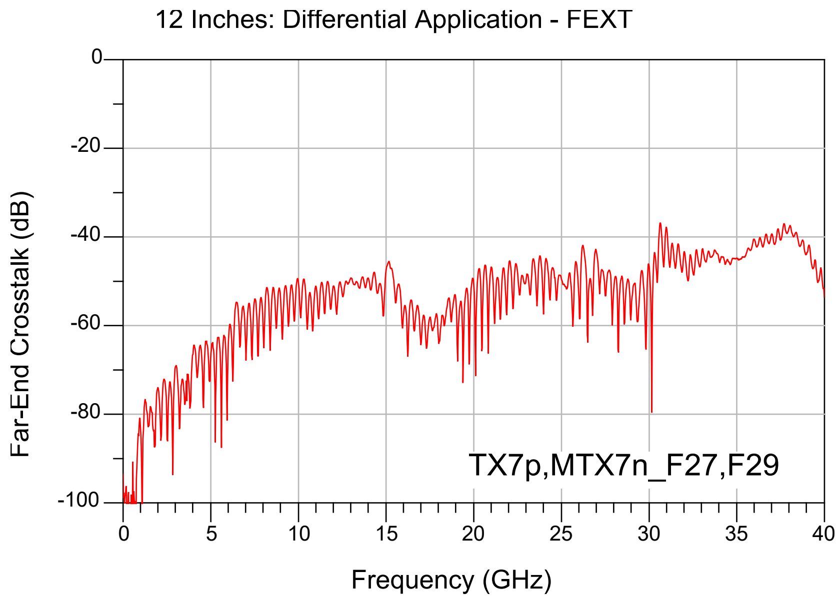


Figure 24

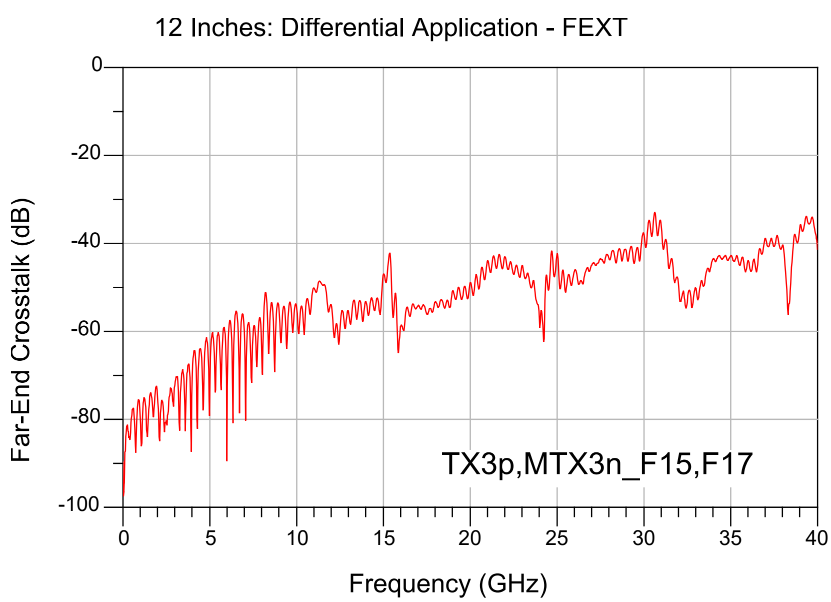


Figure 25

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

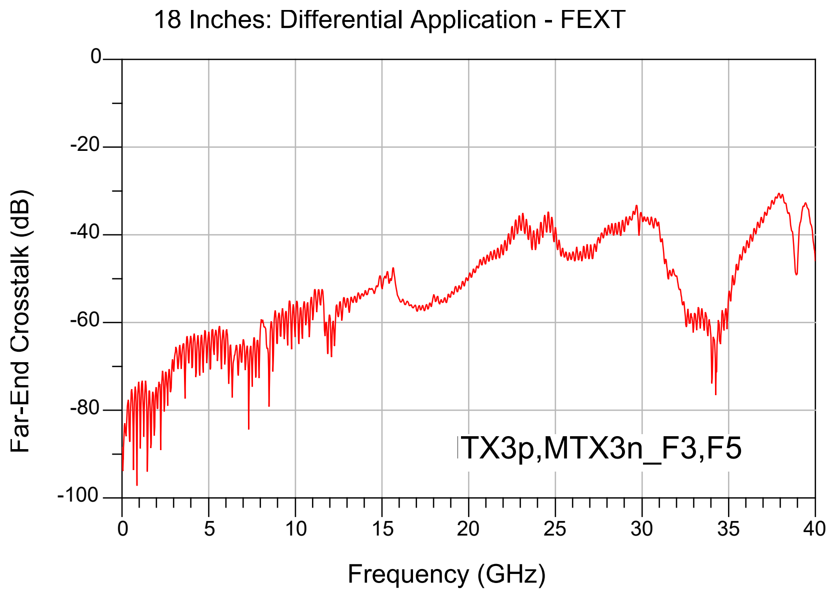


Figure 26

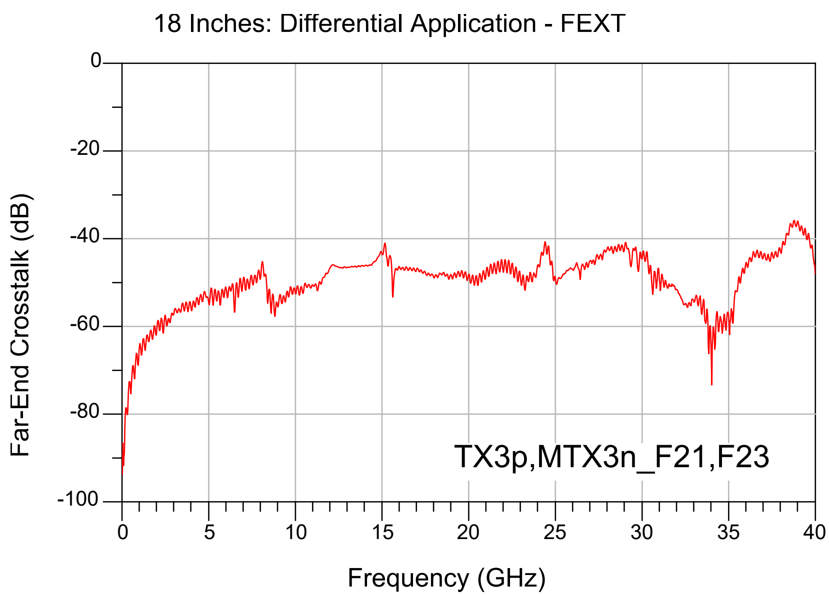


Figure 27

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

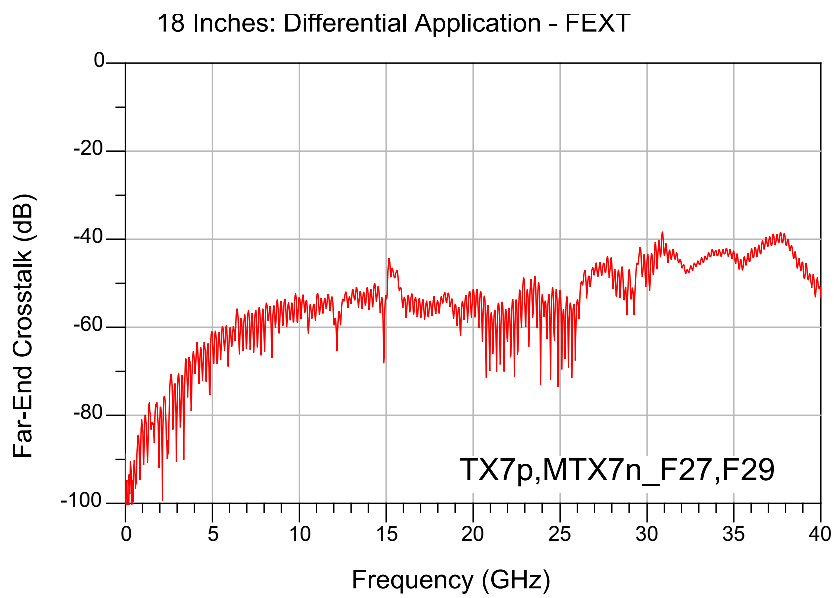


Figure 28

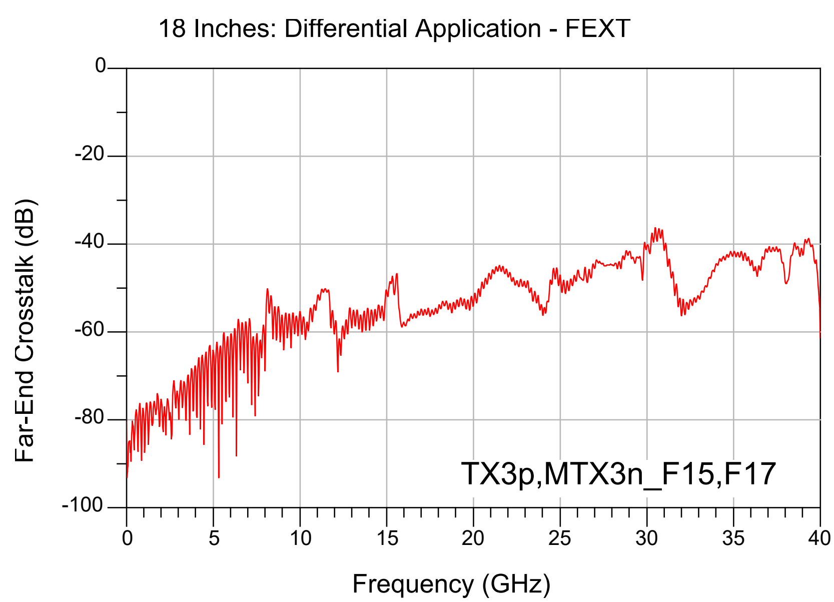


Figure 29

