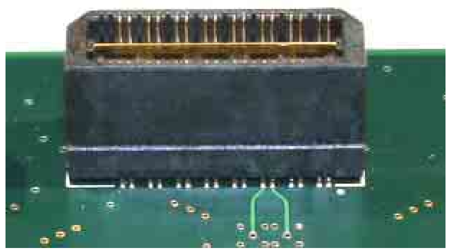
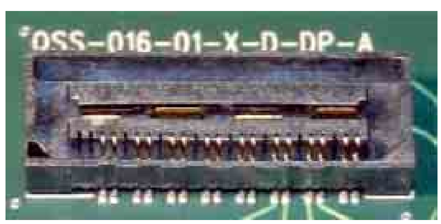
High Speed Characterization Report

QTS-016-03-L-D-DP-A



Mated With

QSS-016-01-L-D-DP-A



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

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Report Revision: 5/20/2005

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Connector Overview

Q Strip® .635mm (.025") pitch interfaces (QSS/QTS Series) are available with up to 160 I/Os and with standard board-to-board spacing of 5mm (0.197"), 8mm (0.315"), 11mm (0.433"), and 16mm (0.630") between boards. The data in this report is applicable only to the differential pair 11mm (0.433") board-to-board stack height version.

Connector System Speed Rating

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

Signaling	Speed Rating
Differential:	**6.0 GHz / 12 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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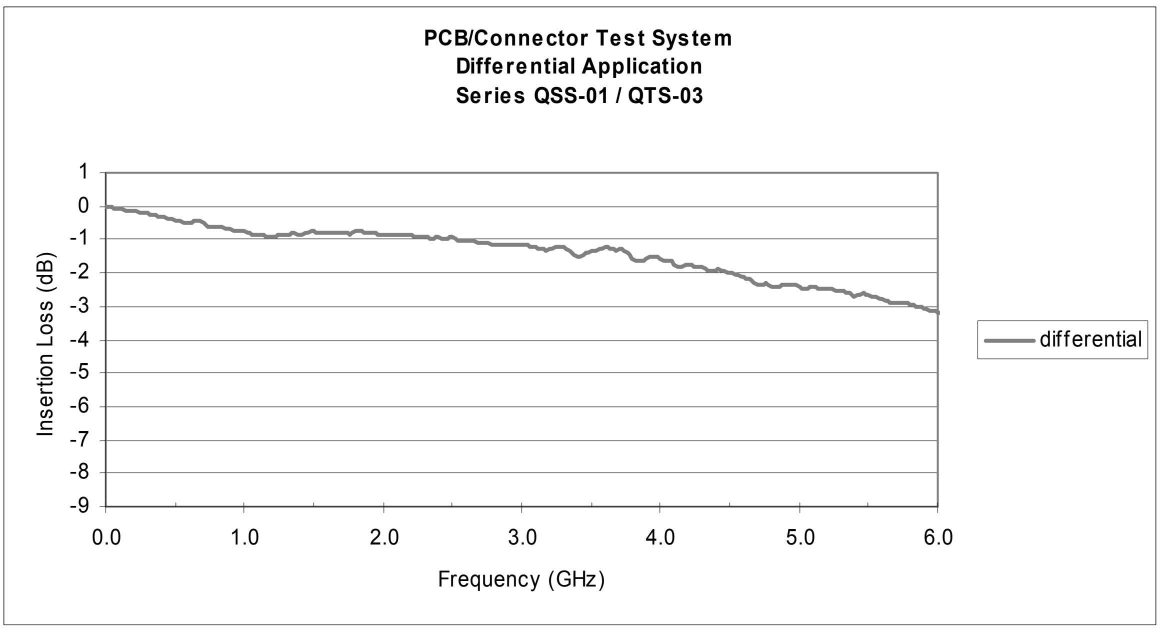
Frequency Domain Data Summary

Table 1 - Differential Connector System Bandwidth		
Test Parameter	**Configuration**	
Insertion Loss	. SS .	**-3dB @ 5.86GHz**
Return Loss	. SS .	< -5dB to 5.86GHz
Near-End Crosstalk	. AA . QQ .	< -18dB to 5.86GHz
	Xrow, AA to QQ	< -28dB to 5.86GHz
Far-End Crosstalk	. AA . QQ .	< -30dB to 5.86GHz
	Xrow, AA to QQ	< -32dB to 5.86GHz



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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	103.5	103.3	103.0	102.6	102.4	102.1	101.8
Minimum Impedance	65.8	69.1	74.8	82.9	89.1	92.6	94.5

