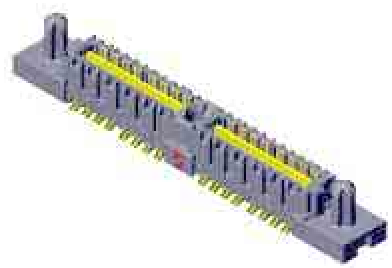
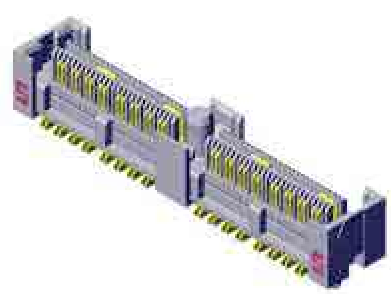
High Speed Characterization Report

QMS-032-11-L-D-DP-A



Mated With

QFS-032-01-D-DP-A



Description:
Micro High Speed Board-to-Board,
.635mm Pitch, 11mm (0.433”) Stack Height

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Report Revision: 11/9/2005

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Table of Contents

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Connector Overview

Micro High Speed .635mm (.025") pitch interfaces (QFS-DP/QMS-DP Series) are available with up to 64 contacts per row and a board-to-board spacing of 11mm (0.433"). The data in this report is applicable only to the 11mm (0.433") board-to-board DP connector version stack height

Connector System Speed Rating

QFS-DP/QMS-DP Series, Parallel Board-to-Board, 0.635mm Pitch, 11mm (0.433") Stack Height

Signaling	Speed Rating
Differential:	**7.0 GHz / 14 Gbps**

The Speed Rating is based on the -3 dB insertion loss point of the connector system. The -3 dB point can be used to estimate usable system bandwidth in a typical, two-level signaling environment.

To calculate the Speed Rating, the measured -3 dB point is rounded up to the nearest half-GHz level. The up-rounding corrects for a portion of the test board's trace loss, since trace losses are included in the loss data in this report. The resulting loss value is then doubled to determine the approximate maximum data rate in Gigabits per second (Gbps).

For example, a connector with a -3 dB point of 7.8 GHz would have a Speed Rating of 8 GHz/ 16 Gbps. A connector with a -3 dB point of 7.2 GHz would have a Speed Rating of 7.5 GHz/ 15 Gbps.

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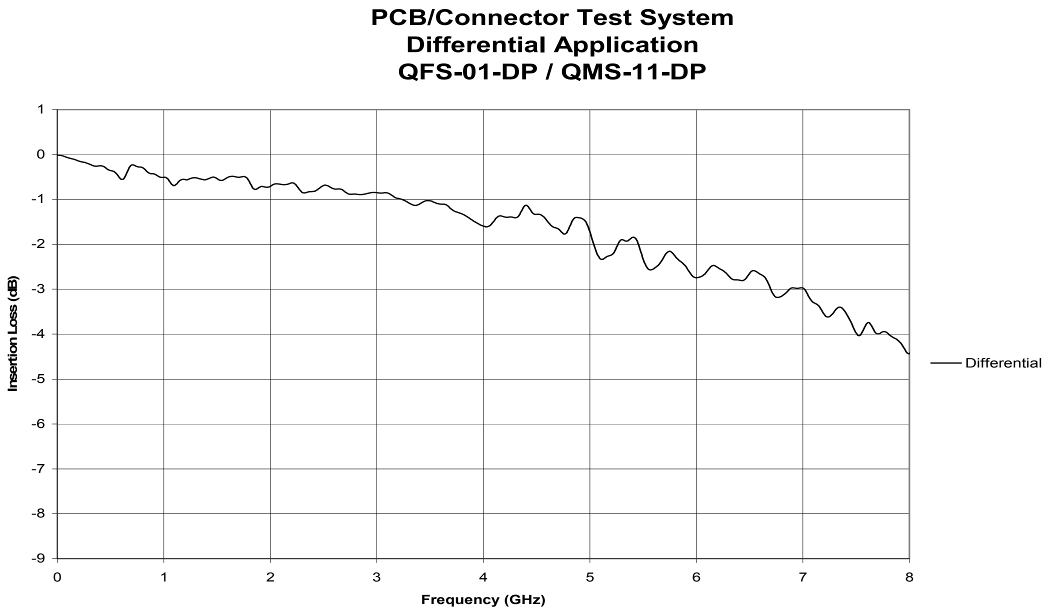
Frequency Domain Data Summary

Table 1 - Differential Connector System Bandwidth		
Test Parameter	**Configuration**	
Insertion Loss	SS	**-3dB @ 6.70 GHz**
Return Loss	SS	< -5dB to 6.70 GHz
Near-End Crosstalk	AA QQ	< -22dB to 6.70 GHz
	Xrow, AA to QQ	< -30dB to 6.70 GHz
Far-End Crosstalk	AA QQ	< -25dB to 6.70 GHz
	Xrow, GAAG to GQQG	< -28dB to 6.70 GHz



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Time Domain Data Summary

Table 2 - Differential Impedance (Ω)							
Signal Risetime	**30±5ps**	**50 ps**	**100 ps**	**250 ps**	**500 ps**	**750 ps**	**1 ns**
Maximum Impedance	101.9	101.3	101.2	101.2	101.1	101.0	100.9
Minimum Impedance	60.9	69.7	78.6	85.0	89.3	92.0	93.9

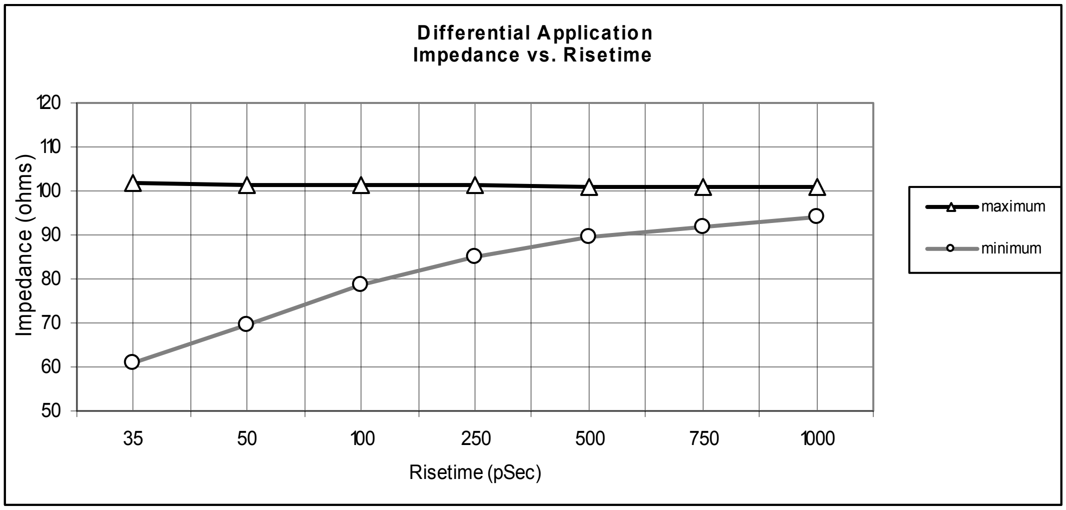

Table 3 - Differential Crosstalk (%)								
Input (t_r)		**30±5ps**	**50 ps**	**100 ps**	**250 ps**	**500 ps**	**750 ps**	**1 ns**
NEXT	AA QQ	1.9	1.8	1.6	< 1.0%	< 1.0%	< 1.0%	< 1.0%
	$Xrow^{diff}$	< 1.0%	< 1.0%	< 1.0%	< 1.0%	< 1.0%	< 1.0%	< 1.0%
FEXT	AA QQ	1.6	< 1.0%	< 1.0%	< 1.0%	< 1.0%	< 1.0%	< 1.0%
	$Xrow^{diff}$	< 1.0%	< 1.0%	< 1.0%	< 1.0%	< 1.0%	< 1.0%	< 1.0%