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Differential Application – Differential to Common Mode Conversion

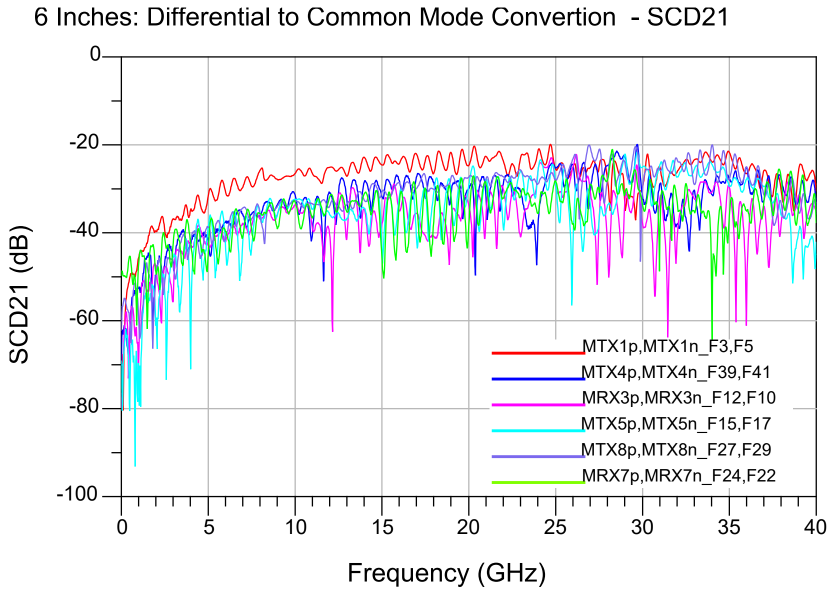


Figure 30

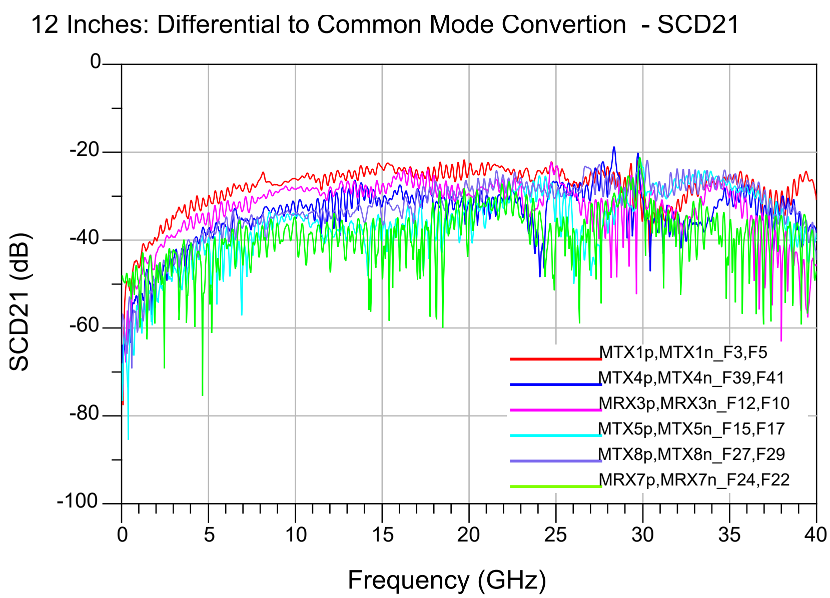


Figure 31

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

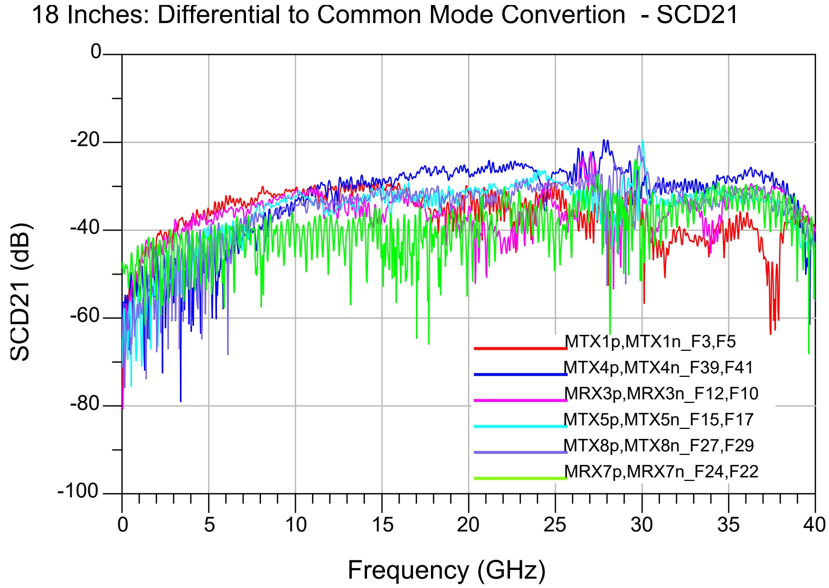


Figure 32

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Appendix B – Time Domain Response Graphs