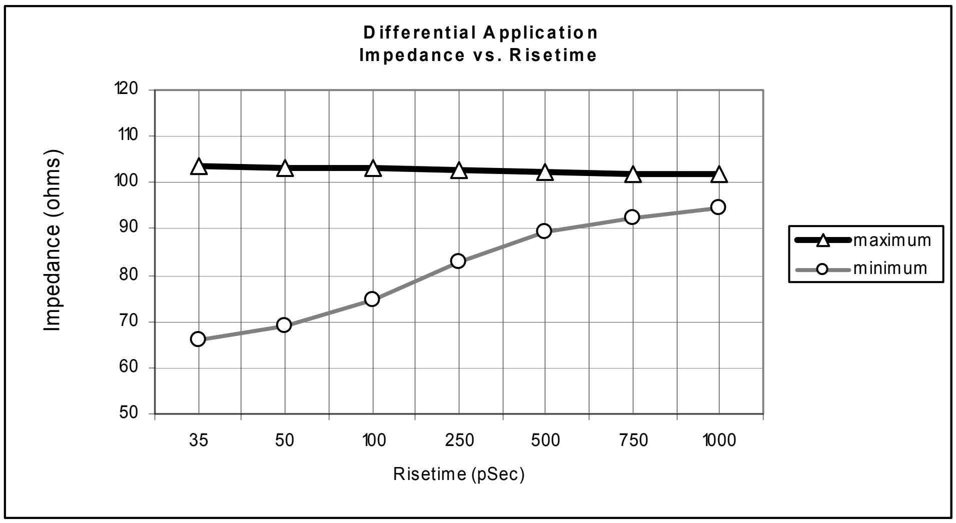

Table 3 - Differential Crosstalk (%)								
Input (t_r)		**30±5ps**	**50 ps**	**100 ps**	**250 ps**	**500 ps**	**750 ps**	**1 ns**
NEXT	. AA . QQ .	2.1	2.0	1.7	1.1	< 1.0	< 1.0	< 1.0
	$Xrow^{diff}$	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
FEXT	. AA . QQ .	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
	$Xrow^{dif}$	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

Table 4 - Propagation Delay (Mated Connector)	
Differential	115.0 ps

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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:

- SS (positive signal-negative signal)

Differential Crosstalk:

- Electrical “worst case”: . AA . QQ . 1.12mm spacing-active-active-1.12mm spacing -quiet-quiet-1.12mm spacing)
- Across row:Xrow^{diff} (from one row of terminals to the other row across the isolated 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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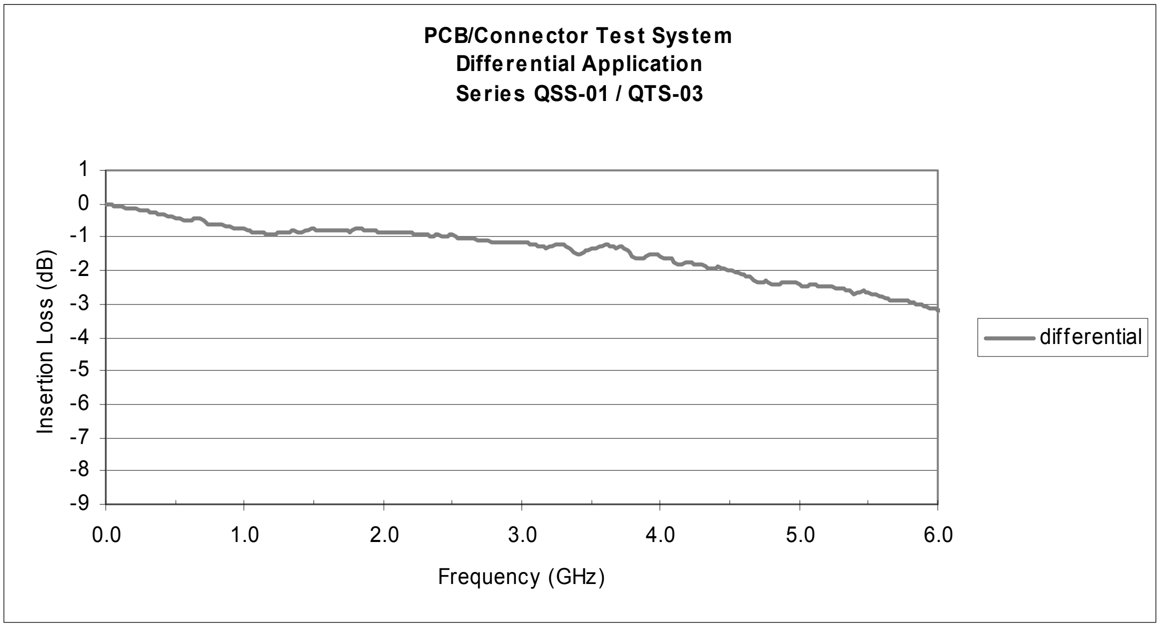
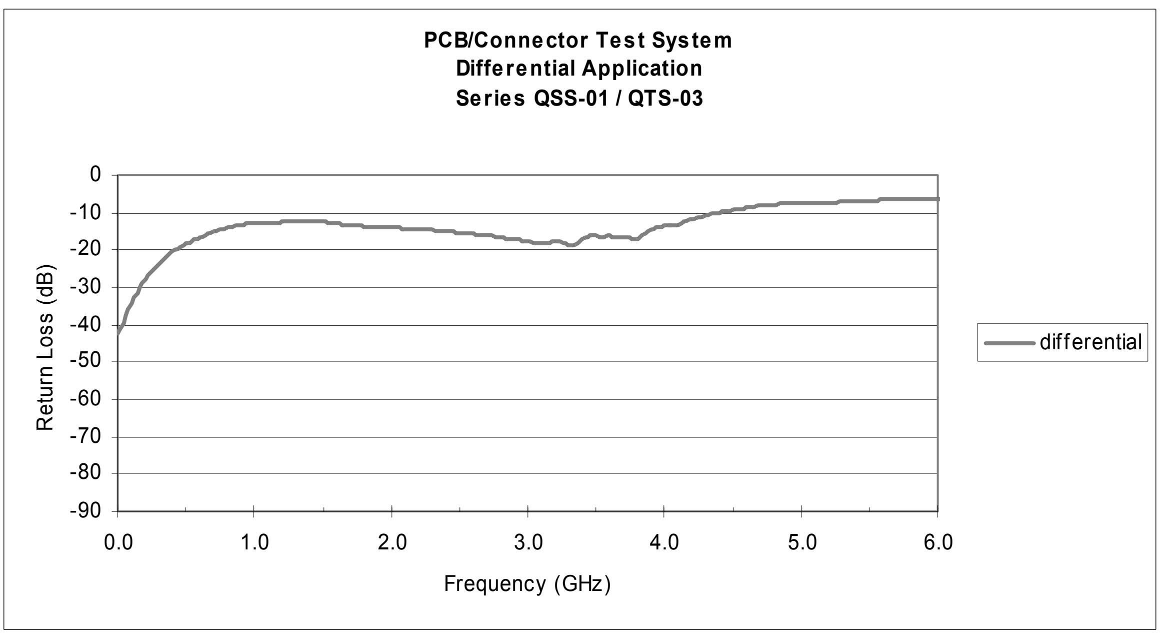
Appendix A – Frequency Domain Response Graphs

