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## High Speed Characterization Report

QTH-030-01-L-D-RA-WT



Mates with

QSH-030-01-L-D-RA-WT



Description:

**Q Strip® High Speed Ground Plane Terminal/Socket Strip  
Coplanar Board-to-Board, 0.5mm (.0197") Pitch**

**Series:** QTH-RA/QSH-RA**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

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## Connector Overview

Samtec's QTH-RA/QSH-RA Q Strip® High-Speed Ground Plane Terminal/Socket Strip is designed for high-speed board-to-board applications. The connectors have surface mount contacts as well as a ground plane between the two rows of signals for improved crosstalk performance. Right-angle Q Strips ® are available for traditional single-side processing. QTH-RA/QSH-RA is a double row contact system available with up to 180 I/Os . The data in this report is applicable only to the right-angle to right-angle mated interconnect.

## Connector System Speed Rating

QTH-RA/QSH-RA Q Rate® High-Speed Ground Plane Terminal Strip, Board-to-Board, 0.5mm (.0197") Pitch, Right-Angle

<u>Signaling</u>	<u>Case</u>	<u>Speed Rating</u>
Single-Ended:	Long Row	<b>4 GHz/ 8Gbps</b>
	Short Row	<b>7.0 GHz/ 14Gbps</b>
Differential:	Long Row	<b>3.5 GHz/ 7Gbps</b>
	Short Row	<b>6.5 GHz/ 13Gbps</b>

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 a short length of trace loss 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 – Single-Ended Connector System Performance**

Test Parameter	Configuration	Case	Threshold Limits
Insertion Loss	GSG	Long Row	3dB @ 3.8 GHz
		Short Row	3dB @ 6.8 GHz
Return Loss	GSG	Long Row	>10dB to 1.1 GHz
		Short Row	>10dB to 6.1 GHz
Near-End Crosstalk	GAQG	Long Row	< -20dB to 0.2 GHz
		Short Row	< -20dB to 0.3 GHz
	GAGQG	Long Row	< -20dB to 3.2 GHz
		Short Row	< -20dB to 4.1 GHz
Xrow, GAG to GQG	-	< -20dB to 20.0 GHz	
Far-End Crosstalk	GAQG	Long Row	< -20dB to 1.4 GHz
		Short Row	< -20dB to 2.7 GHz
	GAGQG	Long Row	< -20dB to 2.0 GHz
		Short Row	< -20dB to 2.3 GHz
Xrow, GAG to GQG	-	< -20dB to 20.0 GHz	

**Table 2 – Differential Connector System Performance**

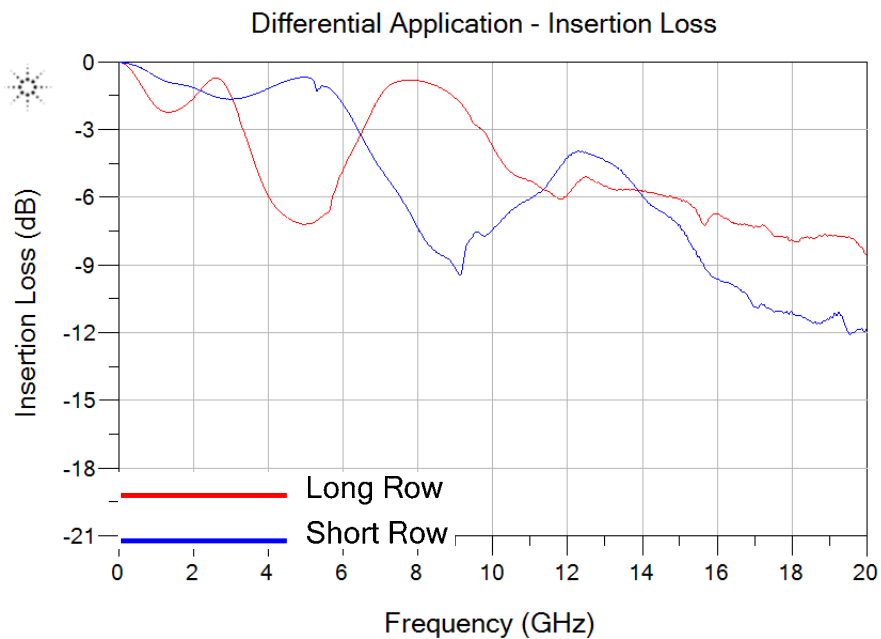
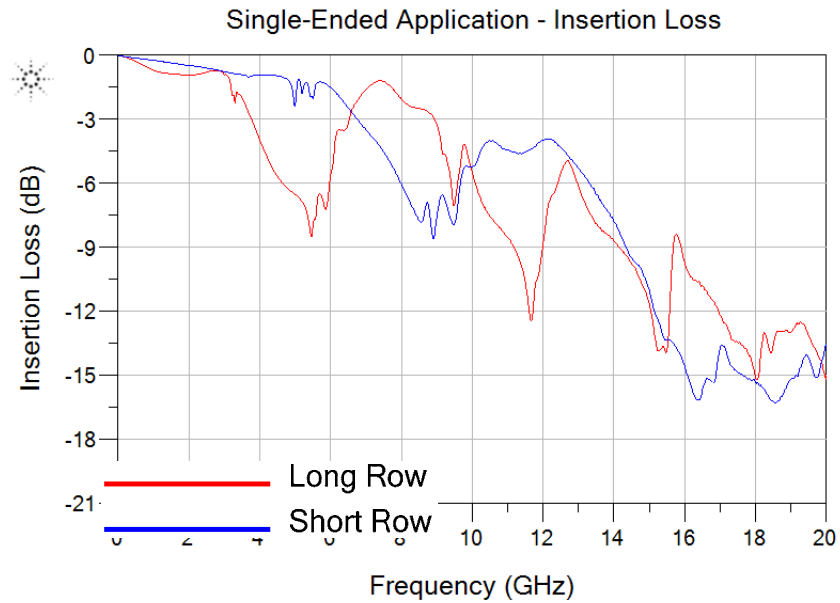
Test Parameter	Configuration	Case	Threshold Limits
Insertion Loss	GSSG	Long Row	3dB @ 3.3 GHz
		Short Row	3dB @ 6.4 GHz
Return Loss	GSSG	Long Row	>10dB to 0.4 GHz
		Short Row	>10dB to 0.9 GHz
Near-End Crosstalk	GAAQQG	Long Row	< -20dB to 13.5 GHz
		Short Row	< -20dB to 5.3 GHz
	GAAGQQG	Long Row	< -20dB to 13.8 GHz
		Short Row	< -20dB to 13.1 GHz
Xrow, GAAG to GQQG	-	< -20dB to 20.0 GHz	
Far-End Crosstalk	GAAQQG	Long Row	< -20dB to 5.8 GHz
		Short Row	< -20dB to 12.2 GHz
	GAAGQQG	Long Row	< -20dB to 20.0 GHz
		Short Row	< -20dB to 20.0 GHz
Xrow, GAAG to GQQG	-	< -20dB to 20.0 GHz	

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## Bandwidth Chart – Single-Ended & Differential Insertion Loss