Table 4 - Propagation Delay (Mated Connector)	
Differential	90ps

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Characterization Details

This report presents data which 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 test PCB from drive side probe tips to receive side probe tips. PCB effects are not removed or de-embedded from the test data. PCB designs with impedance mismatch, large losses, skew, cross talk, or similar impairments can have a significant impact on observed test data. Therefore, great design effort is put forth to limit these effects in the PCB utilized in these tests. Some board related effects, such as pad-to-ground capacitance and trace loss, are included in the data presented in this report. But other effects, such as via coupling or stub resonance, are not evaluated here. Such effects are addressed and characterized fully by the Samtec Final Inch® products.

Additionally, intermediate test signal connections can mask the connectors' true performance. Such connection effects are minimized by using high performance test cables, adapters, and microwave probes. Where appropriate, calibration and de-embedding routines are also used to reduce residual effects.

Differential 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 a differentially driven only scenario where every third pin of the standard Samtec connector is removed.

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. So care must be taken when choosing signal/ground ratios in cost- or density-sensitive applications.

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For this connector, the following configurations were evaluated:

Differential Impedance:
- GSSG (Ground-positive signal-negative signal-ground)

Differential Crosstalk:
- Electrical “worst case”: S . AA . QQ . S - static terminals -active-active-quiet-quiet- static terminals)
- Across row:Xrow^{diff} (from one row of terminals to the other row across the ground blade, same spacing within the row)

In all cases in this report, the center ground blade of the connector was grounded to the PCB. Only one differential pair was driven for crosstalk measurements.

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.

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Signal Edge Speed (Rise Time):
In pulse signaling applications, the perceived performance of an 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 +/-5 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 1.0 ns.

For this report, rise times were measured at 10%-90% signal levels.

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 from time domain measurements using Fourier Transform calculations. Procedures and methods used in generating the SUT's frequency domain data are provided in the frequency domain test procedures in Appendix E of this report.

Time Domain Data
Time Domain parameters indicate impedance mismatch versus length, signal propagation time, and crosstalk in a pulsed signal environment. Time Domain data 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.

Reference plane impedance is 100 ohms for differential measurements. The fastest risetime signal exciting the SUT is 30 ± 5 picoseconds.

In this report, propagation delay is defined as the signal propagation time through the PCB connector pads and connector pair. It does not include PCB traces. Delay is measured at 30 ± 5 picoseconds signal risetime. Delay is calculated as the difference in time measured between the 50% amplitude levels of the input and output pulses.

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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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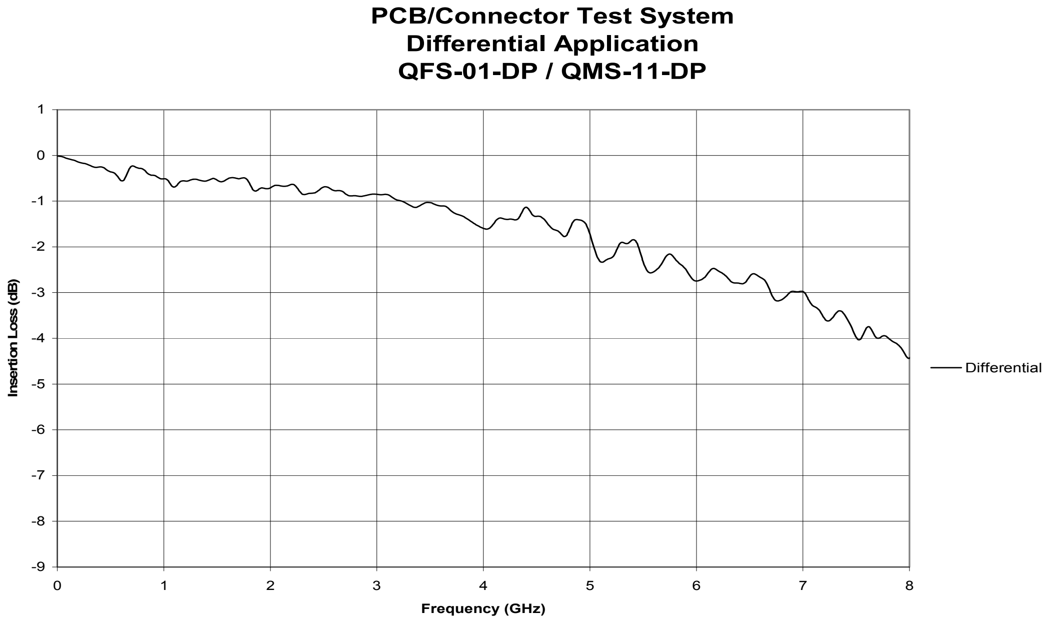
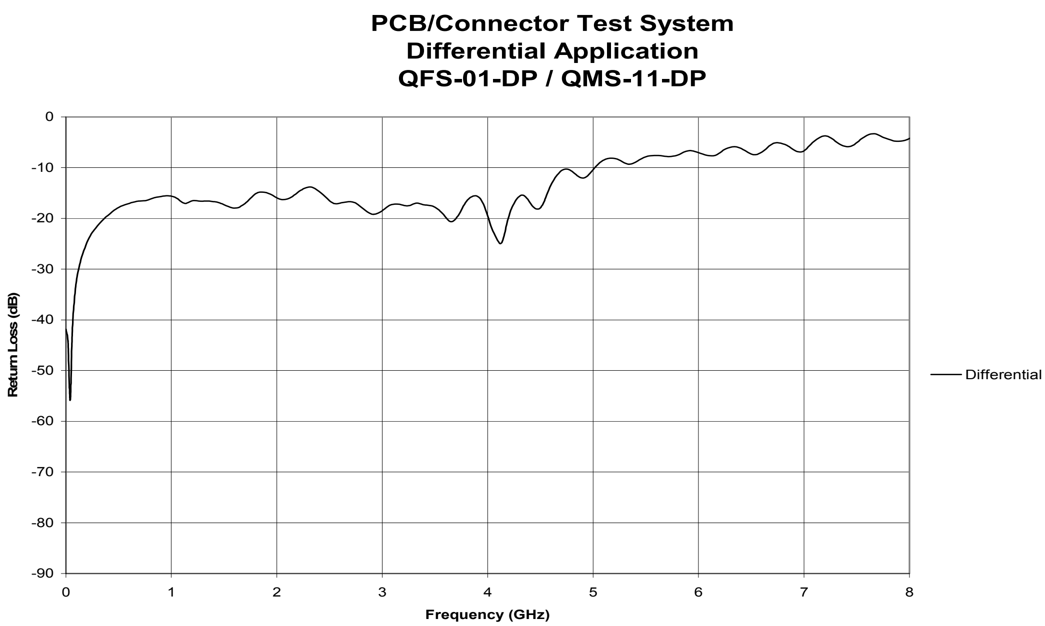
Appendix A – Frequency Domain Response Graphs