Differential Application – Insertion Loss



Differential Application – Return Loss



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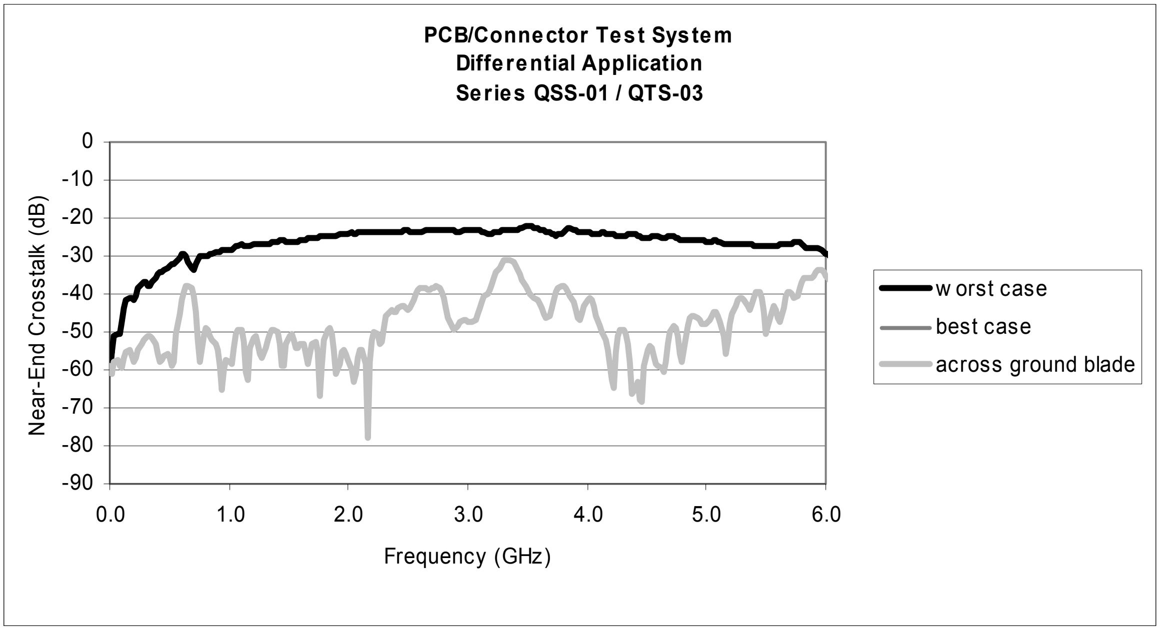
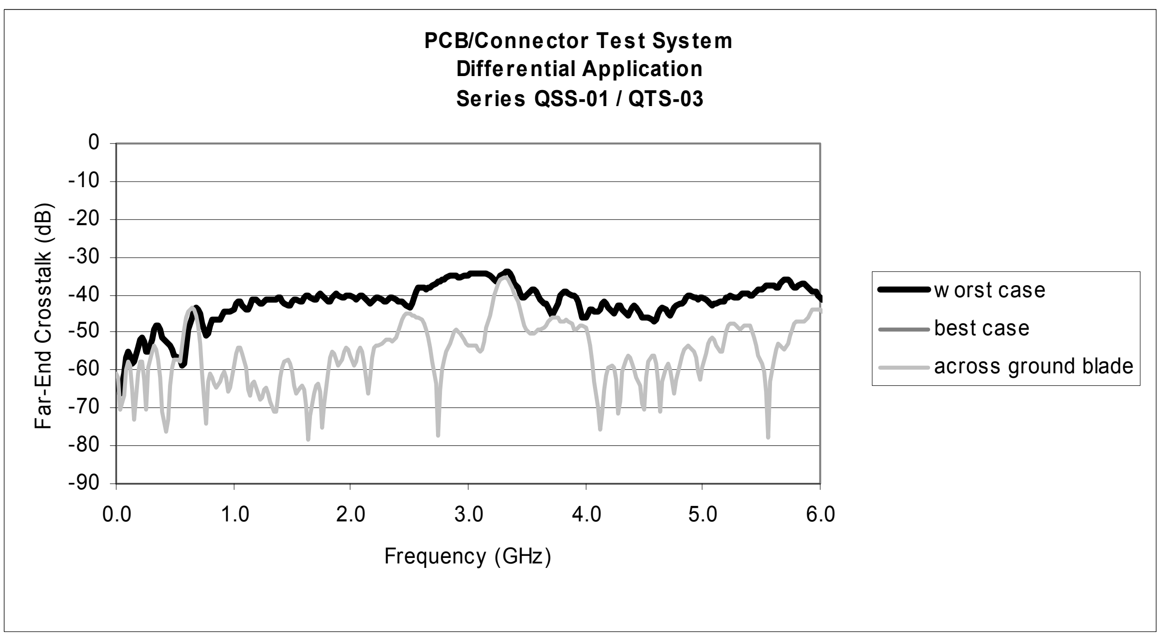
Differential Application – NEXT