QTH-RA/QSH-RA Series

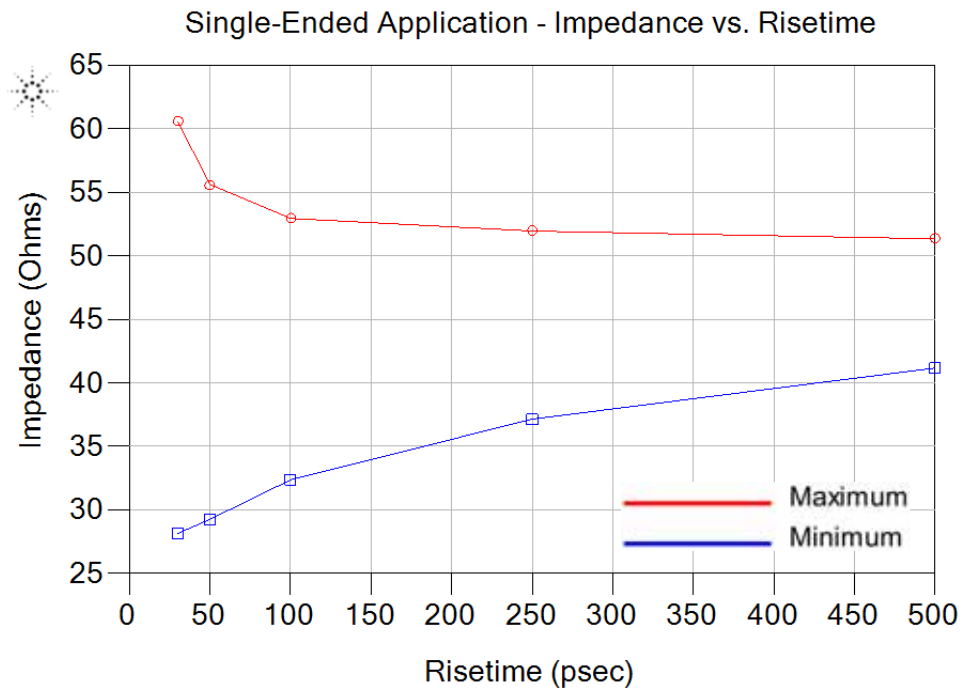


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## Time Domain Data Summary

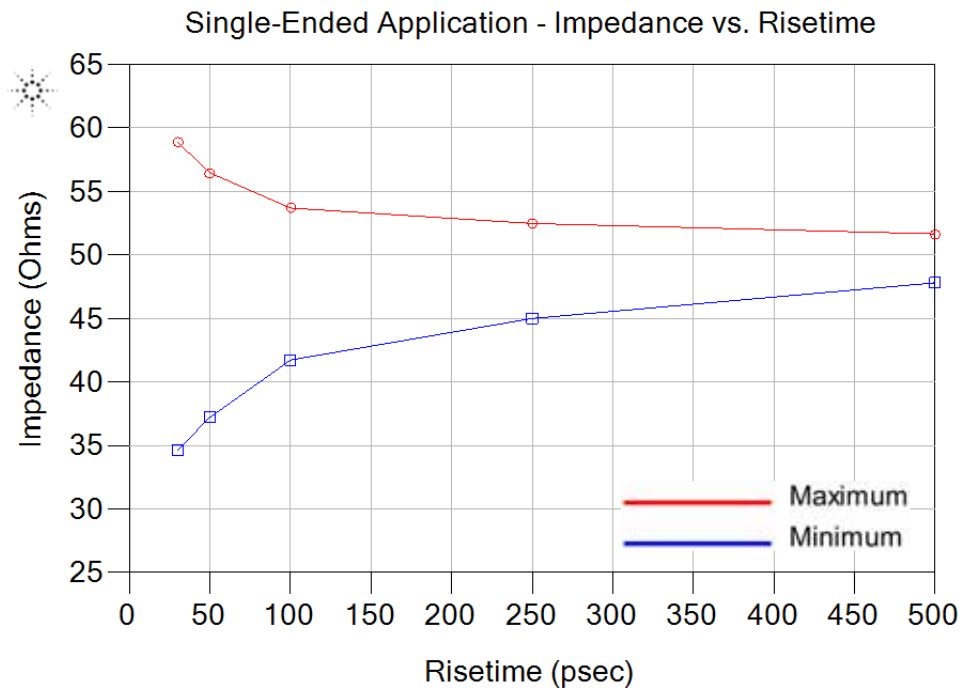
Table 3 – Long Row Single-End Impedance ( $\Omega$ )					
Signal Risetime	30 ps	50 ps	100 ps	250 ps	500 ps
Maximum Impedance	60.6	55.6	52.9	51.9	51.3
Minimum Impedance	28.1	29.2	32.3	37.1	41.2



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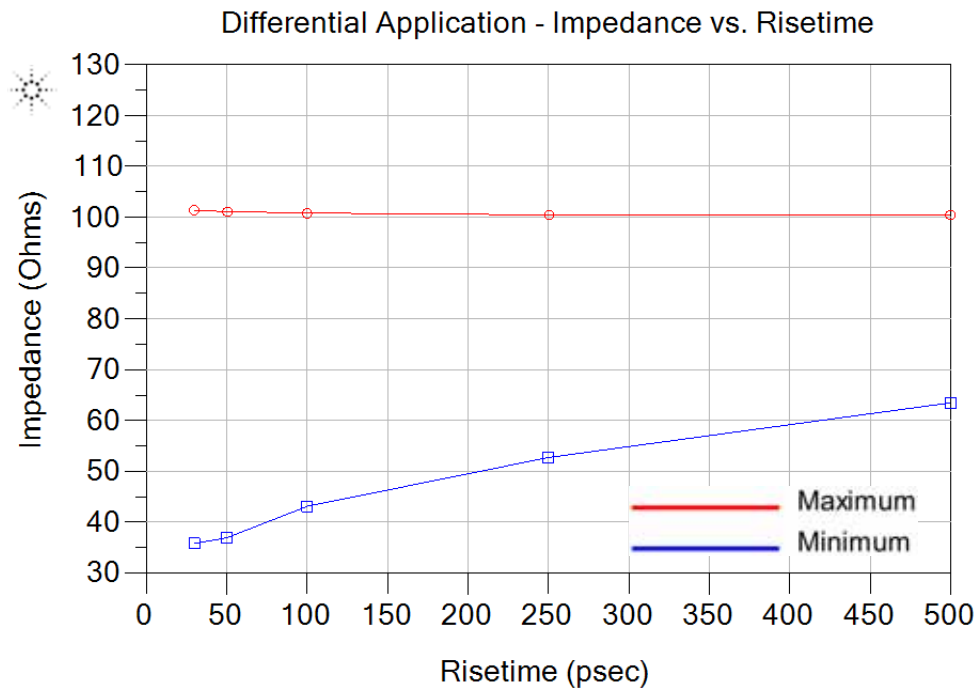
Table 4 – Short Row Single-End Impedance ( $\Omega$ )					
Signal Risetime	30 ps	50 ps	100 ps	250 ps	500 ps
Maximum Impedance	58.9	56.5	53.7	52.5	51.7
Minimum Impedance	34.7	37.2	41.7	45	47.8



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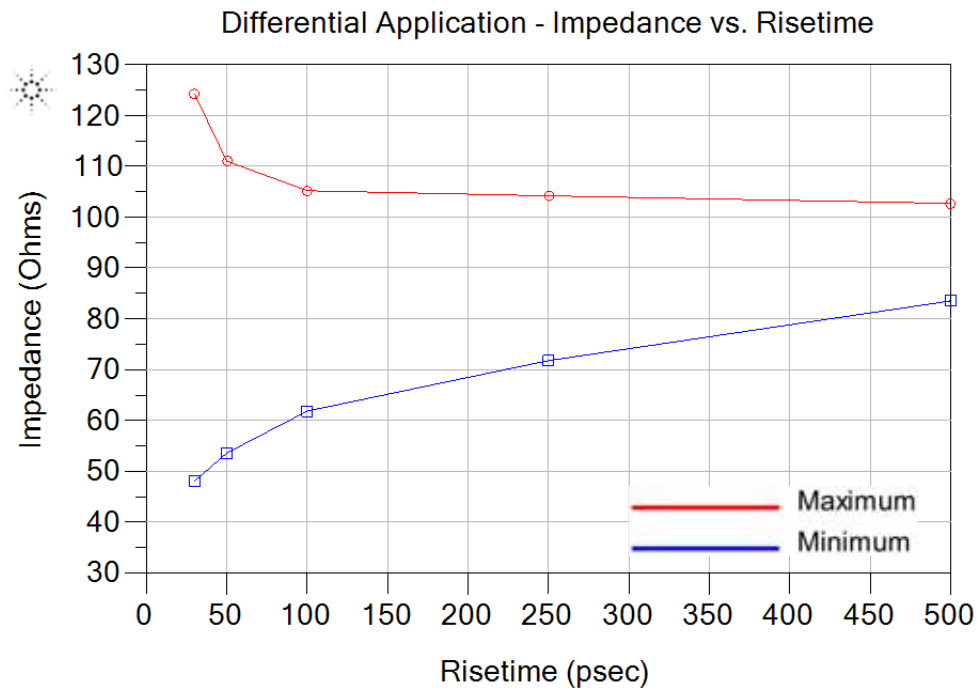
Table 5 – Long Row Differential Impedance ( $\Omega$ )					
Signal Risetime	30 ps	50 ps	100 ps	250 ps	500 ps
Maximum Impedance	101.3	101	100.8	100.4	100.4
Minimum Impedance	35.7	36.9	43.1	52.6	63.4



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Table 6 – Short Row Differential Impedance ( $\Omega$ )					
Signal Risetime	30 ps	50 ps	100 ps	250 ps	500 ps
Maximum Impedance	124.2	111	105.2	104.1	102.7
Minimum Impedance	48	53.5	61.8	71.7	83.5



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Table 7 - Single-Ended Crosstalk (%)							
Input(tr)	Configuration	Case	30ps	50 ps	100 ps	250 ps	500 ps
NEXT	GAQG	Long Row	28.2	25.2	21.8	19.5	14.3
		Short Row	24.4	21.4	18.3	14.8	9.2
	GAGQG	Long Row	9.3	8.3	5.7	2.7	1.9
		Short Row	8	6.3	3.8	1.9	1.4
	Xrow	-	0.2	0.1	<0.1	<0.1	<0.1
FEXT	GAQG	Long Row	11.3	8	5	4.3	2.7
		Short Row	10.7	8.1	4.1	1.2	0.4
	GAGQG	Long Row	12.3	10.2	6.5	2.9	1.3
		Short Row	13.2	10.6	6.6	2.7	1.3
	Xrow	-	0.1	0.1	<0.1	<0.1	<0.1

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Table 8 - Differential Crosstalk (%)							
Input(tr)	Configuration	Case	30ps	50 ps	100 ps	250 ps	500 ps
NEXT	GAQG	Long Row	6.8	6.5	6.1	5.7	4.4
		Short Row	7.3	6.5	5.5	4.5	2.9
	GAGQG	Long Row	2	1.3	0.8	0.3	0.2
		Short Row	2	1.6	0.9	0.5	0.3
	Xrow	-	<0.1	<0.1	<0.1	<0.1	<0.1
	FEXT	GAQG	Long Row	4.9	4.6	3.9	2.9
Short Row			2.4	2.1	1.9	1.3	0.7
GAGQG		Long Row	1.8	1.2	0.7	0.3	0.1
		Short Row	1.7	1.4	0.9	0.3	0.1
Xrow		-	<0.1	<0.1	<0.1	<0.1	<0.1

Table 9 - Propagation Delay (Mated Connector)		
Configuration	Case	Delay (ps)
Single-Ended	Long Row	204
	Short Row	130
Differential	Long Row	193
	Short Row	132

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### Characterization Details

This report presents data that 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 connector pair 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 connector'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 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 both differential and single-ended drive scenarios.