Differential Application – Insertion Loss



Differential Application – Return Loss



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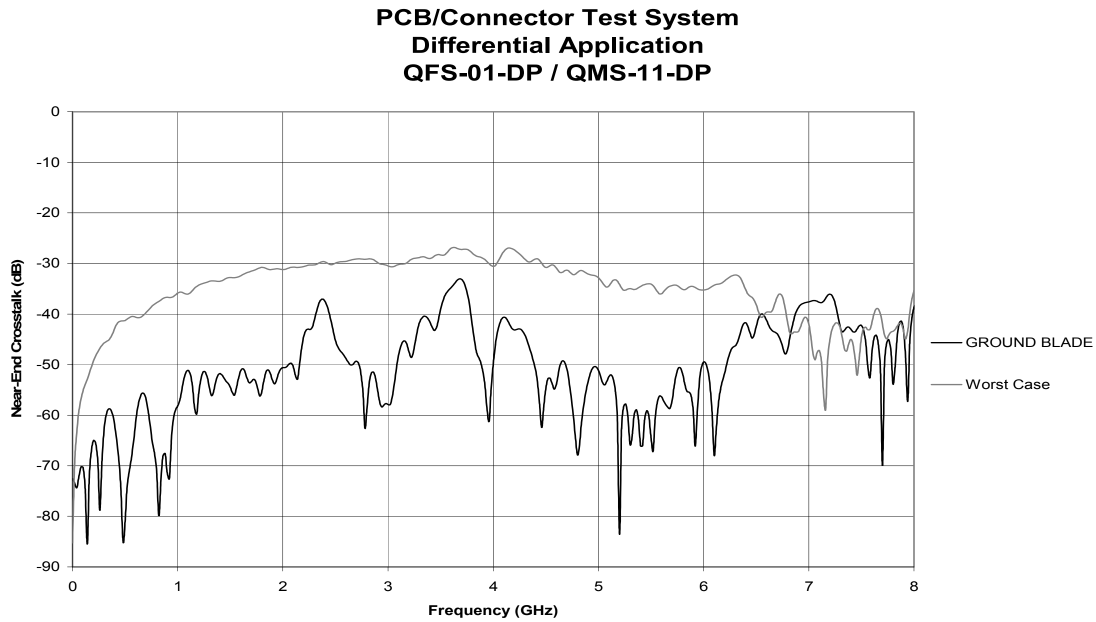
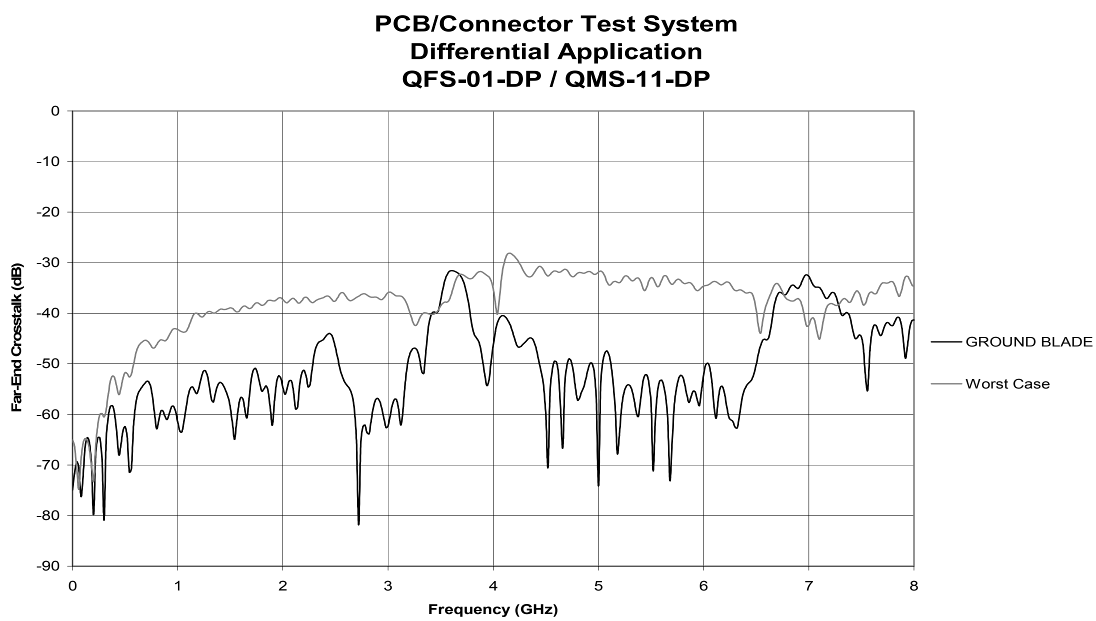
Differential Application – NEXT



Differential Application – FEXT



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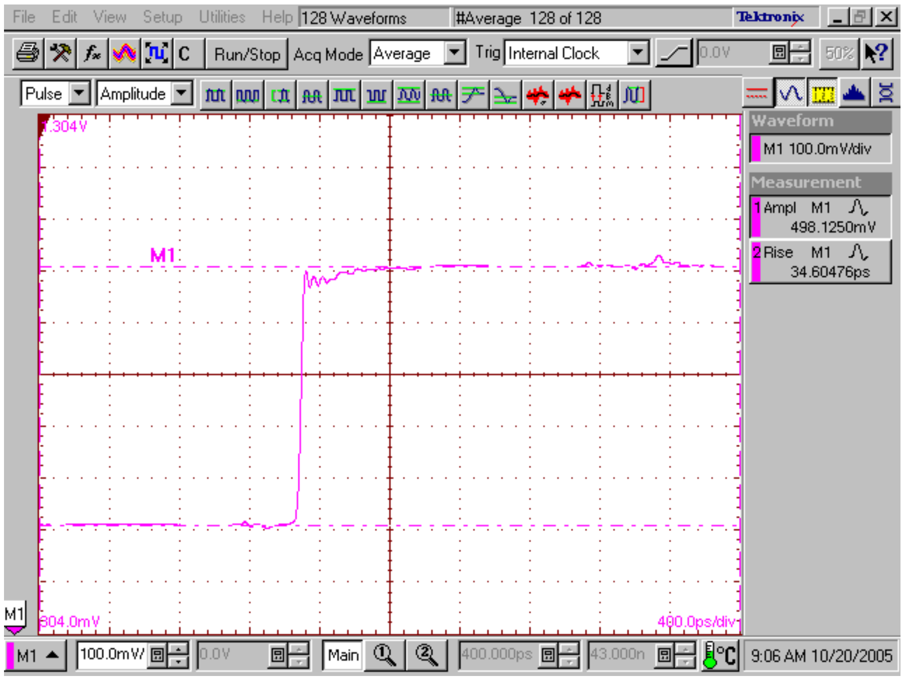
Appendix B – Time Domain Response Graphs