Differential Application – FEXT



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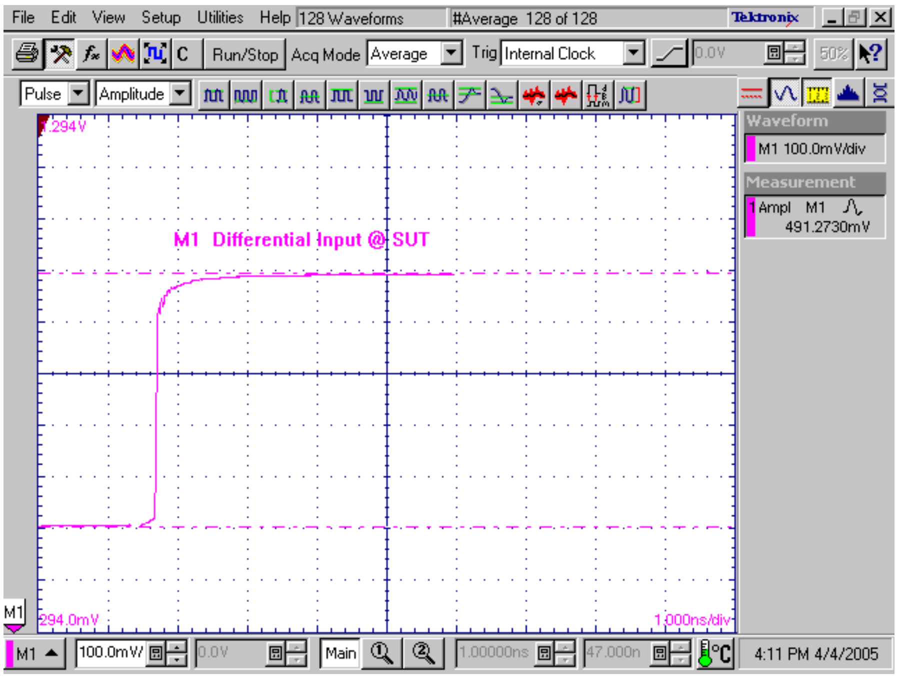
Appendix B – Time Domain Response Graphs