### 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. However, dedicating pins to ground reduces signal density of a connector. Therefore, care must be taken when choosing signal/ground ratios in cost or density-sensitive applications.

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For this connector, the following array configurations are evaluated:

Single-Ended Impedance:

- GSG (ground-signal-ground)

Single-Ended Crosstalk:

- Electrical “worst case”: GAQG (ground-active-quiet-ground)
- Electrical “best case”: GAGQG (ground-active-ground-quiet-ground)
- Across row: “xrow case”: GAG to GQG (from one row of terminals to the other row)

Differential Impedance:

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

Differential Crosstalk:

- Electrical “worst case”: GAAQQG (ground-active-active-quiet-quiet-ground)
- Electrical “best case”: GAAGQQG (ground-active-active-ground-quiet-quiet-ground)
- Across row: “xrow case”: GAAG to GQQG (from one row of terminals to the other row)

Only one single-ended signal or differential pair was driven for crosstalk measurements. Other configurations can be evaluated upon request. Please contact [sig@samtec.com](mailto: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. However, in most applications, performance can safely be considered equivalent.

Signal Edge Speed (Rise Time):

In pulse signaling applications, the perceived performance of the interconnect can vary significantly depending on the edge rate or rise time of the exciting signal. For this report, the fastest rise time used was 30 ps. Generally, this should demonstrate worst-case performance.

In many systems, the signal edge rate will be significantly slower at the connector than at the driver launch point. To estimate interconnect performance at other edge rates, data is provided for several rise times between 30ps and 500ps.

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

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### 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](mailto: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, signal propagation time, and crosstalk in a pulsed signal environment. The measured S-Parameters from the network analyzer are post-processed using Agilent Advanced Design System to obtain the time domain response. Time Domain procedure 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](mailto:sig@samtec.com) for more information.

In this report, propagation delay is defined as the signal propagation time through the connector and connector footprint. It includes 10 mils of PCB trace on the QTH-RA connector side and 10 mils of PCB trace on the QSH-RA connector side. Delay is measured at 30 picoseconds signal rise-time. Delay is calculated as the difference in time measured between the 50% amplitude levels of the input and output pulses.

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](mailto: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. However, 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](mailto:sig@samtec.com).



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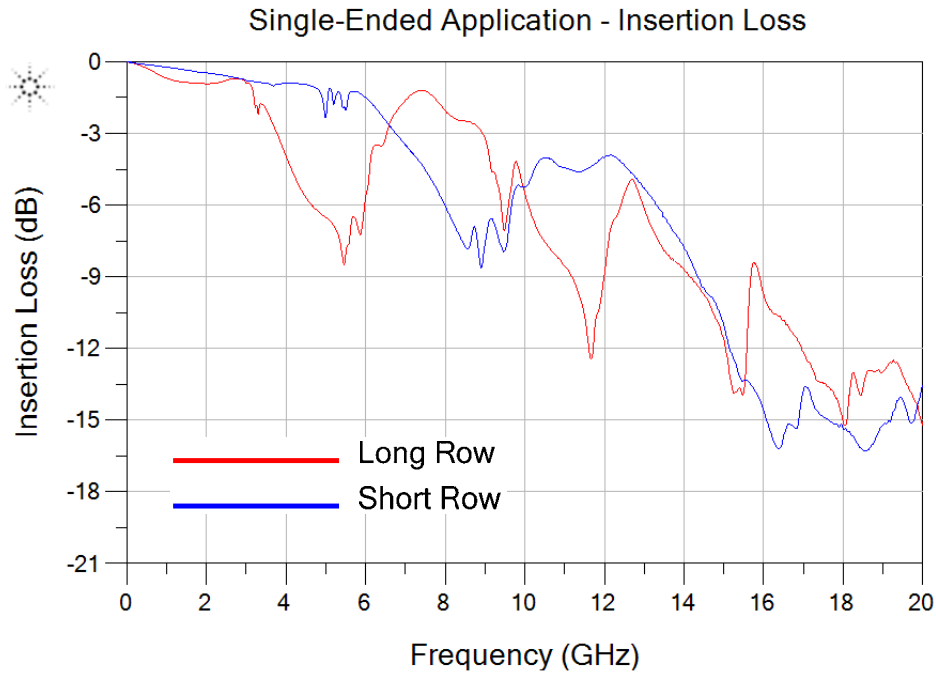
Additional information concerning test conditions and procedures is located in the appendices of this report. Further information may be obtained by contacting our Signal Integrity Group at [sig@samtec.com](mailto:sig@samtec.com).

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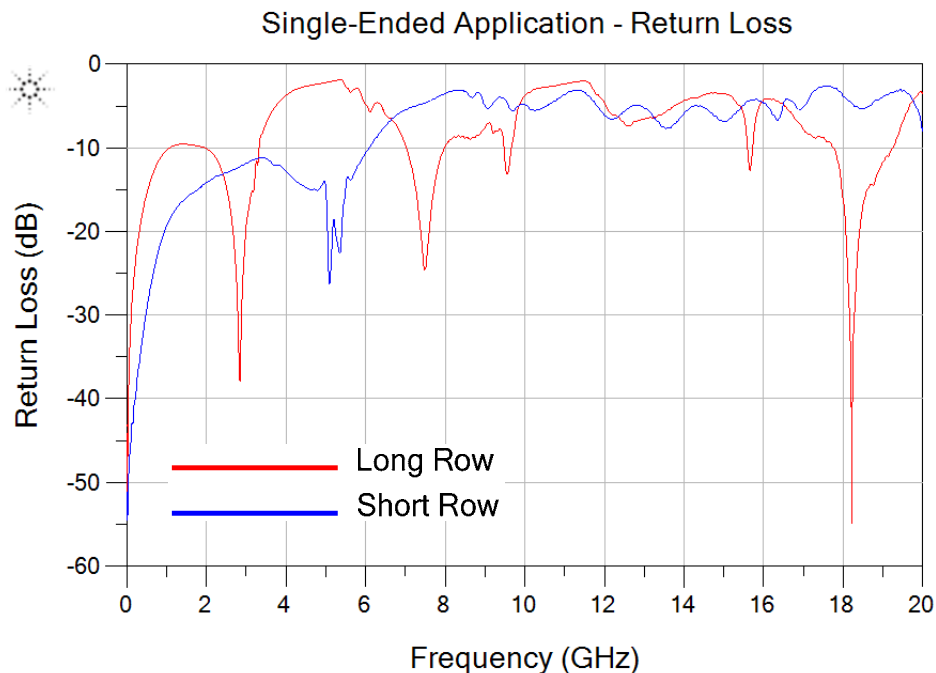
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## Appendix A – Frequency Domain Response Graphs