Differential Application – Input Pulse



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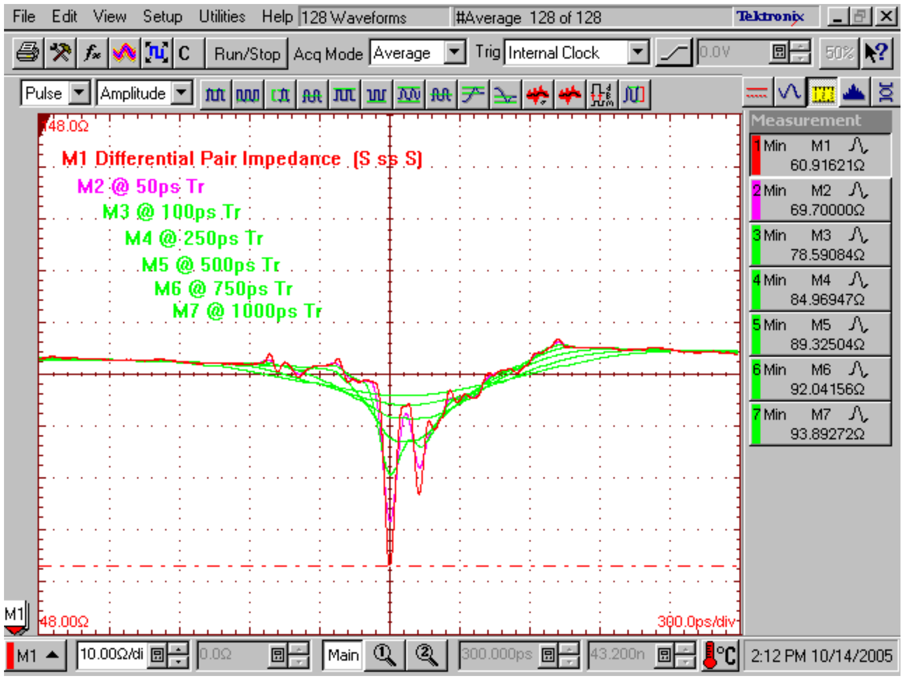
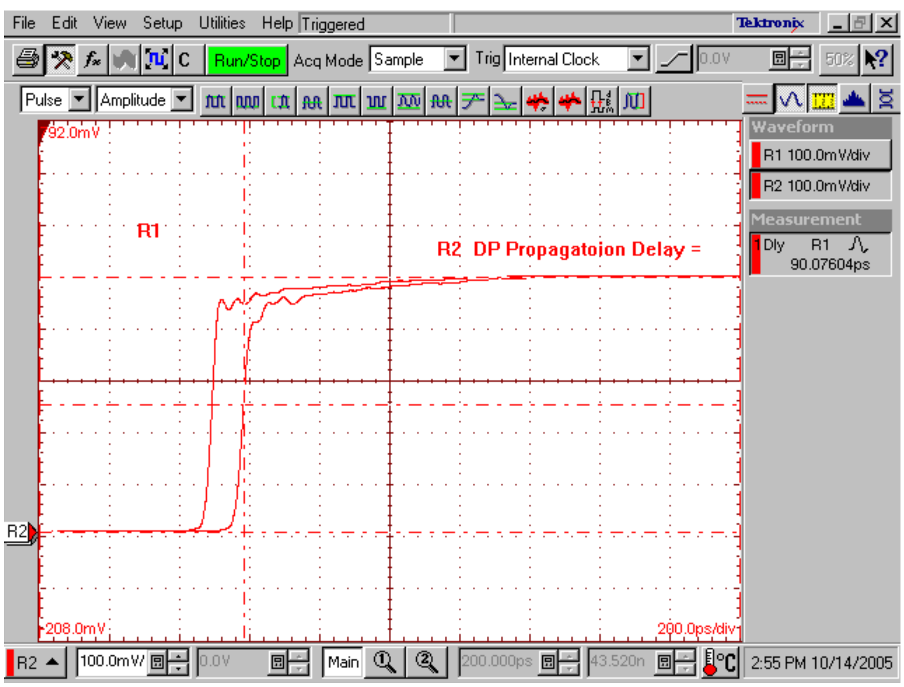
Description: Parallel Board-to-Board, 0.635mm Pitch, 11mm (0.433”) Stack Height

Differential Application – Impedance



Differential Application – Propagation Delay



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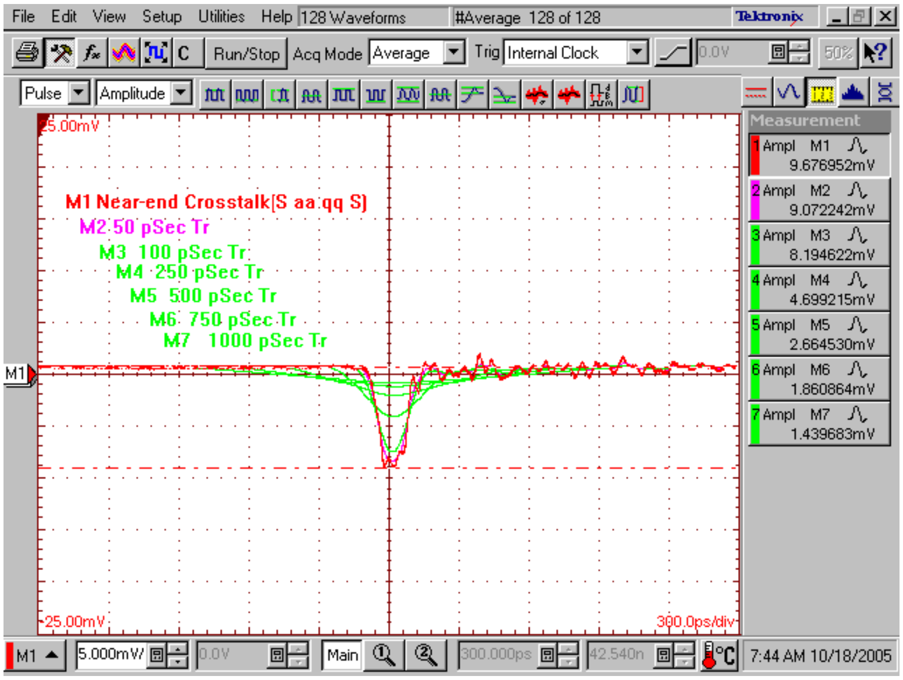
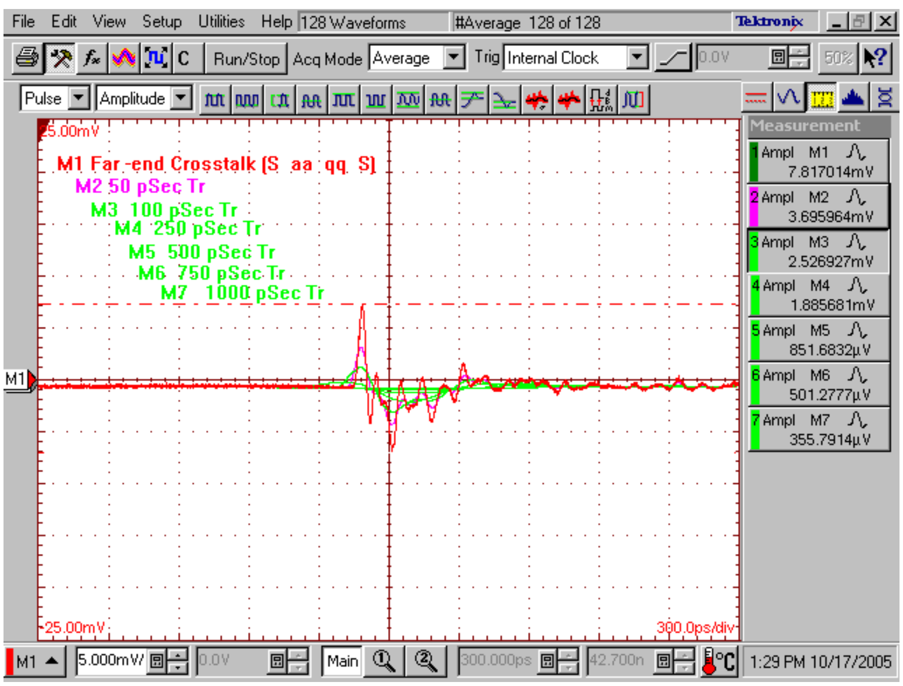
Differential Application – NEXT, "Worst Case In Row" Configuration