Differential Application – Input Pulse



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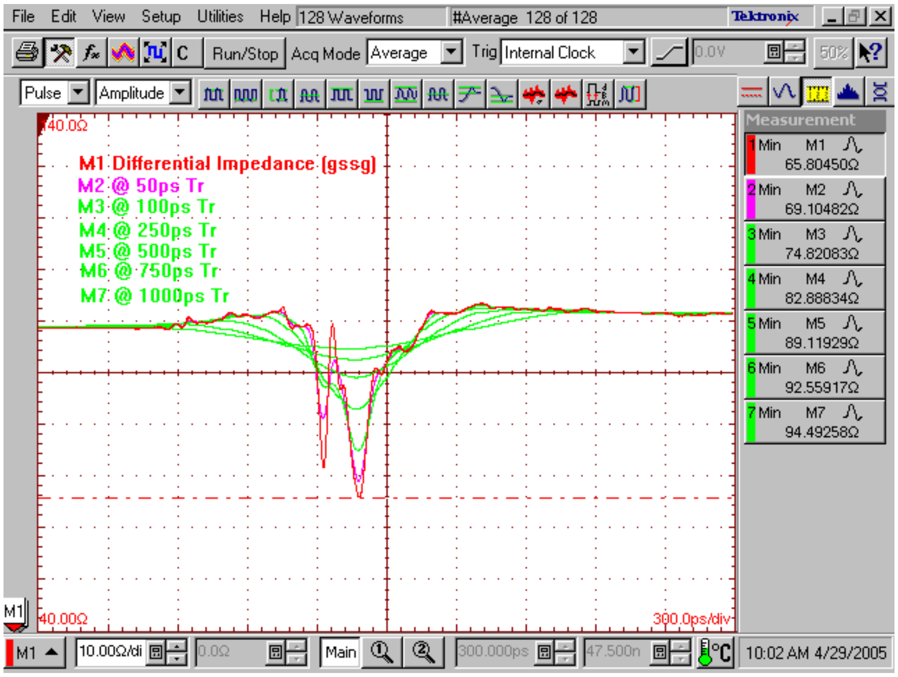
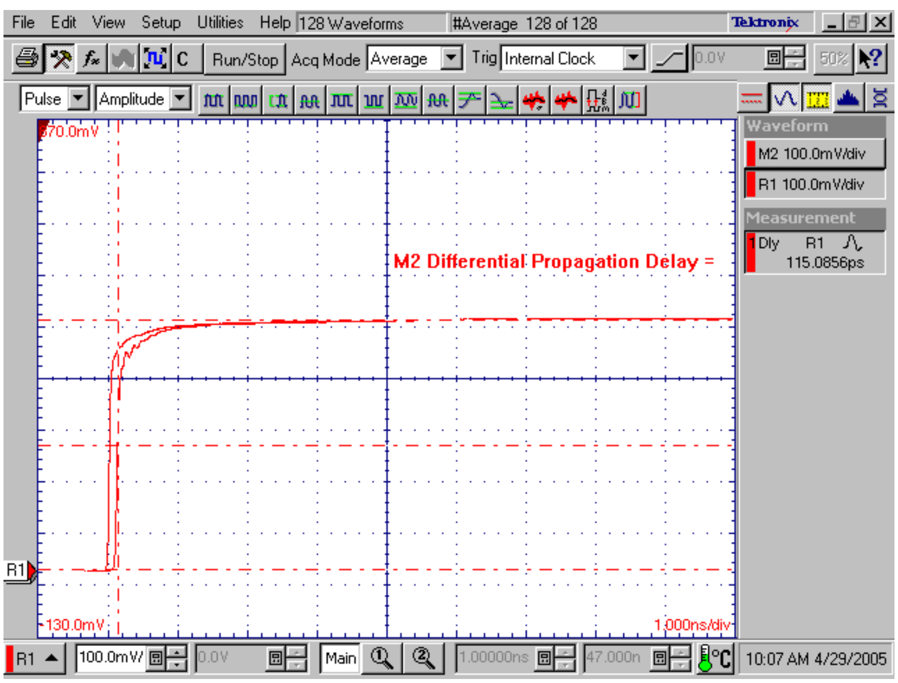
Differential Application – Impedance



Differential Application – Propagation Delay



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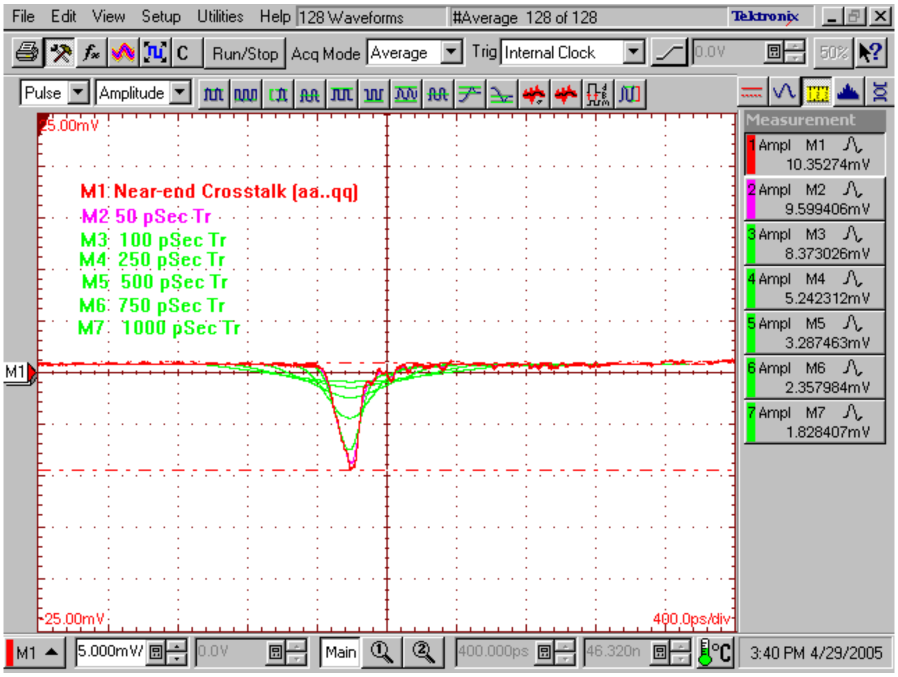
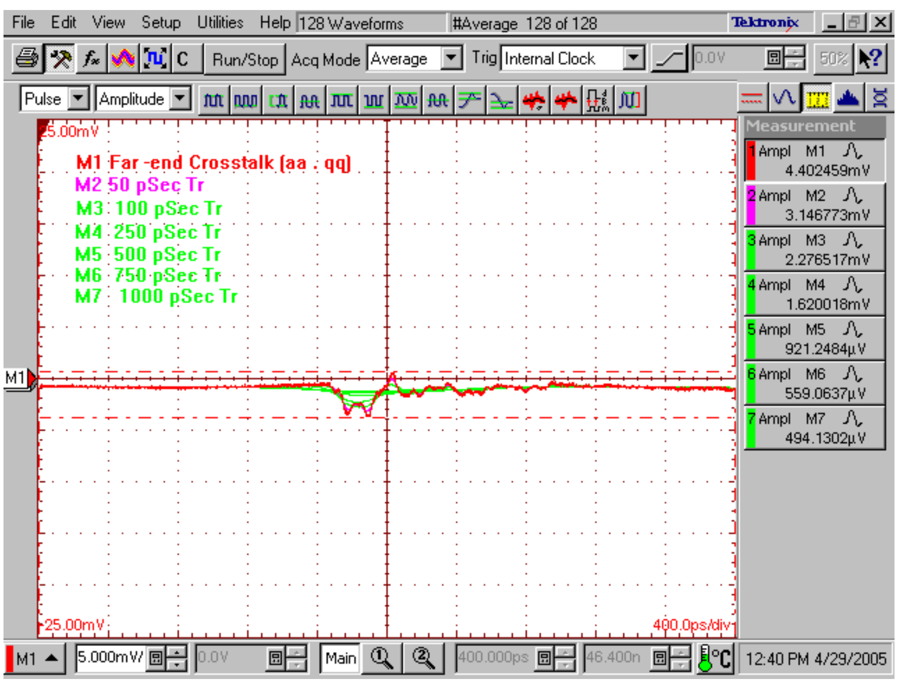
Differential Application – NEXT, "Worst Case" Configuration