### Single-Ended Application – Insertion Loss



### Single-Ended Application – Return Loss

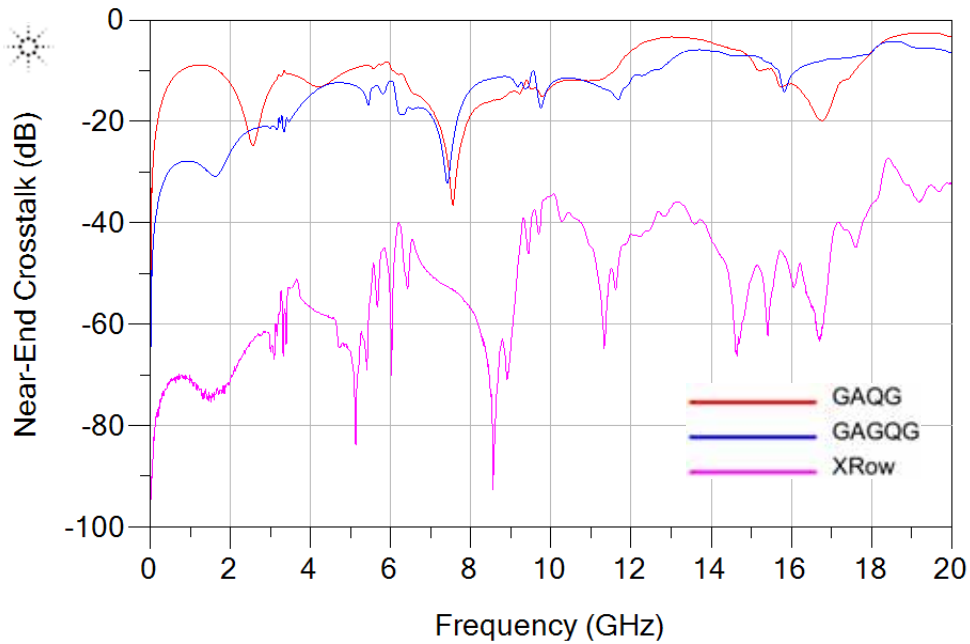


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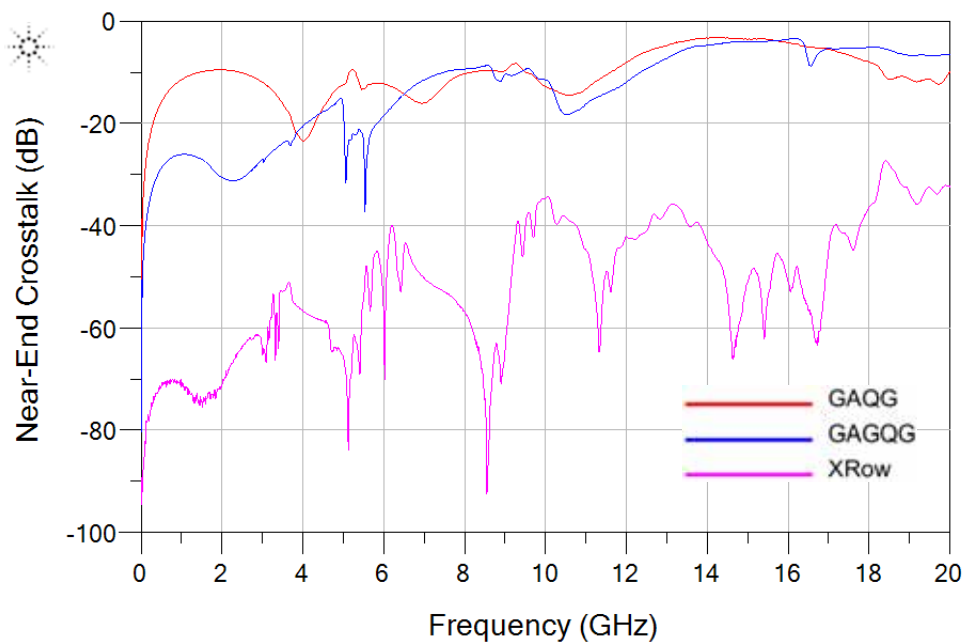
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## Single-Ended Application – NEXT Configurations

Single-Ended Application - NEXT - Long Row



Single-Ended Application - NEXT - Short Row

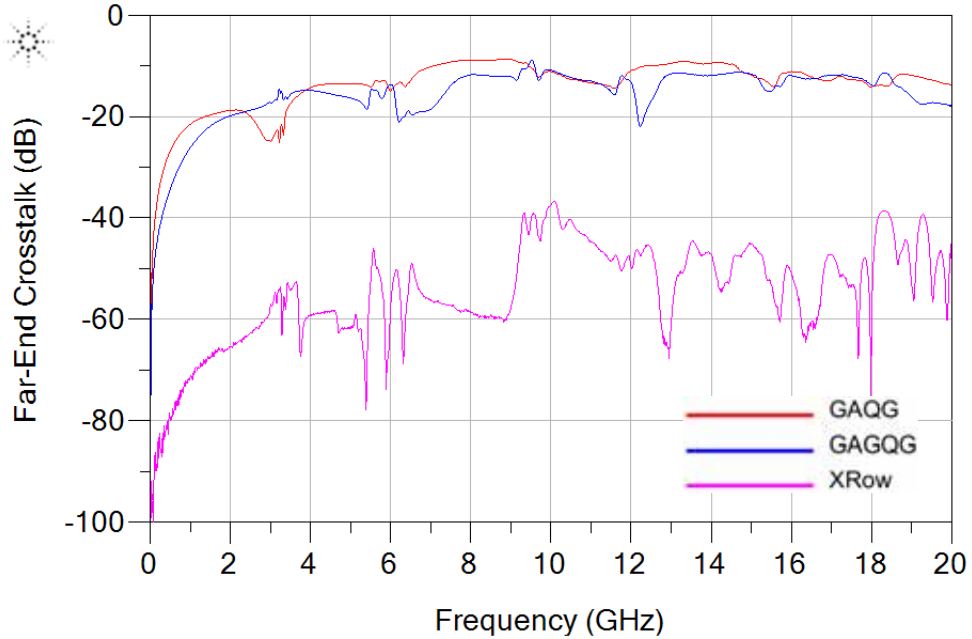


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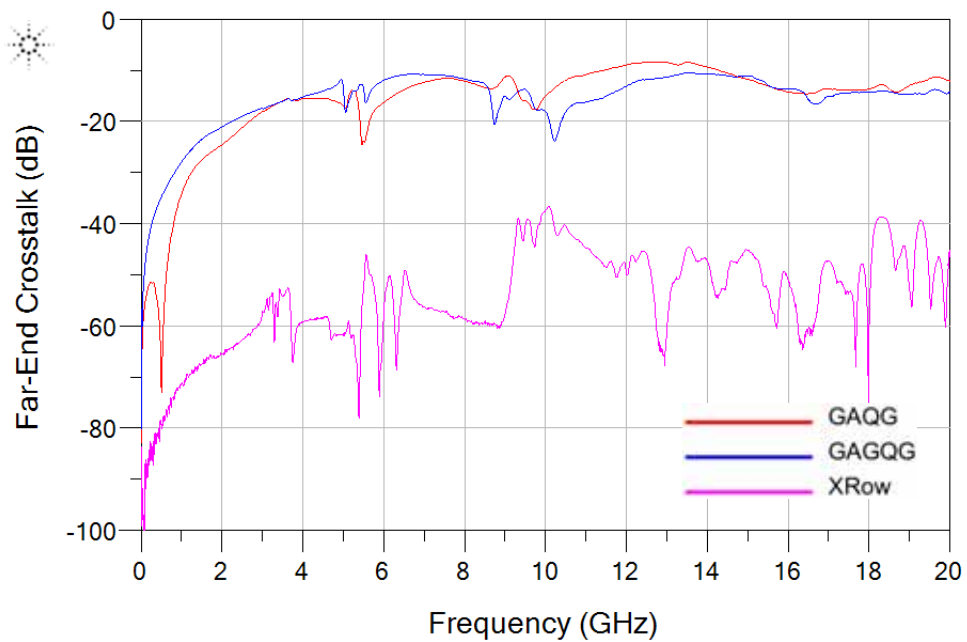
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Single-Ended Application – FEXT Configurations