Differential Application – Input Pulse

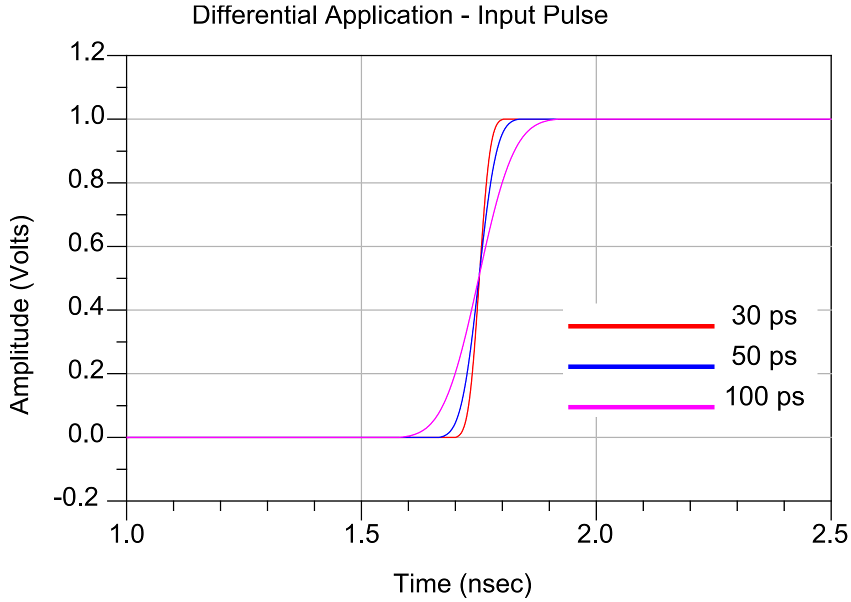


Figure 33

Differential Application – Cable Assembly Impedance

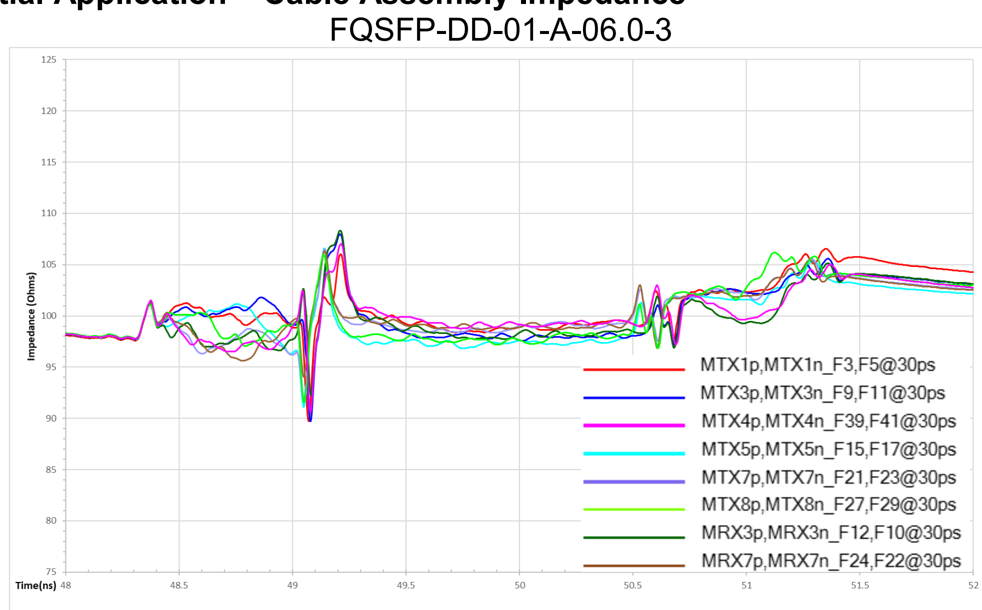


Figure 34

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

FQSFP-DD-01-A-06.0-3

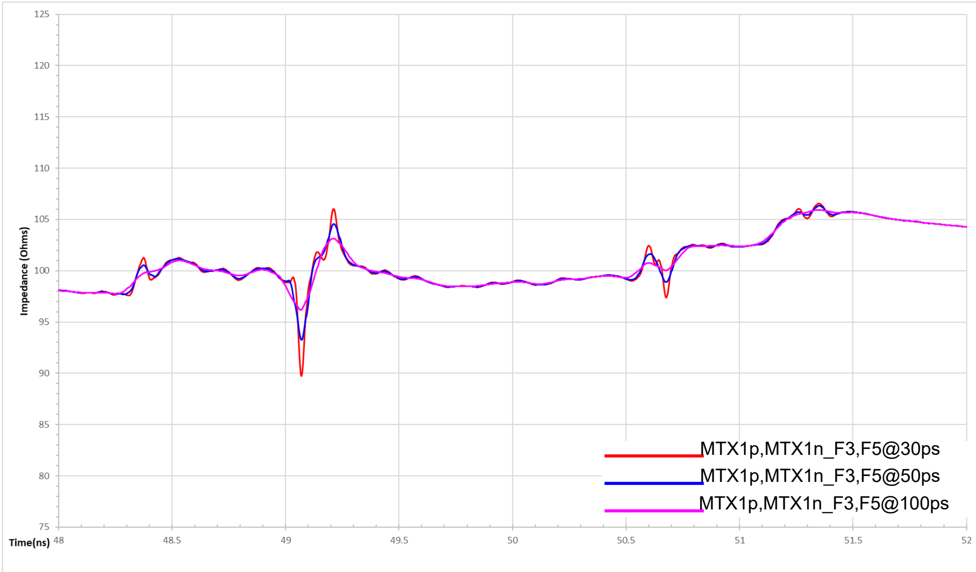


Figure 35

FQSFP-DD-01-A-06.0-3

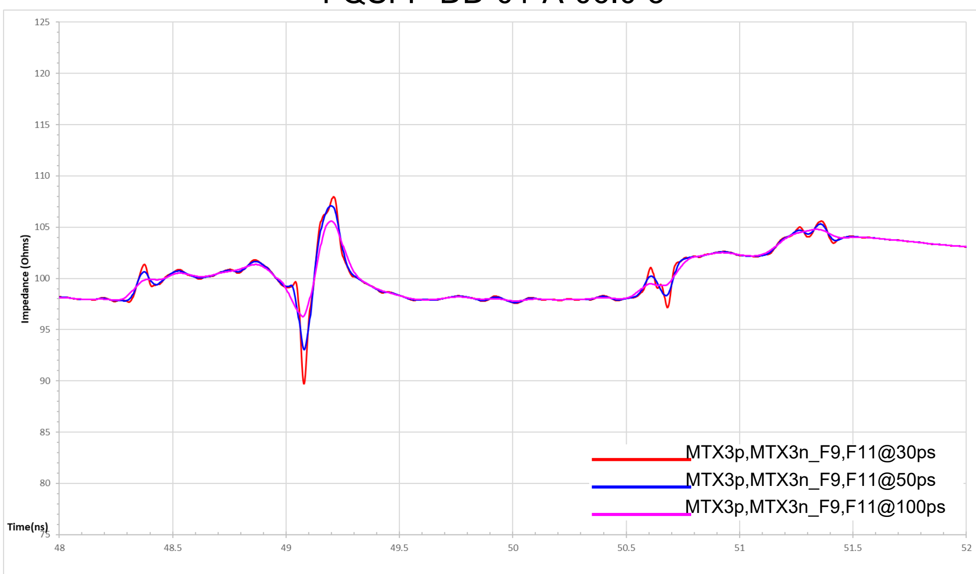