Differential Application – FEXT, "Worst Case In Row" Configuration



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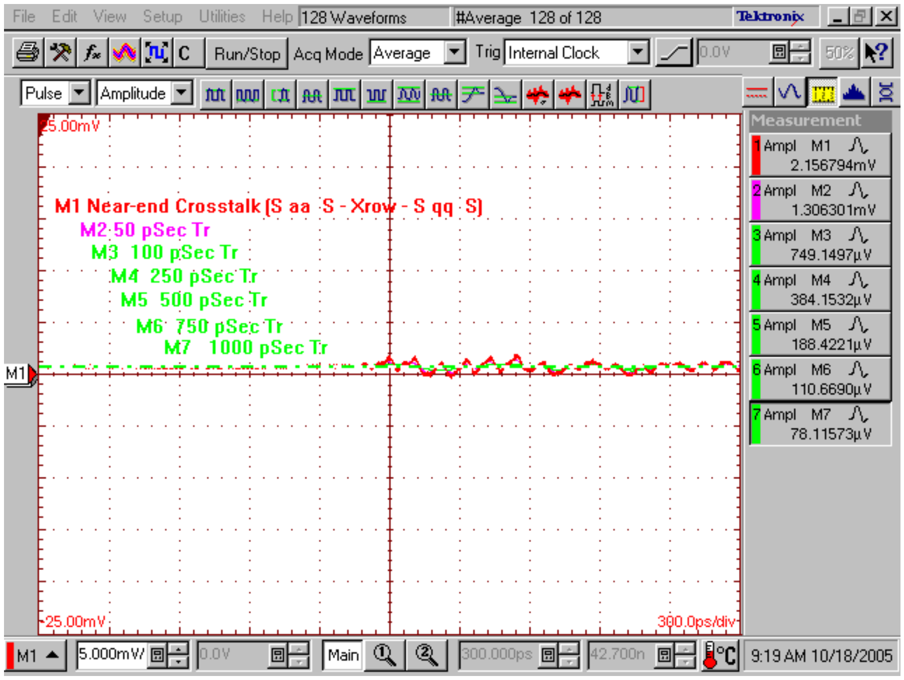
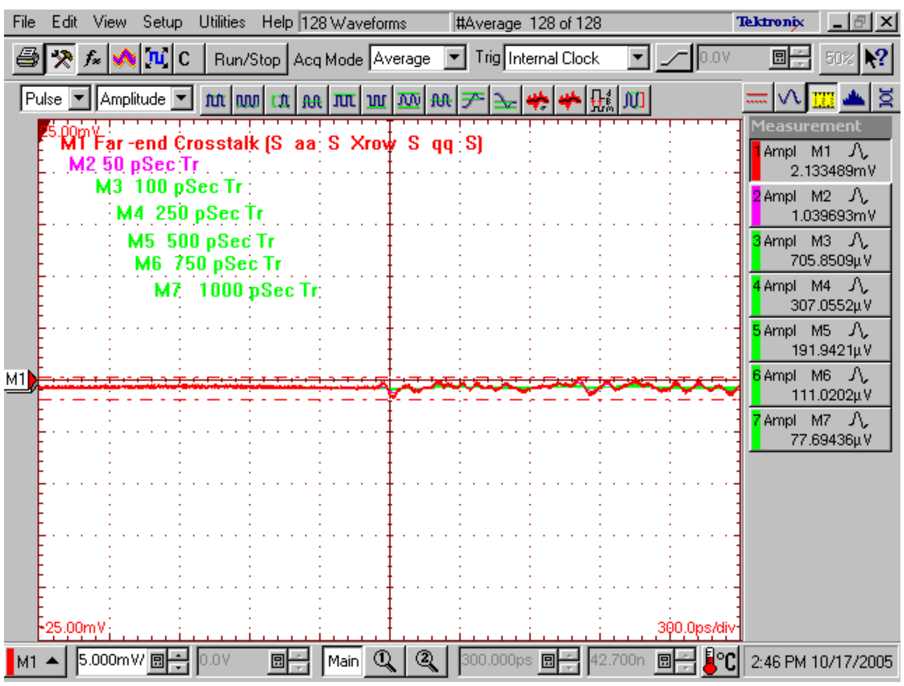
Differential Application – NEXT, Across Power/Ground Blade



Differential Application – FEXT, Across Power/Ground Blade



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Appendix C – Product and Test System Descriptions

Product Description

Product samples used in testing were the QFS-032-01-L-D-DP-A and QMS-032-11-L-D-DP-A. When mounted to the respective footprint of the PCB a 11mm (0.4331”) stack height exists between boards

The connector structures consists of 2 rows of 16 copper alloy gold contact pair positions mounted into an insulating plastic housing with a surface mount design. The contacts are evenly spaced at a .635mm (.025”) pitch. A ground/power blade lies lengthwise between terminal rows in the housing.

Test System Description

The test fixtures are composed of a 4-layer FR-4 material with 50Ω and100Ω signal trace and pad configurations designed for the electrical characterization of Samtec Hi-Speed connector products. The pictured fixtures are specific for the QFS-DP/QMS-DP surface mount connector series and are identified by Samtec P/N PCB-100281-TST-01 and P/N PCB-100281-TST-02 (Figure 1)