Single-Ended Application - FEXT - Long Row



Single-Ended Application - FEXT - Short Row

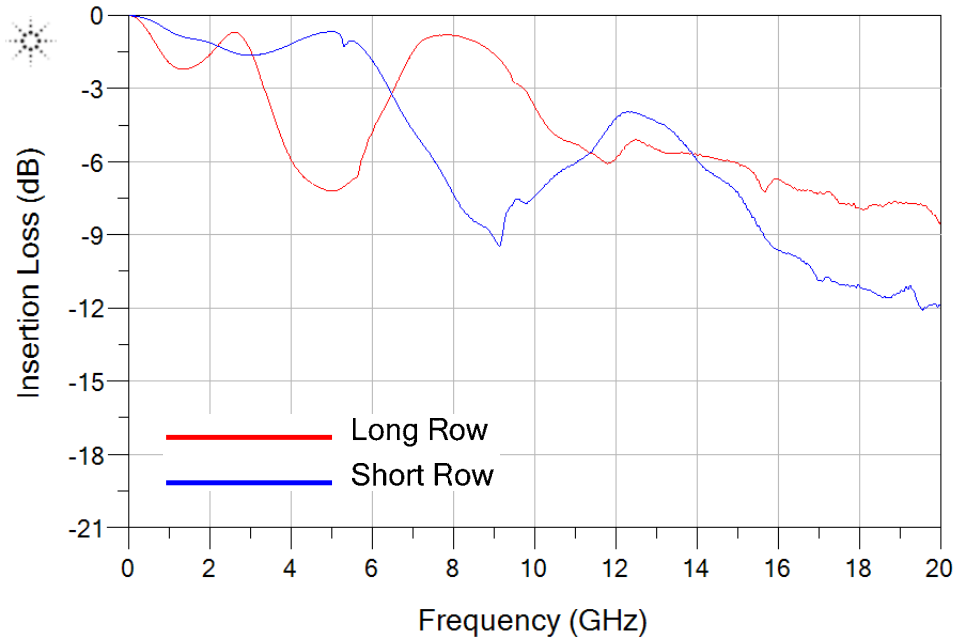


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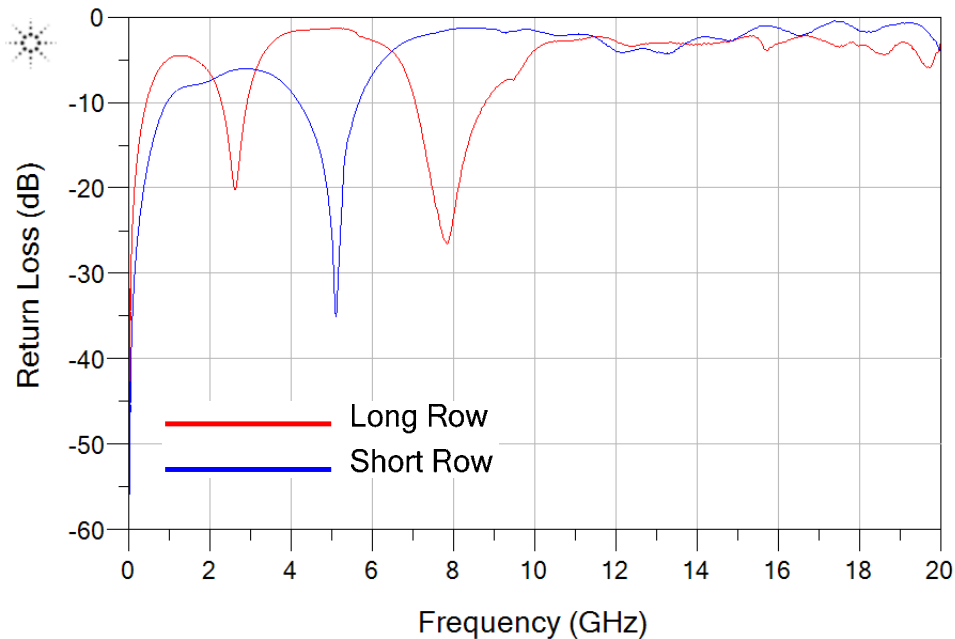
## Differential Application – Insertion Loss

Differential Application - Insertion Loss



## Differential Application – Return Loss

Differential Application - Return Loss

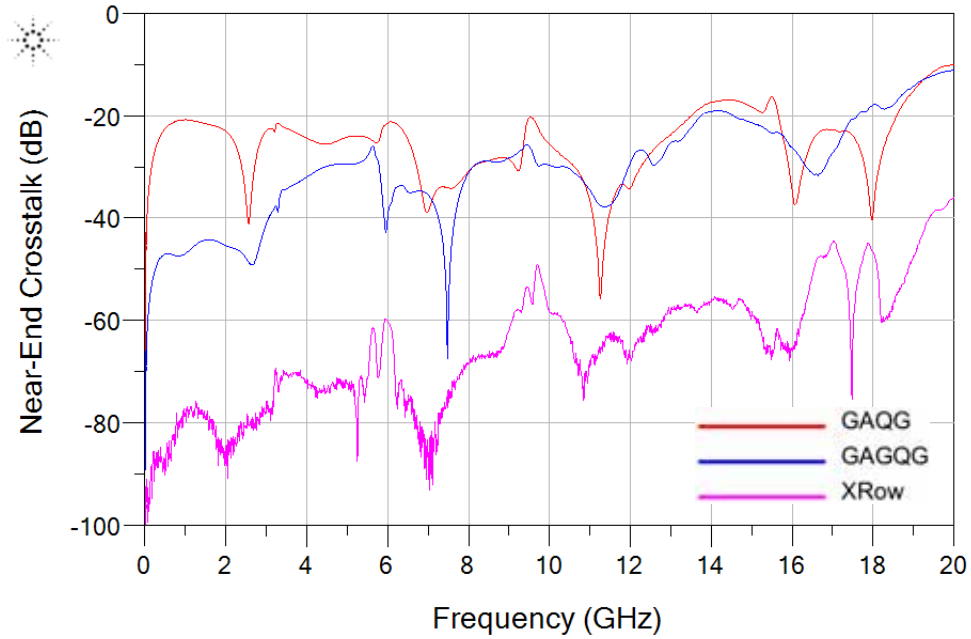


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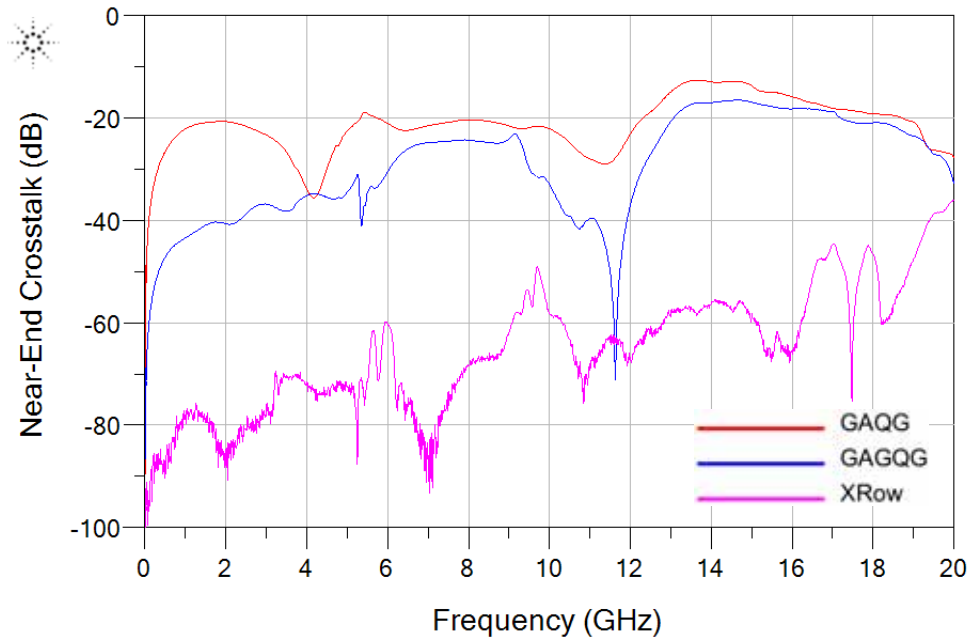
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Differential Application – NEXT Configurations