Figure 36

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

FQSFP-DD-01-A-06.0-3

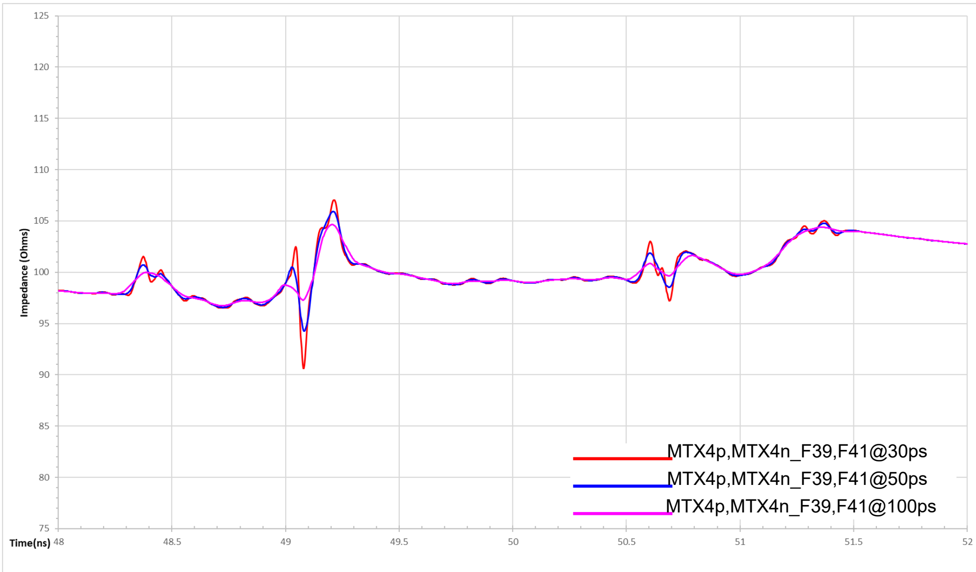


Figure 37

FQSFP-DD-01-A-06.0-3

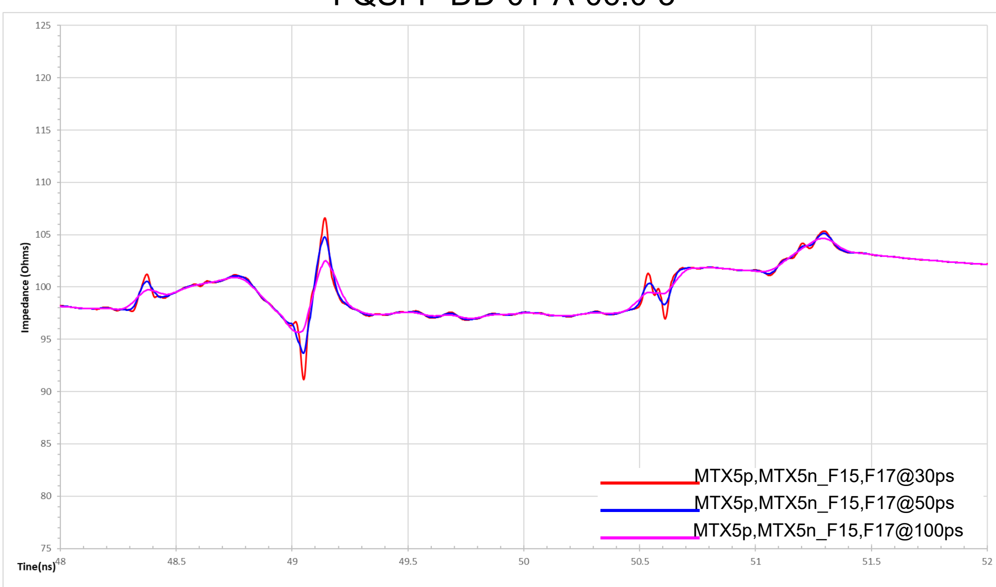


Figure 38

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

FQSFP-DD-01-A-06.0-3

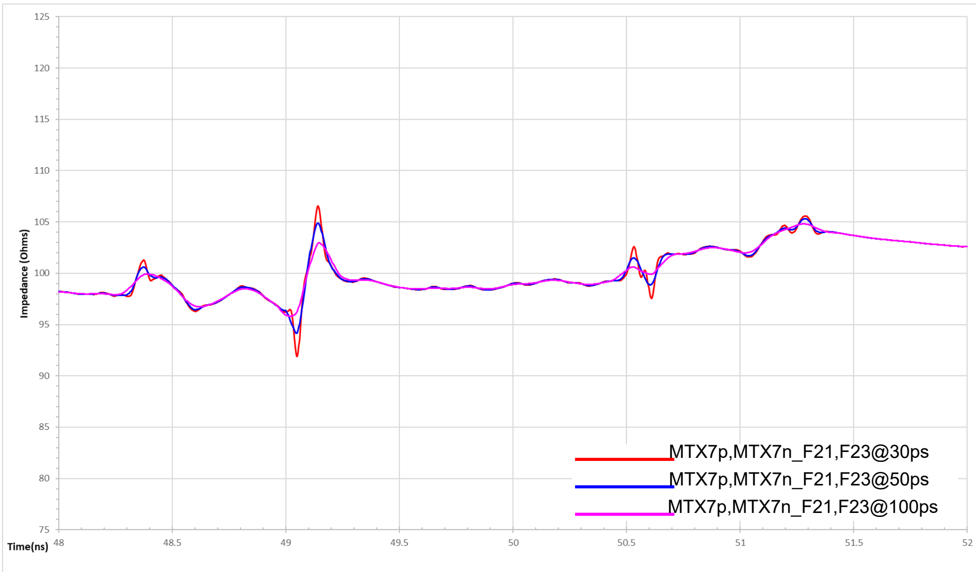


Figure 39