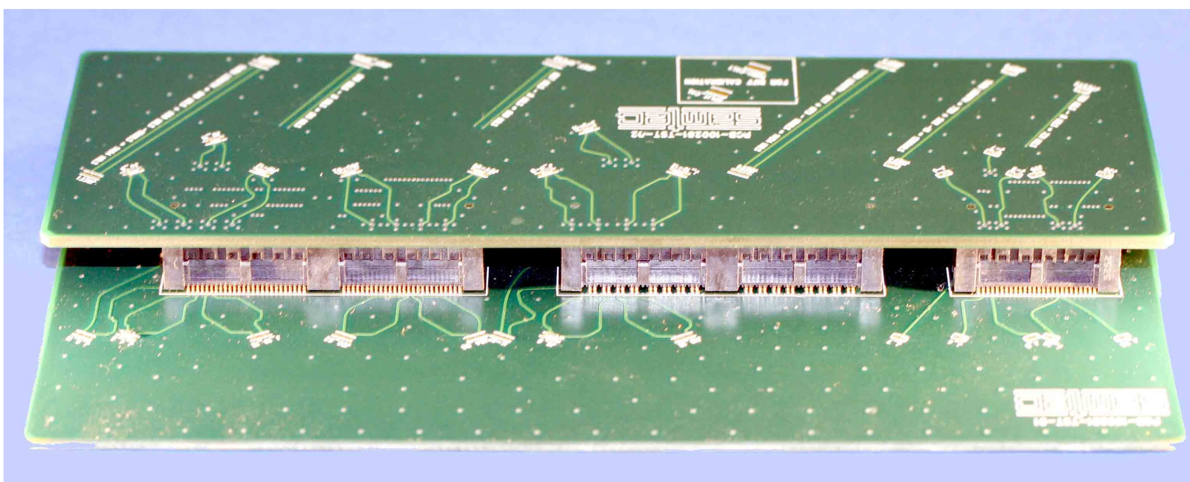

Figure 1 Mated PCB Test Fixture with Mounted Test Connectors

PCB-100281-TST-01 (Figure 1, bottom pcb) anchors three QFS socket series connector types and serves as the test signal launch board. The DP connector is located between the two outer connector types and its performance data is the subject for this report. The standard 26 signals/row connector (right) and 52 signals/row connector (left),

located on the outer surfaces on each board fixture, characteristic performance is the subject in a separate report.
Test fixture PCB-100281-TST-02 contains the mating QMS-DP terminal connector (Figure 1, top pcb) and is considered the main signal monitoring section for the fixture. When the two board fixtures are mated the labeled probe points coordinate to create continuous electrical transmission paths between the signal launch pads and monitoring junctions. Both the single-ended and differential fixtures "J" number represents each signal terminal's designated position within the connector. The PCB-100281-TST-02 also provides the reference plane and/or calibration standards used in post-processing time delay and s-parameter information. All data and waveforms presented are results from a socket side signal launch. **Table 8** below identifies the launch, monitoring and adjacent line termination points used in generating the performance characteristics reported

Table 8 – PCB Fixture Characterization & Termination Matrix

	Differential Pair			
	Launch	Monitor	100Ω Across Signal Pair Termination	
USE PCB	**TST-01**	**TST-02**	**TST-01**	**TST-02**
IL, RL Z, PD	J6_8	J_6-8	J10_12	J_10-12
USE PCB	**TST-01**	**TST-01**	**TST-01**	**TST-02**
NEXT(worst)	J6_8	J10_12	J9_11	J_6-8 J_9-11 J_10-12
NEXT(xrow)	J9_11	J10_12	J6_8	J_6-8 J_9-11 J_10-12
USE PCB	**TST-01**	**TST-02**	**TST-01**	**TST-02**
FEXT(worst)	J6_8	J_10-12	J9_11 J10_12	J_6-8 J_9-11
FEXT(xrow)	J9_11	J_10-12	J6_8 J10_12	J_6-8 J_9-11

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Signal Conditioning, Calibration Standards And Signal Launch/Monitoring

Figure 2 represents the layout of the footprint, connector, and signal trace transitions where test signal configuration conditions can be determined. In general these GSG or GSSG conditions are spelled out in the characterization details section of the report. Be aware that the geometry or signal conditioning adjacent to active or monitored test points may have aggressive or response changing behaviors and should be terminated to the SUT’s characteristic impedance as specified in Table 8.

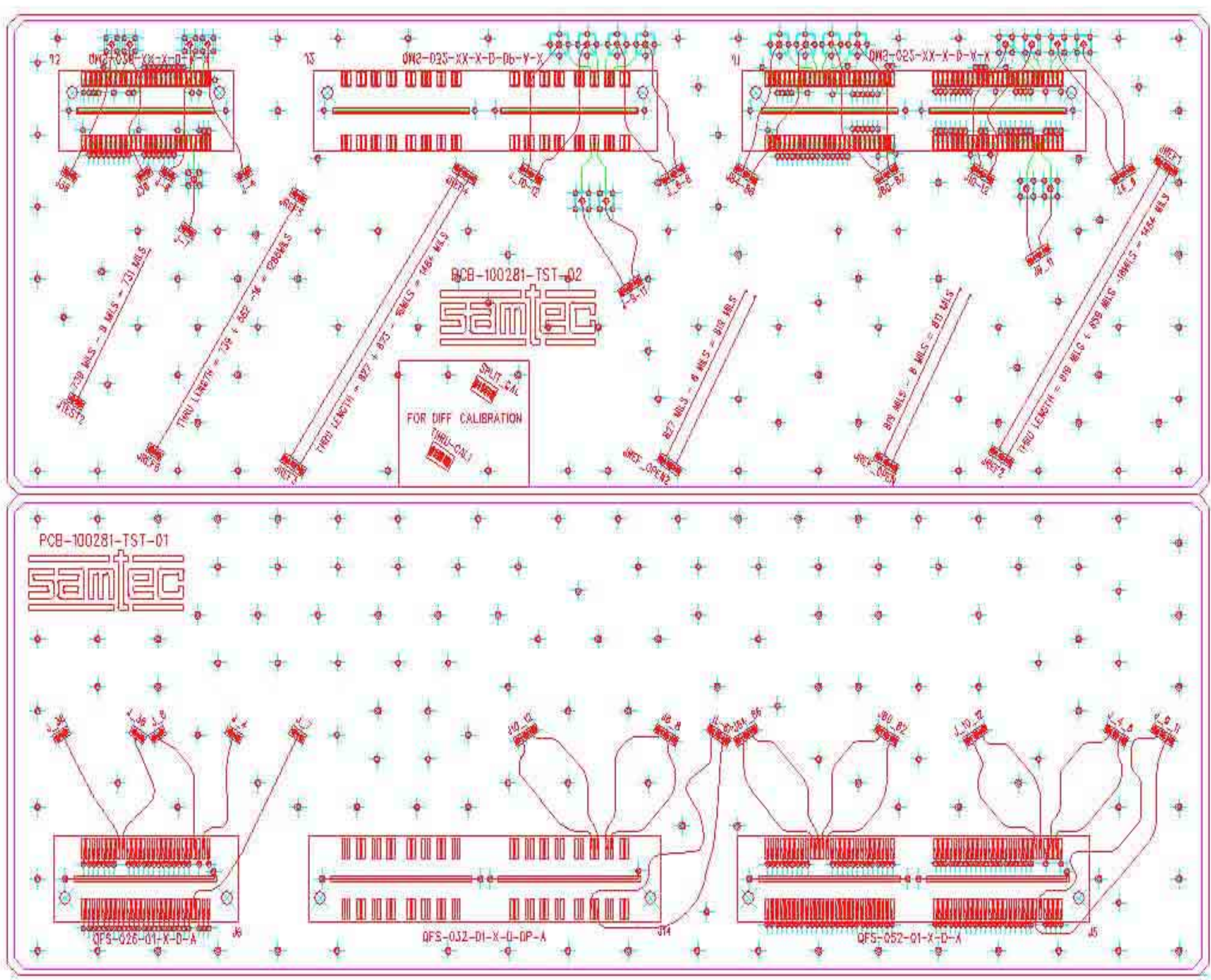

Figure 2 Signal Conditioning, Calibration Standards And Signal Launch/Monitoring Map

Series: QFS-DP/QMS-DP, Micro High Speed
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Appendix D – Test and Measurement Setup

Test instruments are a Tektronix CSA8000 Communication Signal Analyzer Mainframe and the Agilent 8720ES Vector Network Analyzer. Four bays of the CSA8000 are occupied with three Tektronix 80E04 TDR/Sampling Heads and one Tektronix 80E03 Sampling Head. For this series of tests, four of the eight TDR/Sampling Head capability is used *(Figure 8)*. The 8720ES serves as a supporting test instrument for verification or troubleshooting results obtained from the TDA Systems IConnect Software package. IConnect is a TDR based measurement software tool used in generating frequency domain related responses from high speed interconnects.