Differential Application – FEXT, "Worst Case" Configuration



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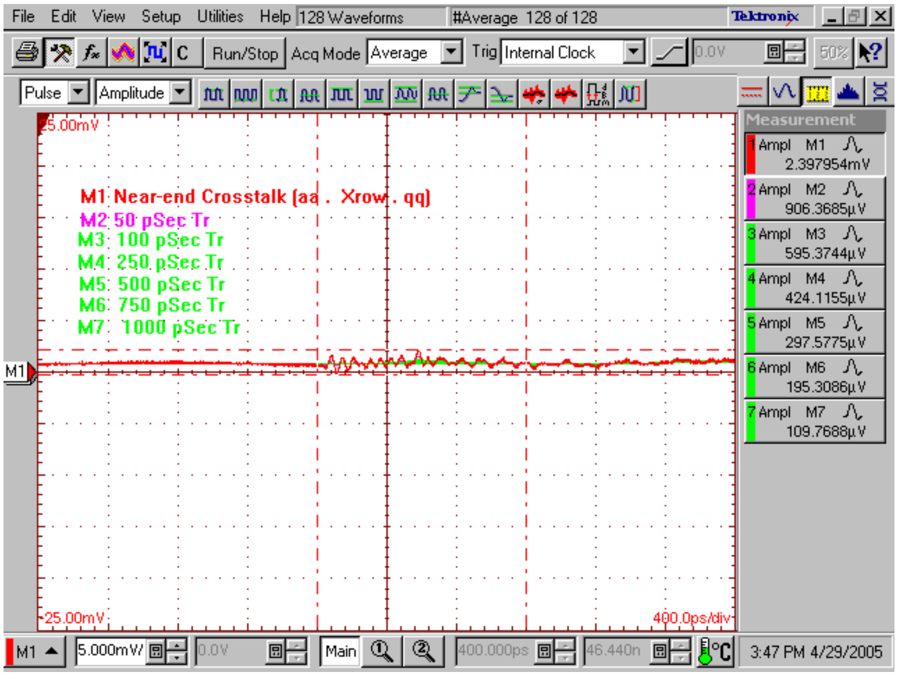
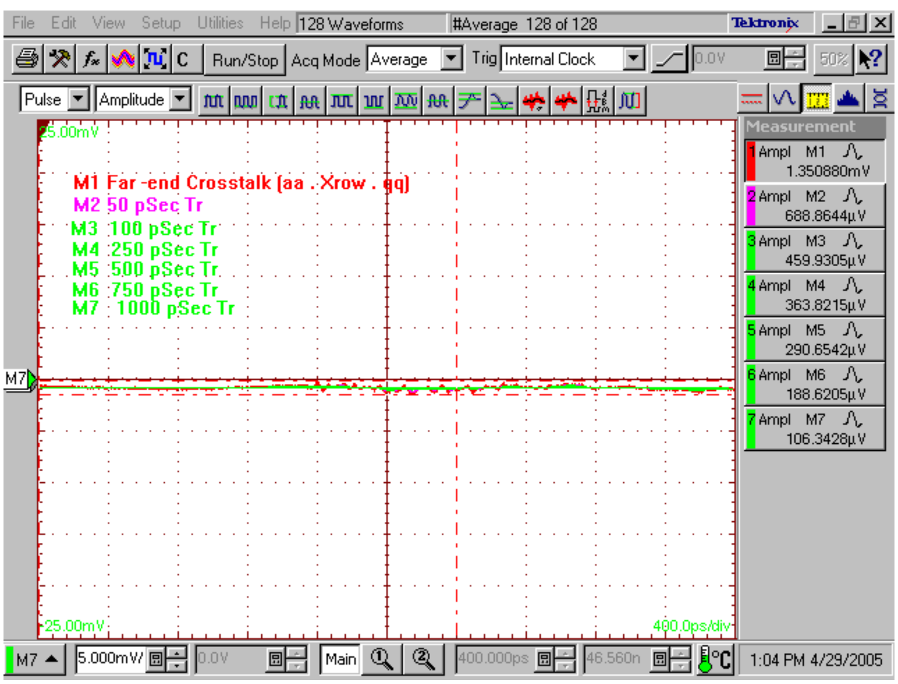
Differential Application – NEXT, Across Power/Ground Blade