FQSFP-DD-01-A-06.0-3

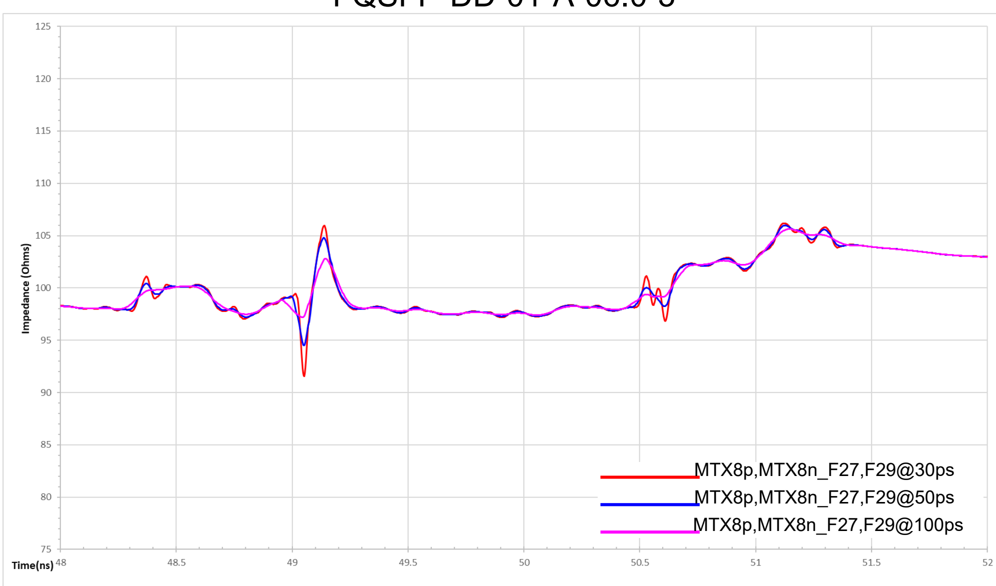


Figure 40

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

FQSFP-DD-01-A-06.0-3

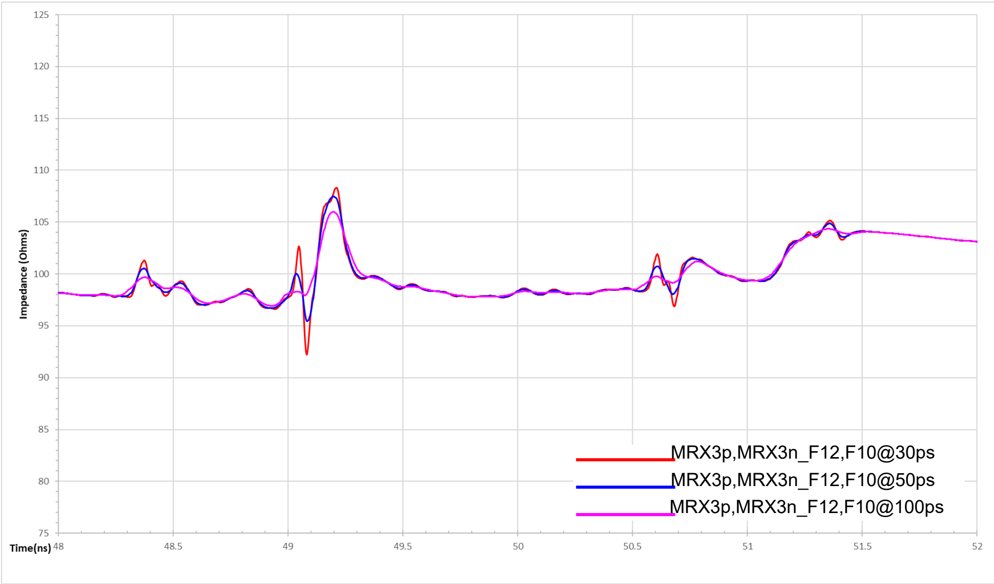


Figure 41

FQSFP-DD-01-A-06.0-3

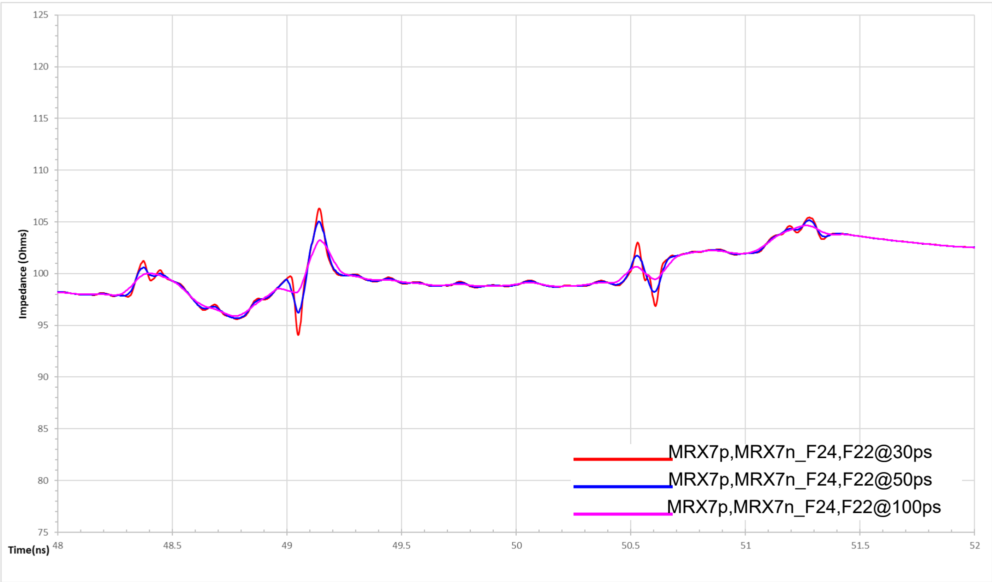


Figure 42

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Differential Application – Propagation Delay