The probe stations illuminated video microscopy system, microprobe positioners, and 40GHz capable probes provide both the mechanical properties and electrical characteristics for obtaining the precise signal launch and calibrations that are critical in obtaining accurate high speed measurements. The 450 micron pitch probes are located to PCB launch points with 25X to 175X magnification and XYZ fine positioning adjustments available from both the probe table and micro-probe positioners. Electrically the microwave probes rate a < 1.0 dB insertion loss, a < 18 dB return loss, and an isolation of 38 dB to 40 GHz *(Figure 8)*. Test cables and interconnect adapters are high quality and insure high-bandwidth and low parasitic measurements.

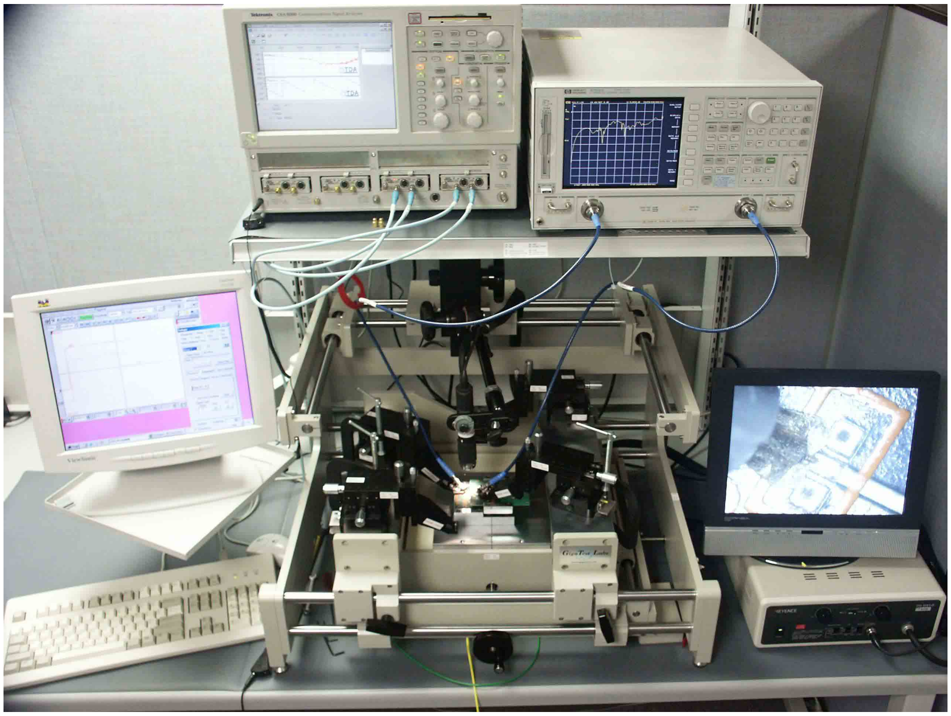

Figure 4 – Probe Station Measurements Capability

Series: QFS-DP/QMS-DP, Micro High Speed
Description: Parallel Board-to-Board, 0.635mm Pitch, 11mm (0.433") Stack Height

Test Instruments

QTY	Description
1	Tektronix CSA8000 Communication Signal Analyzer
3	Tektronix 80E04 Dual Channel 20 GHz TDR Sampling Module
1	Tektronix 80E03 Dual Channel 20 GHz Sampling Module
1	Agilent 8720ES Vector Network Analyzer, 50 MHz to 20 GHz

Measurement Station Accessories

QTY	Description
1	GigaTest Labs Model (GTL3030) Probe Station
4	GTL Micro-Probe Positioners
2	Picoprobe by GGB Ind. Model 40A GSG (single ended applications)
2	Picoprobe by GGB Ind. Dual Model 40A GSG-GSG (differential applications)
1	Keyence VH-5910 High Resolution Video Microscope
1	Keyence VH-W100 Fixed Magnification Lens 100 X
1	Keyence VH-Z25 Standard Zoom Lens 25X-175X
1	CS-9 GSG Picoprobe Calibration Substrate (U9450.sq)
1	CS-11 GS-SG Picoprobe Calibration Substrate (U11450.sq)

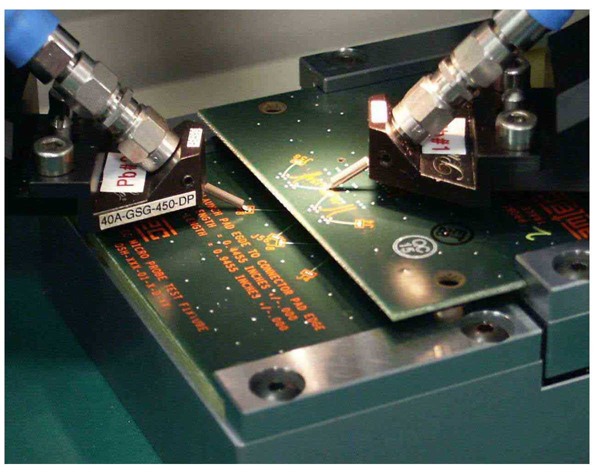

Figure 5 – 40 GHz High Performance Microwave Probes

Test Cables & Adapters

QTY	Description
4	Micro-Coax Cable Assembly 48" 3.5mm Male to 3.5mm Female, 26.5 GHz (IL = .33 dB@ 10 GHz)
2	Huber-Suhner Cable Assembly 36" SMA Female to SMA Female 26.5 GHz (IL = .34 dB @ 10 GHz)
4	Pasternack Precision Adapters, 3.5 mm Male to 2.9(K) Male, Max.VSWR 1.25 @ 34GHz

Series: QFS-DP/QMS-DP, Micro High Speed
Description: Parallel Board-to-Board, 0.635mm Pitch, 11mm (0.433”) Stack Height

Appendix E - Frequency and Time Domain Measurements

It is important to note before gathering measurement data that TDA Systems IConnect measurements and CSA8000 measurements are virtually the same measurements with diverse formats. This means that the operator, being extremely aware, can obtain SI time and frequency characteristics in an almost simultaneous fashion.

Since IConnect setup procedures are specific to the frequency information sought, it is mandatory that the sample preparation and CSA8000 functional setups be consistent throughout the waveform gathering process. If the operators test equipment permits recall sequencing between the various test parameter setups, it insures IConnect functional setups remain consistent with the TDR/TDT waveforms previously recorded. Related time and frequency test parameter data recorded for this report were gathered simultaneously.