Differential Application - NEXT - Long Row



Differential Application - NEXT - Short Row

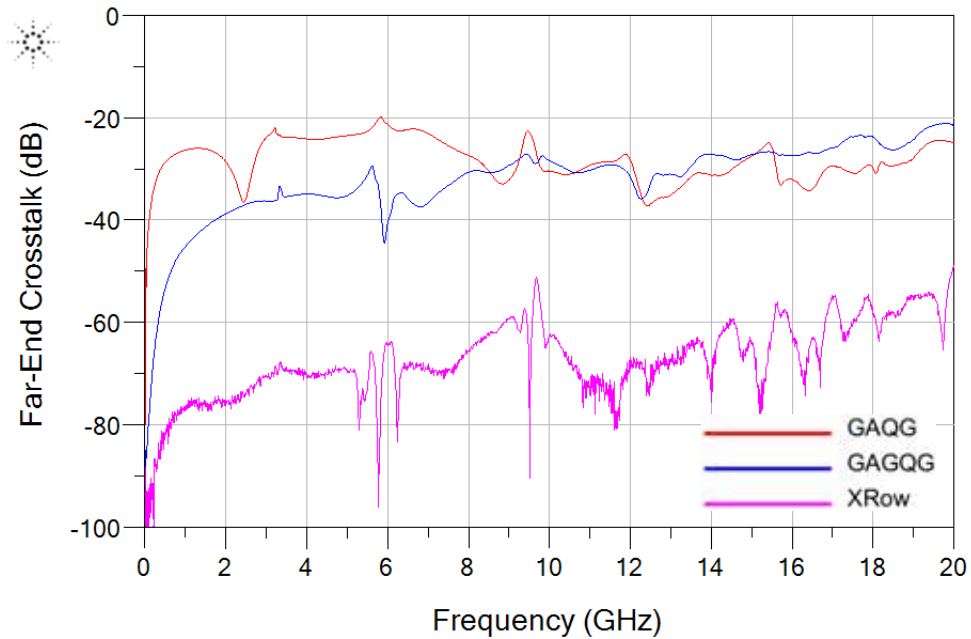


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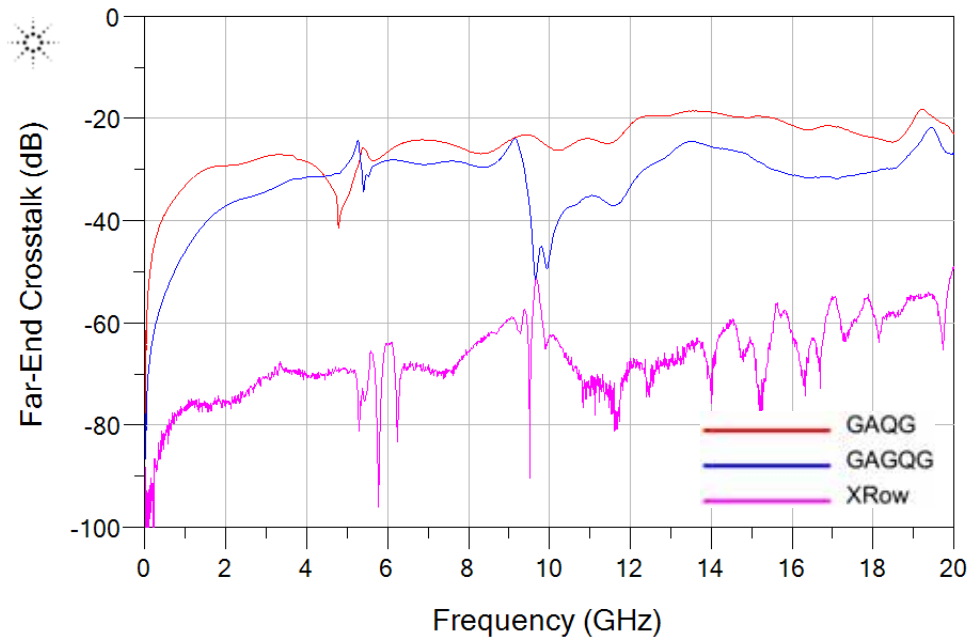
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Differential Application – FEXT Configurations

Differential Application - FEXT - Long Row



Differential Application - FEXT - Short Row



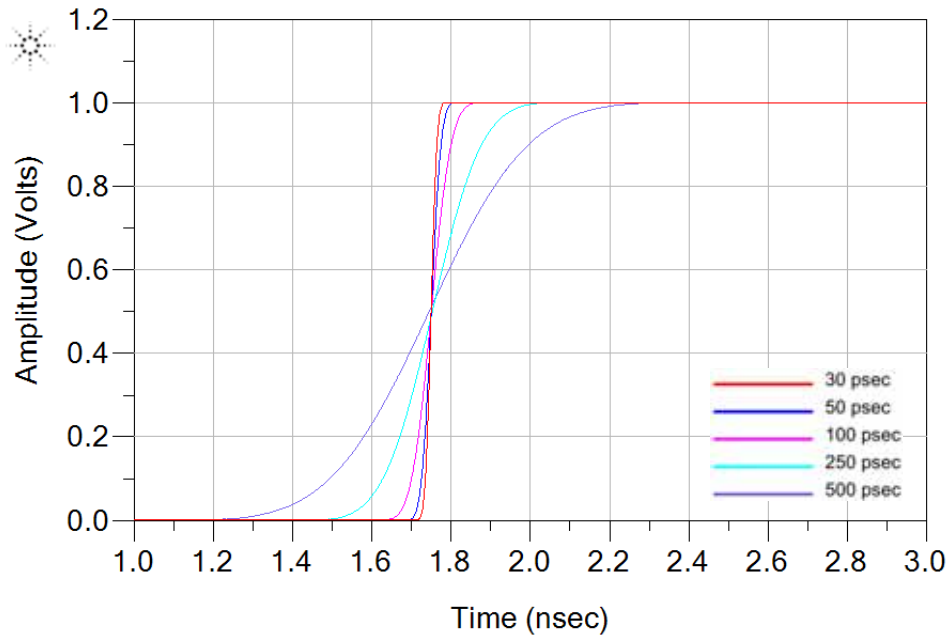
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## Appendix B – Time Domain Response Graphs

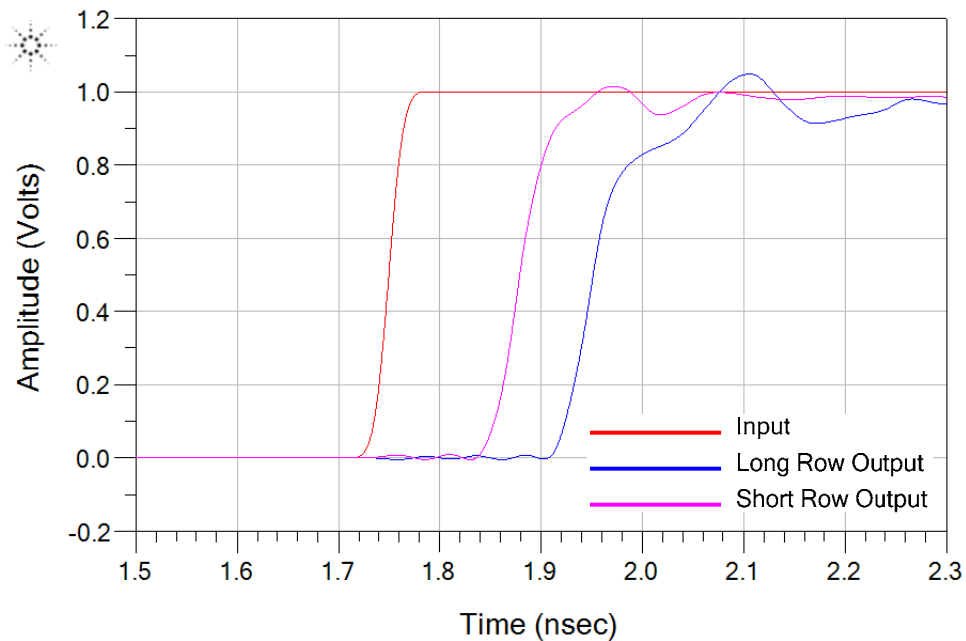
### Single-Ended Application – Input Pulse

Single-Ended Application - Input Pulse



### Single-Ended Application – Propagation Delay

Single-Ended Application - Propagation Delay

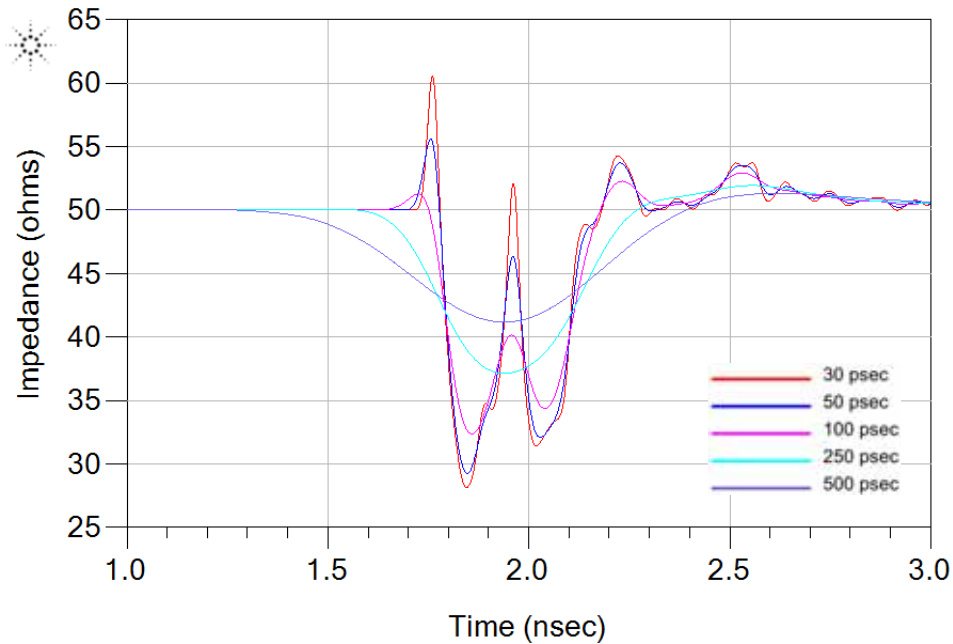


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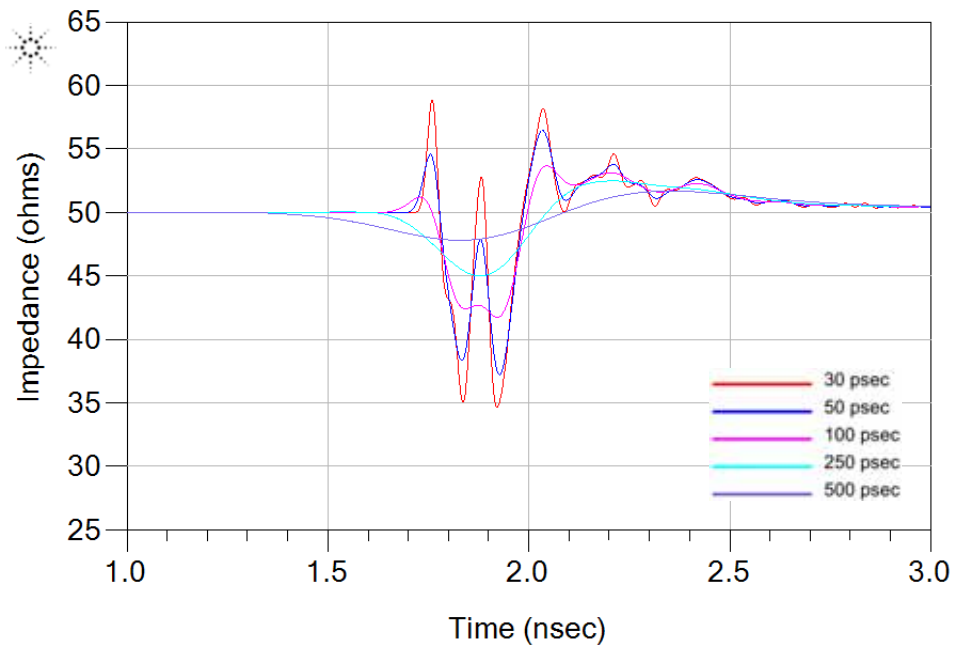
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## Single-Ended Application – Impedance