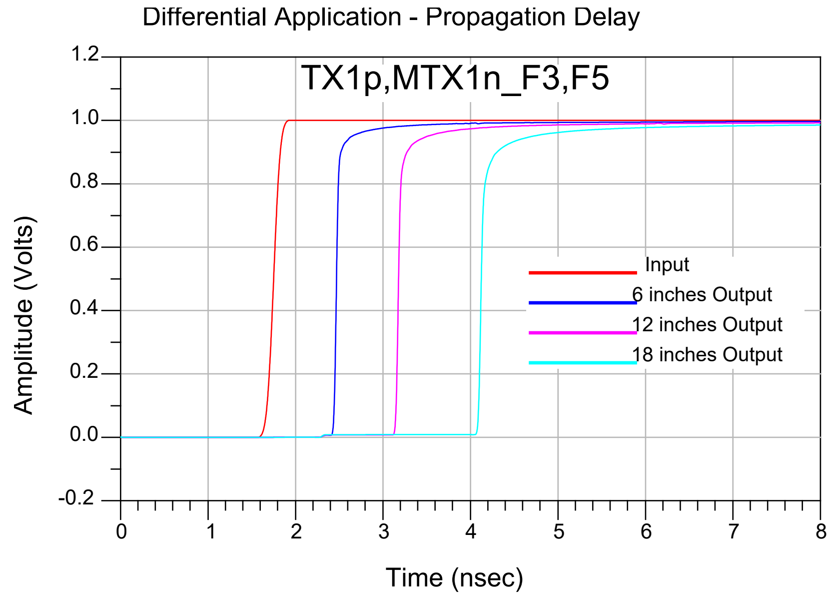


Figure 43

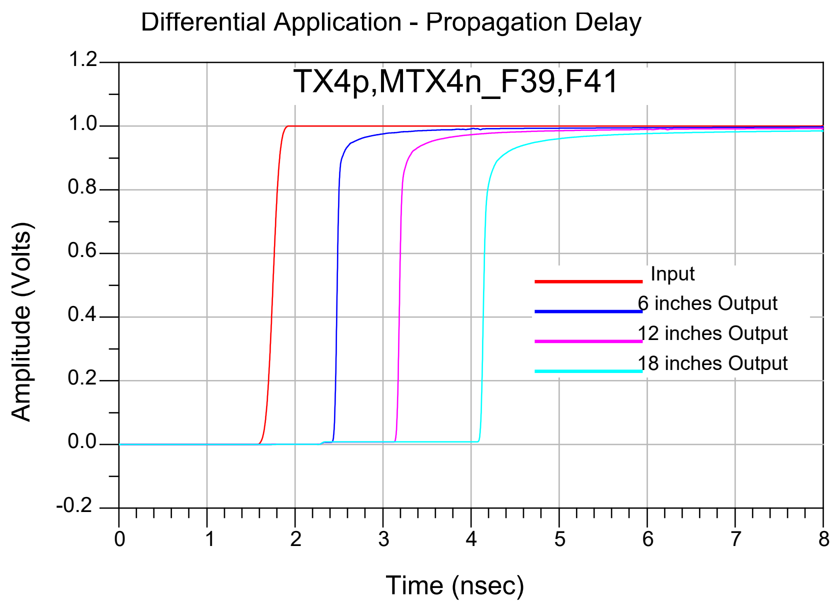


Figure 44

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

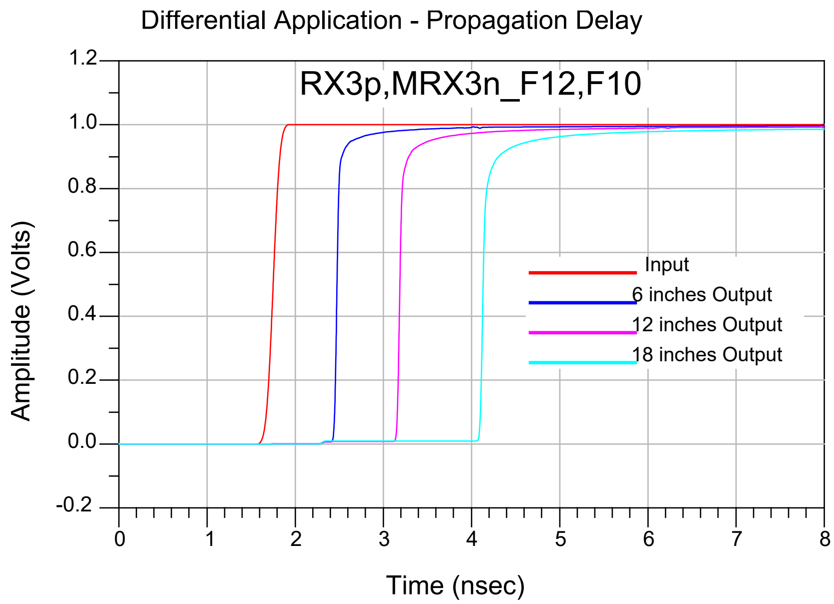


Figure 45

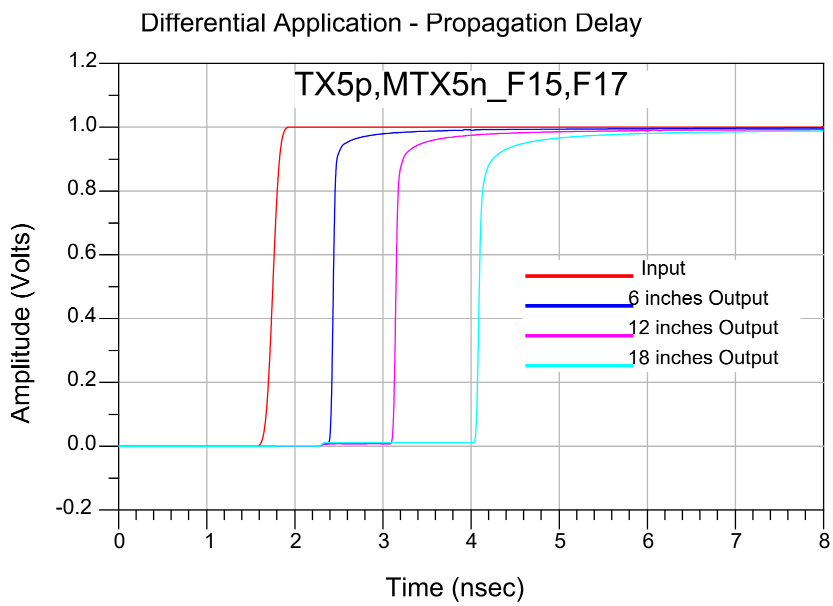


Figure 46

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

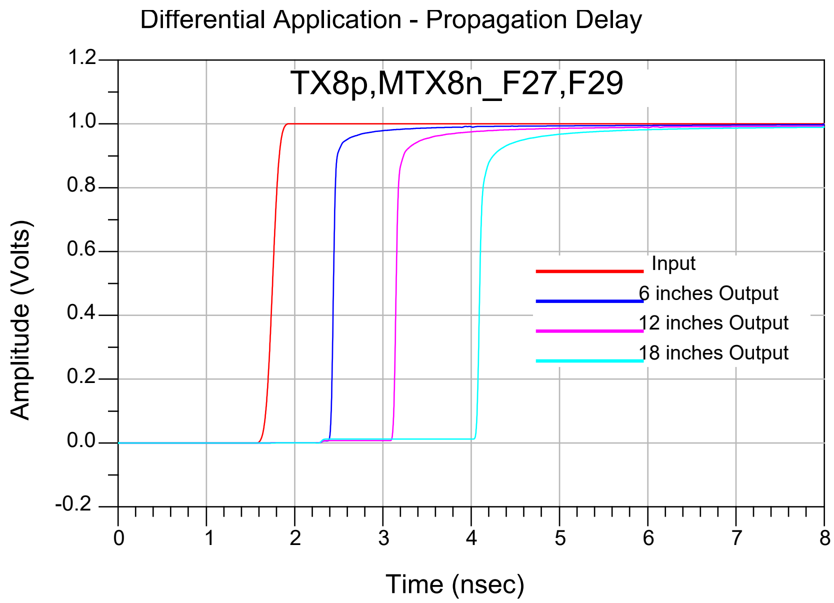


Figure 47

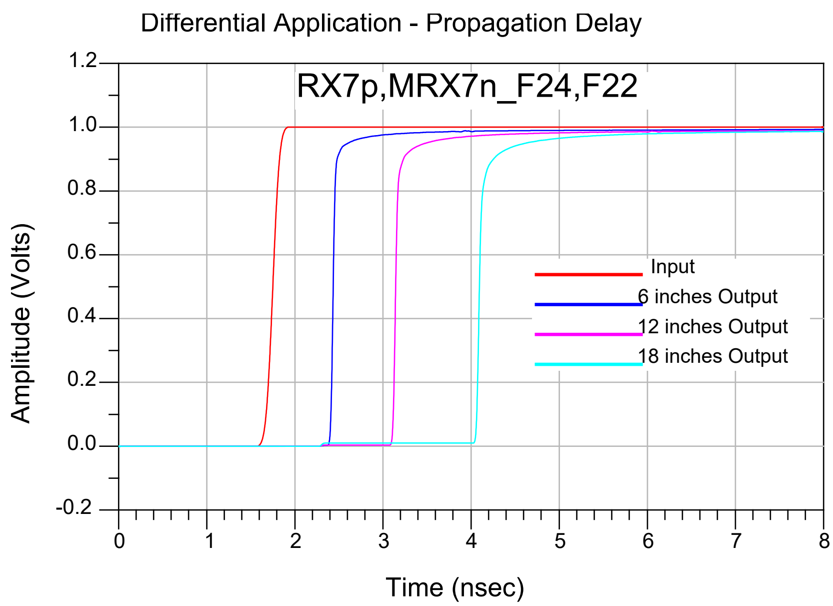


Figure 48

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Appendix C – Product and Test System Descriptions

Product Description

Product test samples are Double Density Flyover FQSFP-DD Cable Assemblies. The part numbers are FQSFP-DD-01-A-06.0-3, FQSFP-DD-01-A-12.0-3 and FQSFP-DD-01-A-18.0-3. They mate with Edge Card and ARF6-16-X-D-A-X-TR. A photo of the mated test article mounted to SI test boards is shown below.