Frequency (S-Parameter) Domain Procedures
Frequency data extraction involves two steps that first measure the frequency related time domain waveform followed by post-processing of the time domain waveforms into loss and crosstalk response parameters versus frequency. The first step utilizes the Tektronix CSA8000 time based instrument to capture frequency related single-ended or differential signal types propagating through an appropriately prepared SUT. The second step involves a correlation of the time based waveforms using the TDA Systems IConnect software tool to post-process these waveforms into frequency response parameters. TDA Systems labels these frequency related waveform relationships as the *Step* and *DUT* reference. This report establishes the setup procedures for defining the *Step* and *DUT* reference for frequency parameters of interest. Once established, the *Step* and *DUT* references are post-processed in IConnect’s S-parameter computations window.

CSA8000 Setup
Listed below are the CSA 8000 functional menu setups used for single-ended and differential frequency response extractions. Both signal types utilize I-Connect software tools to generate S-parameter upper and lower frequency boundaries along with the step frequency. These frequency boundaries are determined by a time domain instruments functional settings such as window length, number of points and averaging capability. Once window length, number of points and averaging functions are set, maintain the same instrument settings throughout the extraction process.

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	Differential Signal
Vertical Scale:	100 mV/ Div:
Offset:	Default / Scroll
Horizontal Scale:	1nSec/ Div = 20 MHz step frequency
Max. Record Length:	4000 = Min. Resolution
Averages:	≥ 128

Insertion Loss

SUT Preparation - For signal launch and monitoring path guidelines reference table 8. Terminate all the suggested active or adjacent signal lines at the impedance values recommended in the table. Signal trace locations and configurations can be verified using figure 2.

Step Reference - Establish this waveform by making a TDT transmission measurement that includes all cables, adapters, and probes connected in the test systems transmission path. The transmission path is completed by inserting a negligible length of transmission standard between the microwave probes. *(**Note:** Use the split-cal1 standard in TDT mode located on Samtec PCB100281-TST-02 fixture).*

DUT Reference - Establish these waveforms by making an active TDT transmission measurement that includes all cables, adapters, and probes connected in the test systems transmission path. Insert the SUT between the probes in place of the transmission standard and record the measurement.

Return Loss

SUT Preparation – For signal launch and monitoring path guidelines reference table 8. Terminate all the suggested active or adjacent signal lines at the impedance values recommended in the table. Signal trace locations and configurations can be verified using figure 2.

Step Reference - Establish the waveform by making an active TDR reflection measurement that includes all cables, adapters, and probes connected in the test systems electrical path up to and including an open standard. *(**Note:** Use split-cal1 standard in TDR mode located on Samtec PCB100281-TST-02 fixture).*

DUT Reference – Retain same signal paths and test setup used in obtaining insertion loss waveforms. Establish these waveforms by making a TDT (matched) reflection measurement that includes all cables, adapters, and probes connected in the test systems transmission path. For this condition the quality cables and adapters located on

Series: QFS-DP/QMS-DP, Micro High Speed
Description: Parallel Board-to-Board, 0.635mm Pitch, 11mm (0.433") Stack Height

the far-end of the inserted SUT serves as the resistive load impedance closely matching the test system input impedance of 50Ω single-ended and100Ω differential.

Near-End Crosstalk (NEXT*)*
SUT Preparation – For signal launch and monitoring path guidelines reference table 8. Terminate all the suggested active or adjacent signal lines at the impedance values recommended in the table. Signal trace locations and configurations can be verified using figure 2.

Step Reference - Establish these waveforms by making an active measurement that includes all cables, adapters, and probes connected in the test systems electrical path up to and including an open standard. *(**Note:** Use split-cal1 standard in TDR mode located on Samtec PCB100281-TST-02 fixture).*

DUT Reference - Establish these waveforms by driving the suggested signal line and monitoring the TDR coupled energy at the adjacent near-end signal line. Establish {6} measurement waveforms of worst case, best case and across row (xrow) coupling conditions for both signal types.

Far-End Crosstalk (FEXT)
SUT Preparation - For signal launch and monitoring path guidelines reference table 8. Terminate all the suggested active or adjacent signal lines at the impedance values recommended in the table. Signal trace locations and configurations can be verified using figure 2.

Step Reference - Establish these waveforms by making a TDT transmission measurement that includes all cables, adapters, and probes connected in the test systems transmission path. The transmission path is completed by inserting a negligible length of transmission standard *(**Note:** Use the split-cal1 standard in TDT mode located on Samtec PCB100281-TST-02 fixture).*

DUT Reference - Establish these waveforms by driving the suggested signal line and monitoring the TDR coupled energy at the adjacent near-end signal line. Establish {6} measurement waveforms of worst case, best case and across row (xrow) coupling conditions for both signal types.

Series: QFS-DP/QMS-DP, Micro High Speed
Description: Parallel Board-to-Board, 0.635mm Pitch, 11mm (0.433") Stack Height

Time Domain Procedures
Measurements involving digital type pulses are performed utilizing either Time Domain Reflectometer (TDR) or Time Domain Transmission (TDT) methods. For this series of tests, TDR methods are employed for the impedance and propagation delay measurements. Crosstalk measurements utilize TDT methods. The Tektronix 80E04 TDR/ Sampling Head provide both the signaling type and sampling capability necessary to accurately and fully characterize the SUT.

Impedance
The signal line(s) of the SUT's signal configuration is energized with a TDR pulse. 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. For signal launch and monitoring path guidelines reference table 8.

Propagation Delay
This connector series uses the fastest edge rate (30ps) of the TDR impedance waveform to measure propagation delay. . Differential or single ended signal delay is the measured difference of propagation between the known signal trace length delay *(reference PCB100281-TST-02 for each mated connectors referenced signal trace length).* and the combined delay through the input signal traces and output signal traces of a mated SUT. The measurement is a one-way propagation result. Termination of the adjacent signal lines into the test systems characteristic impedance eliminate alternate current paths providing for better measurement accuracy. For signal launch and monitoring path guidelines reference table 8.

Crosstalk
An active pulsed waveform is transmitted through a selected SUT signal line. The adjacent quiet signal lines are monitored for the coupled energy at the near-end and far-end. Active and quiet lines not being monitored are terminated in the test systems characteristic impedance. Signal lines adjacent to the quiet lines remain terminated on both ends throughout the test sequence. Failing to terminate the active near or far end, quiet lines, or in some cases, signal lines adjacent to the quiet line may have an effect on amplitude and shape of the coupled energy. For signal launch and monitoring path guidelines reference table 8.

Series: QFS-DP/QMS-DP, Micro High Speed
Description: Parallel Board-to-Board, 0.635mm Pitch, 11mm (0.433”) Stack Height

Appendix F – Glossary of Terms

BC – Best Case crosstalk configuration

DP – Differential Pair signal configuration

DUT – Device under test; TDA IConnect reference waveform

FEXT – Far-End Crosstalk

GSG – Ground–Signal-Ground; geometric configuration

NEXT – Near-End Crosstalk

PCB – Printed Circuit Board

SE – Single-Ended

SI – Signal Integrity

SUT – System under test

TDR – Time Domain Reflectometry

TDT – Time Domain Transmission

WC – Worst Case crosstalk configuration

Xrow^{se} – Cross ground/ power bar crosstalk, single-ended signal

Xrow^{diff} – Cross ground/ power bar crosstalk, differential signal

Z – Impedance (expressed in ohms)

Static (s) – connector terminals with no connection to PCB ground