Single-Ended Application - Impedance - Long Row



Single-Ended Application - Impedance - Short Row

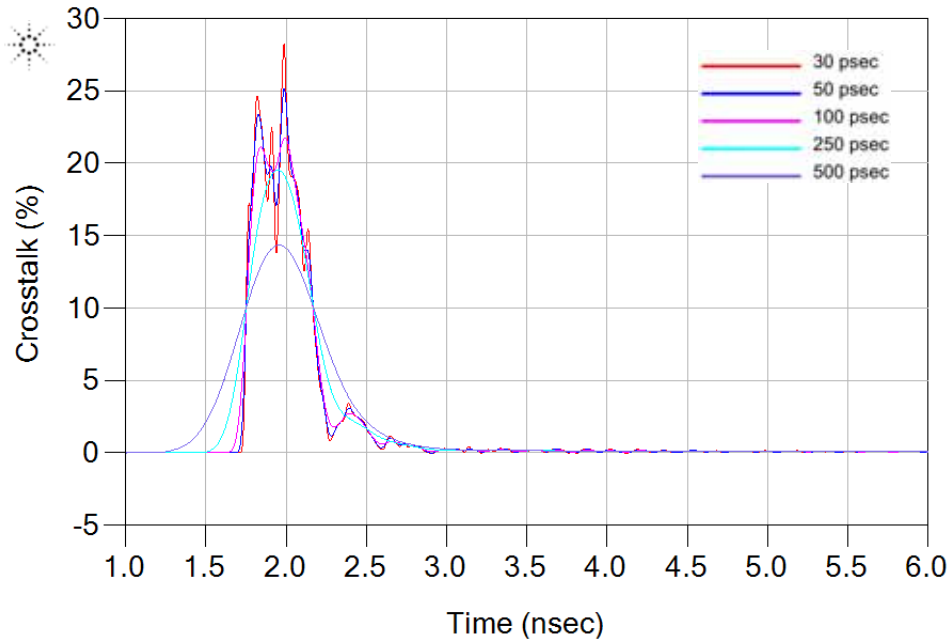


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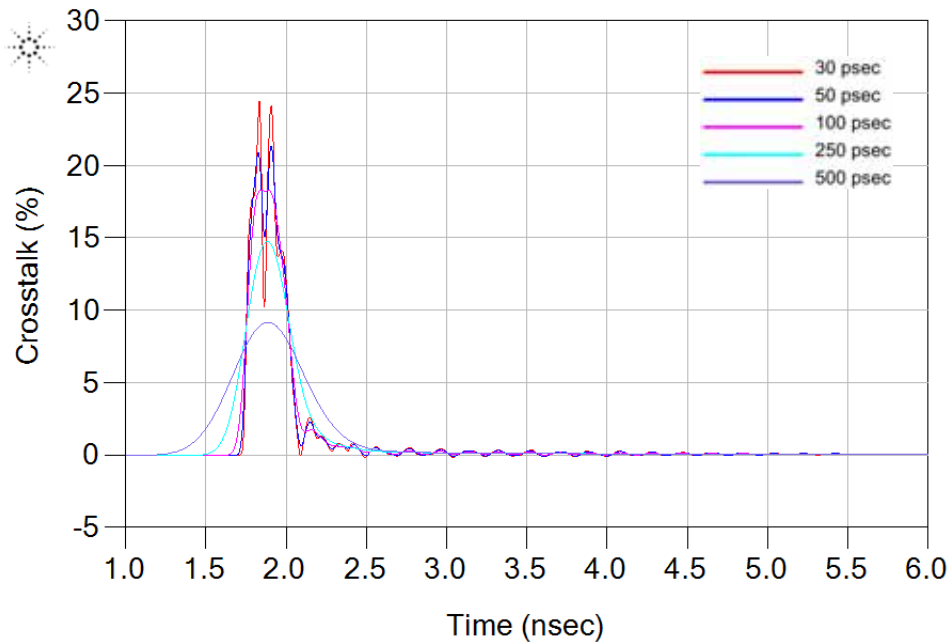
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Single-Ended Application – NEXT, Worst Case Configuration

Single-Ended Application - NEXT - Long Row



Single-Ended Application - NEXT - Short Row

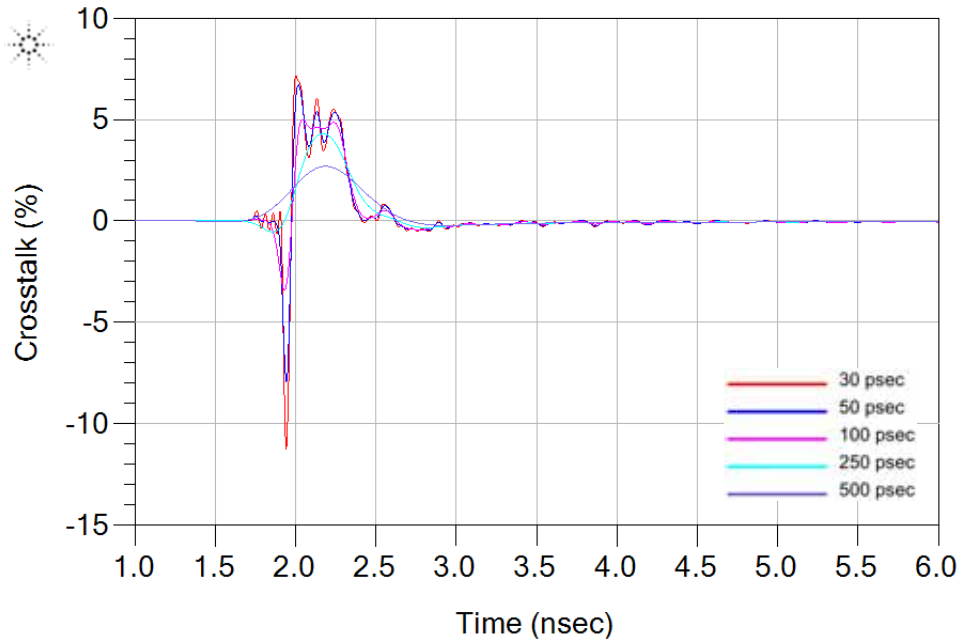


**Series:** QTH-RA/QSH-RA

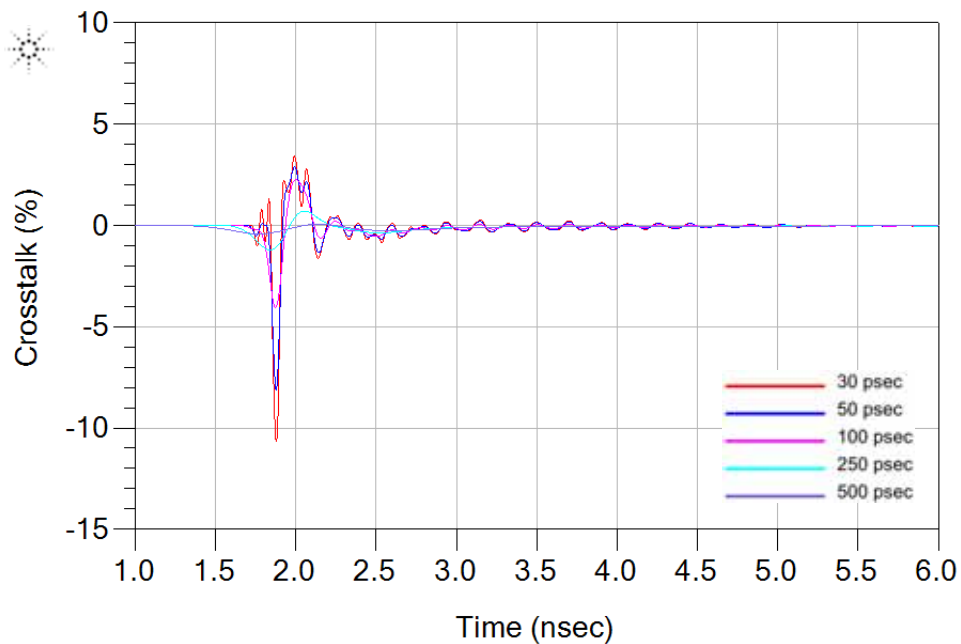
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Single-Ended Application – FEXT, Worst Case Configuration