The cable assemblies have a fixed wiring pattern. The wiring pattern is shown in Table 3.

SIGNAL MAPPING FQSFP-DD TO ARC6											
J1	MSA def	J2 ARC6	J1	MSA def	J2 ARC6	J1	MSA def	J2 ARC6	J1	MSA def	J2 ARC6
1	GND1	GND1	20	GND2	GND2	39	GND1	GND1	58	GND2	GND2
2	TX2n	47	21	RX2n	46	40	TX6n	35	59	RX6n	34
3	TX2p	45	22	RX2p	48	41	TX6p	33	60	RX6p	36
4	GND1	GND1	23	GND2	GND2	42	GND1	GND1	61	GND2	GND2
5	TX4n	41	24	RX4n	40	43	TX8n	29	62	RX8n	28
6	TX4p	39	25	RX4p	42	44	TX8p	27	63	RX8p	30
7	GND1	GND1	26	GND2	GND2	45	GND1	GND1	64	GND2	GND2
8	ModselL	NC	27	ModPrsL	NC	46	Reserved	NC	65	NC	NC
9	ResetL	NC	28	IntL	NC	47	VS1	NC	66	Reserved	NC
10	VccRx	NC	29	VccTx	NC	48	VccRx1	NC	67	VccTx1	NC
11	SCL	NC	30	Vcc1	NC	49	VS2	NC	68	Vcc2	NC
12	SDA	NC	31	InitMode	NC	50	VS3	NC	69	Reserved	NC
13	GND2	GND2	32	GND1	GND1	51	GND2	GND2	70	GND1	GND1
14	RX3p	12	33	TX3p	9	52	RX7p	24	71	TX7p	21
15	RX3n	10	34	TX3n	11	53	RX7n	22	72	TX7n	23
16	GND2	GND2	35	GND1	GND1	54	GND2	GND2	73	GND1	GND1
17	RX1p	6	36	TX1p	3	55	RX5p	18	74	TX5p	15
18	RX1n	4	37	TX1n	5	56	RX5n	16	75	TX5n	17
19	GND2	GND2	38	GND1	GND1	57	GND2	GND2	76	GND1	GND1
WITHIN THIS CABLE ASSEMBLY, POSITIONS LABELED WITH A SPECIFIC GND# ARE COMMON AND TIED TO TWINAX SHIELD											
SAMTEC RECOMMENDS IMPLEMENTING A COMMON GND REFERENCE TYING ALL GND#'s TOGETHER											
ALL NC NETS DO NOT TRANSMIT THROUGH CABLE, THEY WILL ROUTE THROUGH CUSTOMER PCB											

Table 3：Wiring Pattern

Test System Description

The test fixtures are composed of six-layer Itera 2X1035 for PCB-108922-SIG and MT40 material for PCB-109926-SIG with 100Ω differential signal trace and pad configurations designed for the electrical characterization of Samtec high speed cable assembly 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 Edge Card and ARx6 series connector set and identified by part number PCB-108922-SIG and PCB-109926-SIG.

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

PCB-108922-SIG and PCB-109926-SIG Test Fixtures

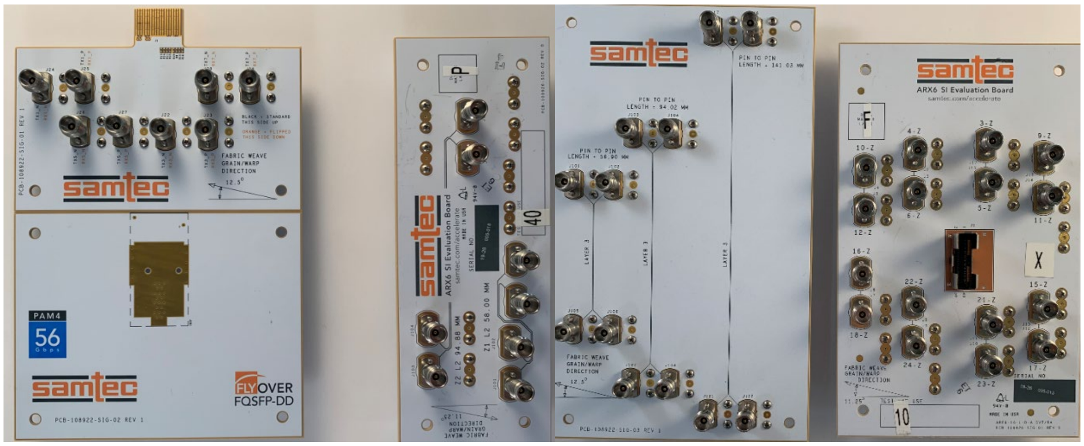


Figure 49

Artwork of the PCB design is shown below.

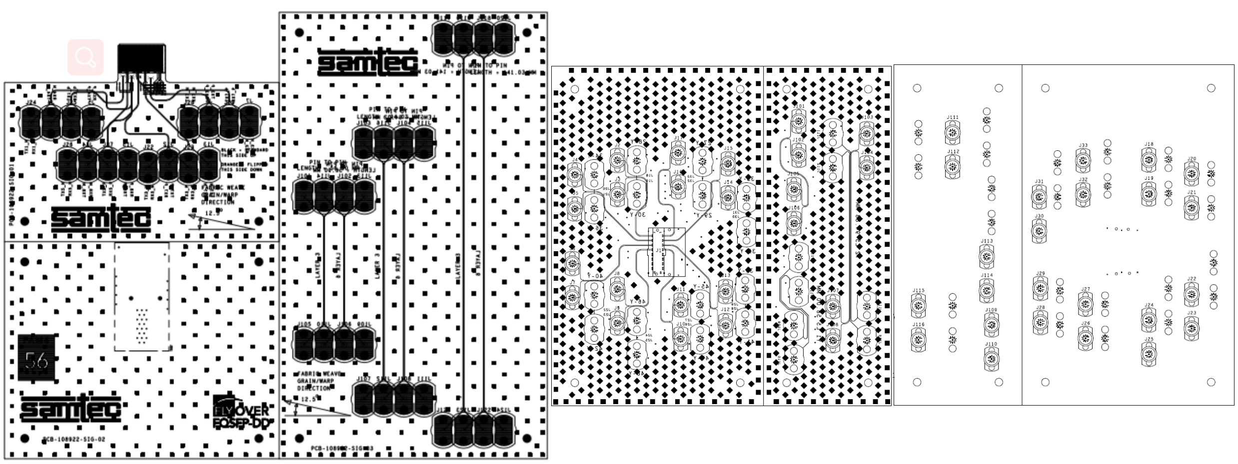


Figure 50

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

PCB Fixtures

The test fixtures used are as follows:

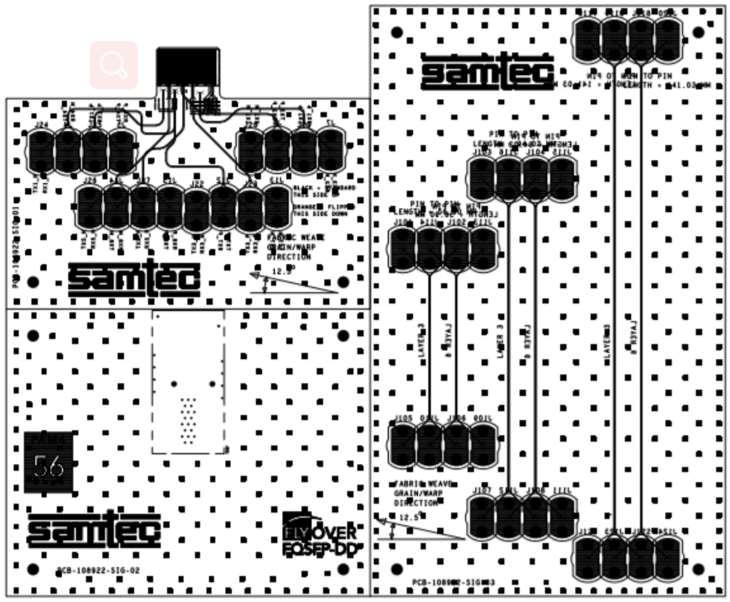


Figure 51

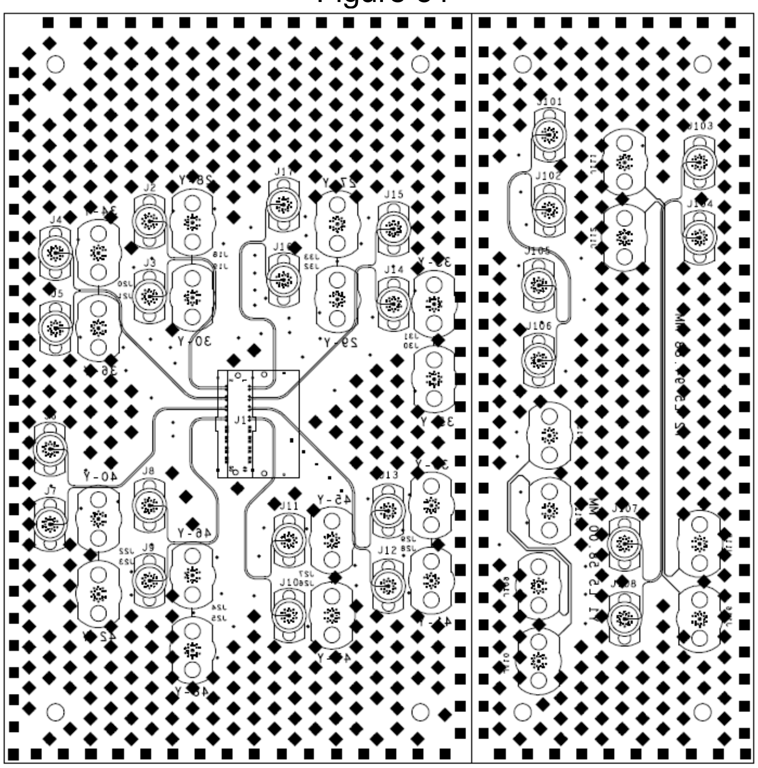


Figure 52

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

Appendix D – Test and Measurement Setup

For frequency domain measurements, the test instrument is the Keysight N5225B 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

N5225B Measurement Setup

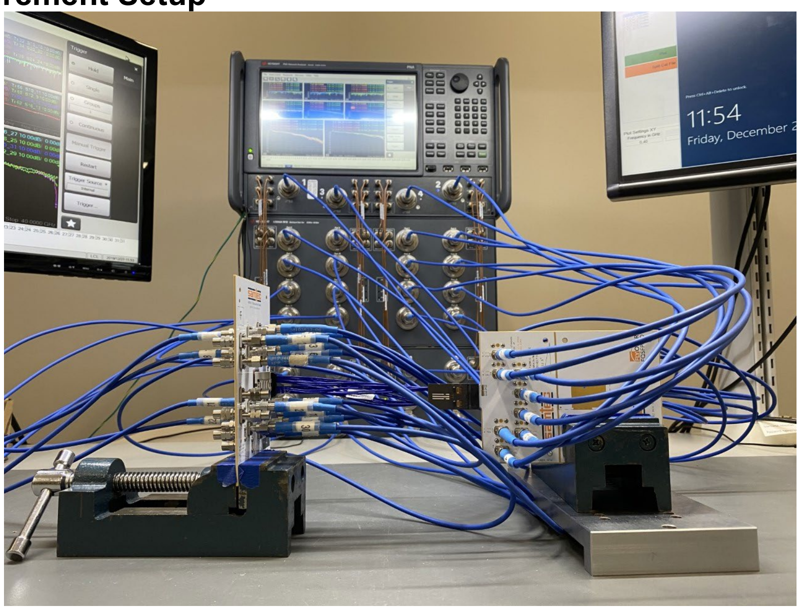


Figure 53

Test Instruments

QTY	Description
1	Keysight N5225B PNA-L Network Analyzer (10 MHz to 40 GHz)
1	Keysight N4694-60003 ECAL Module (10 MHz to 40 GHz)

Test Cables & Adapters

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

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

For impedance measurements, the test instrument is the Tektronix DSA8300 Digital Serial Analyzer 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

DSA8300 Measurement Setup

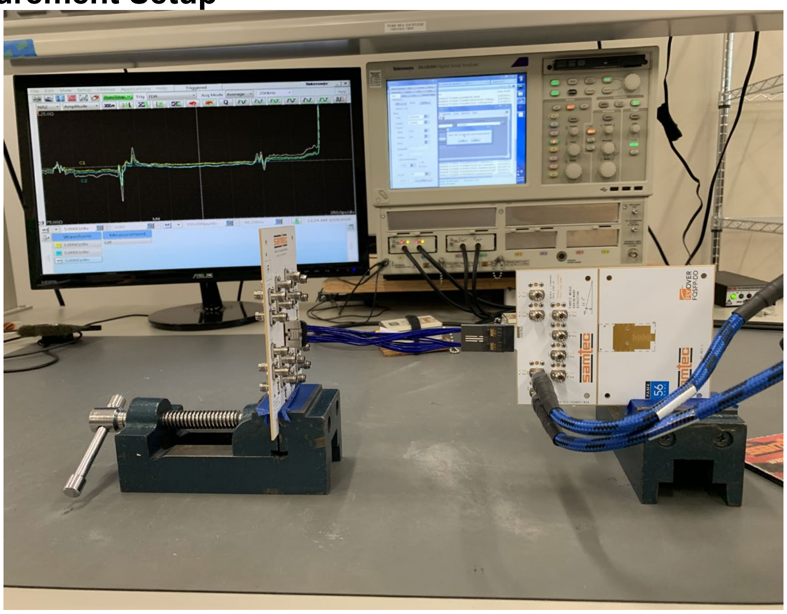


Figure 54

Test Instruments

QTY	Description
1	Tektronix DSA8300 Digital Serial Analyzer Mainframe

Test Cables & Adapters

QTY	Description
4	Junkosha J12J103834-00

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

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

The Time Domain data in this report were taken with Tektronix DSA8300 Digital Serial Analyzer Mainframe.

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.

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 is limited.

Series: FQSFP-DD
Description: Double Density Flyover® QSFP28 Cable System, ARC6-16 End Option

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