Differential Application – FEXT, Across Power/Ground Blade



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Appendix C – Product and Test System Descriptions

Product Description

Product samples are the 11mm (0.433") stack height Q Strip® High Speed QSS Series sockets P/N QSS-016-01-X-D-DP-A and the mating QTS Series header P/N QTS-016-03-X-D-DP-A.

Each connector structure consists of 2 rows of eight terminal pairs mounted into a plastic housing with a surface mount design. A conductive ground/power blade lies lengthwise between terminal rows in the housing. Every third signal pin is removed from each row creating 1.12mm spacing between differential signal pins. Signal contacts are at a.635mm (.025") pitch.

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 to the QSS/QTS series connector and are identified by Samtec P/N PCB-100245-TST-01 and P/N PCB-100245-TST-02 (Figure 1)

Figure 1 Mated PCB Test Fixture with Mounted Test Connectors

Terminated onto P/N PCB-100245-TST-01 (Figure 2) are three QSS socket series connectors. A 25position (Rt.) standard connector is setup for characterizing single ended type signals (GSG). The 50 position connector (Lt.) characterizes differential type signals(GSSG) with adjacent signal pins positions assigned as grounds. The 16 pair center connector characterizes differential pairs in a totally open pin field designation. This report characterizes the SI response of the 16 pair differential connector.

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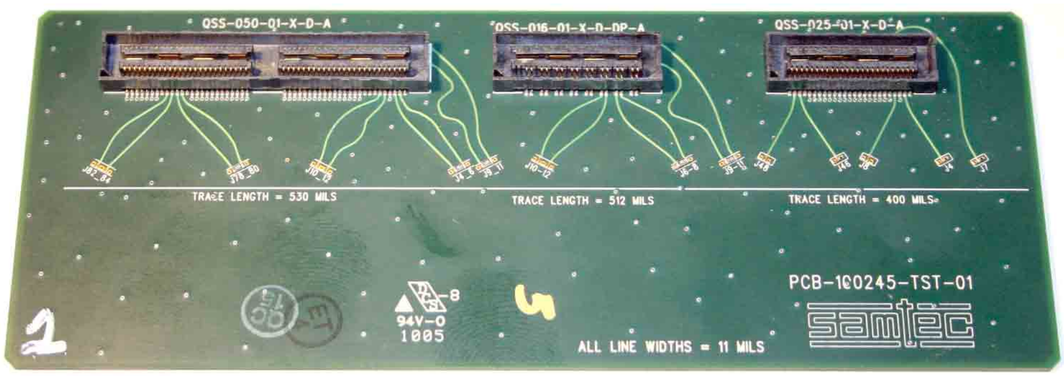

Figure 2 (Lt. to Rt.) QSS-050-01-X-D-A**, QSS-016-01-X-D-DP-A,** QSS-025-01-X-D-A

P/N PCB-100245-TST-02 accepts the QTS terminal connectors (Figure 3) and is designed to mate with PCB-100245-TST-01. Design differences are that signal traces propagate through the board and are located on the opposite side from the mating connectors. QTS trace transitions can be observed on the top board in Figure 1.

Figure 3 (Lt. to Rt.) QTS-050-01-X-D-A, **QTS-016-03-X-D-DP-A,** QTS-025-01-X-D-A

Test point signal paths coincide with each other upon mating and are marked accordingly. Differential signal terminal paths for the 16 pair connector are J6_8, J10_12, and J9_11. All signal paths are for monitoring through or adjacent signaling test conditions with the exception of J9_11. This condition is setup for monitoring signal coupling across terminal rows.

The differential fixtures “J” number represents each terminal’s designated position within the connector. Signals can be launched or received from either the socket or header side of the connector. All data and waveforms presented in the report are results from a socket side signal launch.

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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 4)*. 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 4)*. Test cables and interconnect adapters are high quality and insure high-bandwidth and low parasitic measurements.

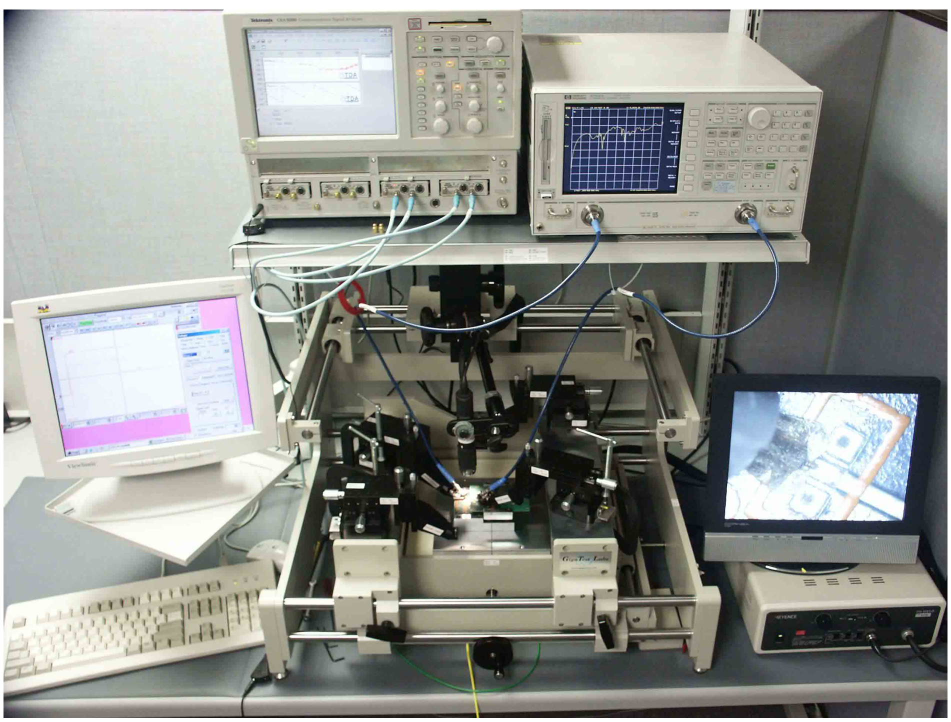

Figure 4 – Probe Station Measurements Capability

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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)

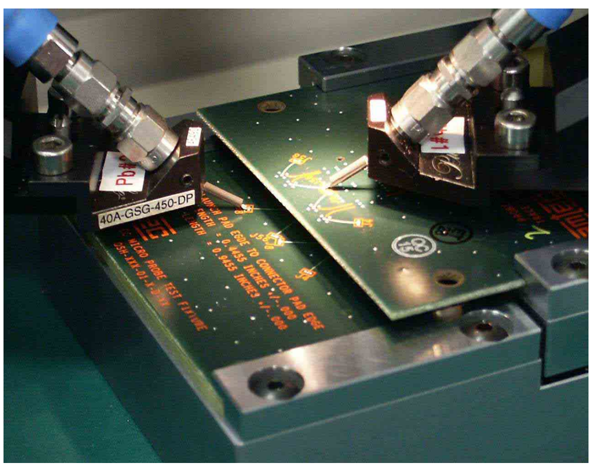

Figure 5 – 40 GHz High Performance Microwave Probes

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

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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 – Use the J6_8 or J10_12 signal path *(Figure 1)* to establish the differential through transmission waveform. Terminate any adjacent signal paths into a 100Ω characteristic impedance.

Step Reference – Establish the waveform by making a TDT transmission measurement that includes all cables, adapters, and probes connected in the test systems transmission path. The through transmission is accomplished by inserting a negligible length of transmission standard *(Figure 5)* between the microwave probes.

DUT Reference - Establish the waveform by making an active TDT transmission measurement that includes the SUT and all cables, adapters, and probes connected in the test systems transmission path.

Return Loss
Use the J6_8 or J10_12 signal path *(Figure 1)* to establish a TDR matched response waveform. Terminate any adjacent signal paths into a 100Ω characteristic impedance.

Step Reference - Establish the waveform by making a TDR measurement of the input cables and adapters leading to an open probe condition on the near end of the test system.

DUT Reference - Establish the waveform by making a TDT (matched) transmission measurement that includes all cables, adapters, and probes connected in the test systems transmission path *(Figure 5).* Cables and adapters located at the far-end of the SUT serve as the test systems characterisitic impedance match.

Near-End Crosstalk (NEXT)
SUT Preparation – Terminate -02 terminal fixture *(Figure 2)* probe pad locations J6_8, J10_12 & J9_11 at a 100Ω characteristic impedance.

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Step Reference - Establish the waveform by making a TDR measurement of the input cables and adapters leading to an open probe condition on the near end of the test system.

DUT Reference - Establish the waveform by driving signal line J10_12 and monitoring worse case coupled energy at J6_8, both located on the -01 socket fixture. Repeat the same procedure for across row coupling condition J9_11.

Far-End Crosstalk (FEXT)

SUT Preparation - Terminate -01 socket fixture *(Figure 2)* probe pad locations J6_8, & J9_11 at 100Ω impedances. Terminate -02 terminal fixture *(Figure 2)* probe pad locations J10_12, & J9_11 at a100Ω characteristic impedance.

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 *(Figure 5)* between the microwave probes.

DUT Reference - Establish the waveform by driving -01 socket fixture signal line J10_12 and monitoring best case coupled energy at J6_8 of the -02 terminal fixture . Repeat procedure for across row condition at J9_11.

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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.

Propagation Delay

This connector series uses the fastest edge rate (30ps) of the TDR impedance waveform to measure propagation delay. Differential mated connector delay is the measured difference of propagation between known signal trace length delays and the delay of the 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.

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.

Series: QSS-DP/QTS-DP
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 – Worse 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)