Single-Ended Application - FEXT - Long Row



Single-Ended Application - FEXT - Short Row

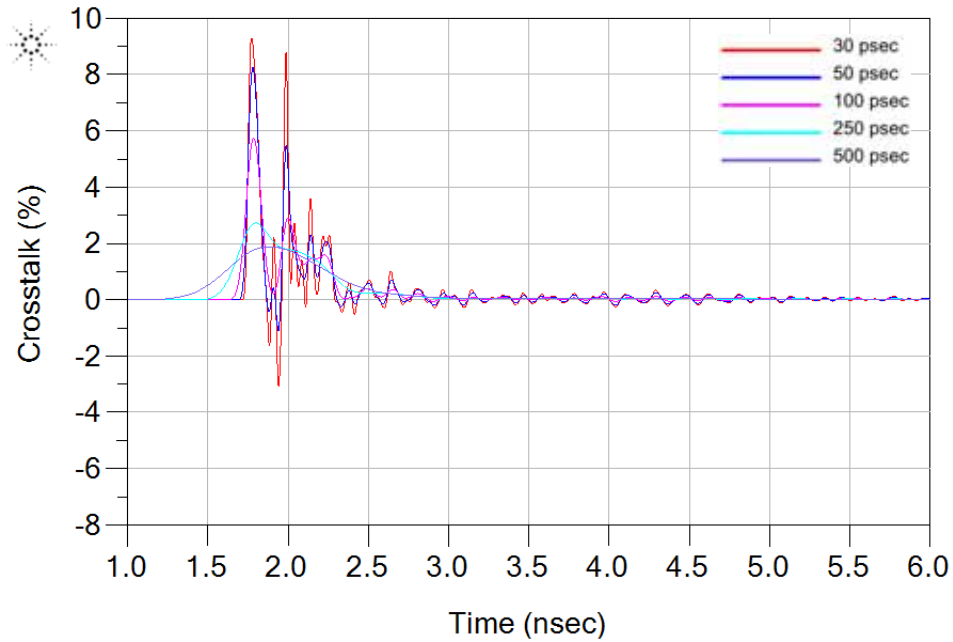


**Series:** QTH-RA/QSH-RA

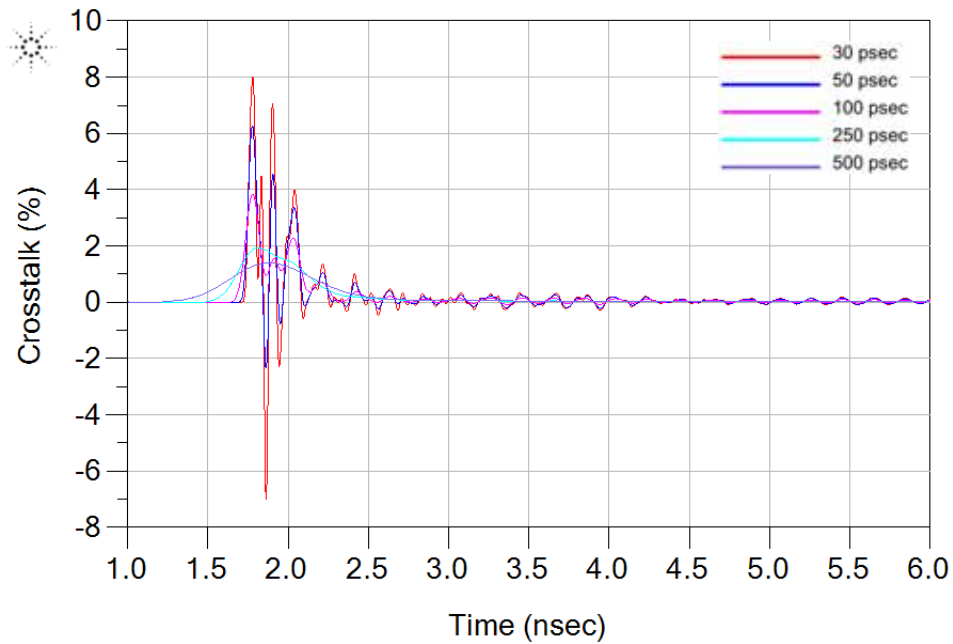
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Single-Ended Application – NEXT, Best Case Configuration

Single-Ended Application - NEXT - Long Row



Single-Ended Application - NEXT - Short Row

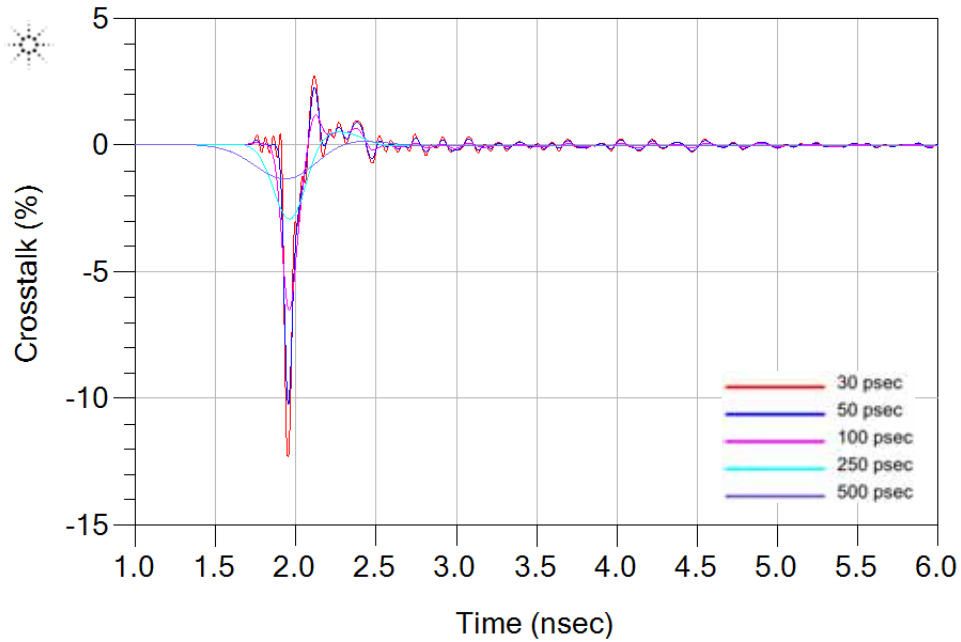


**Series:** QTH-RA/QSH-RA

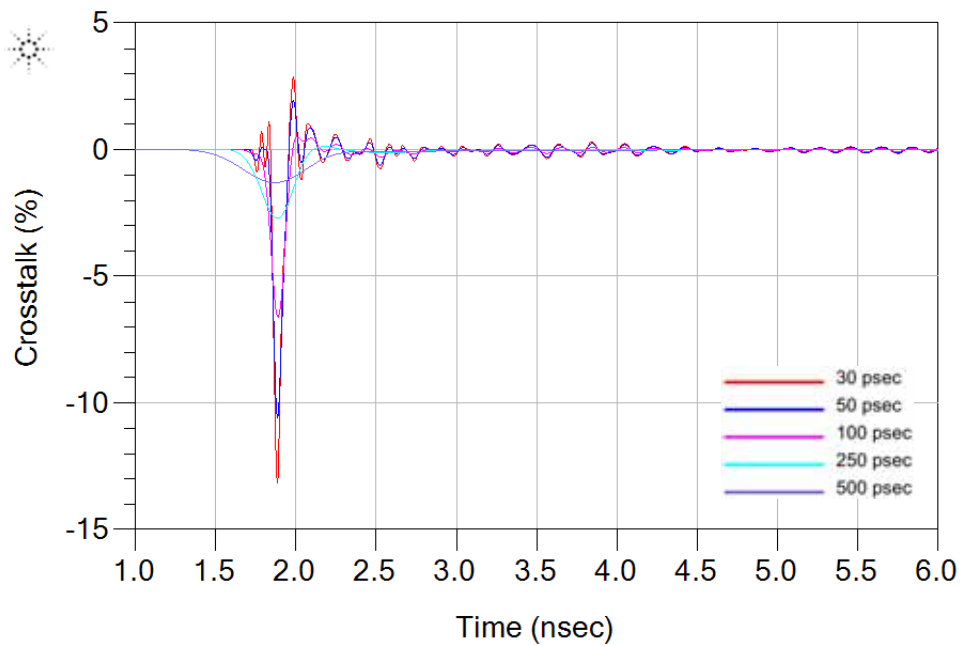
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Single-Ended Application – FEXT, Best Case Configuration

Single-Ended Application - FEXT - Long Row



Single-Ended Application - FEXT - Short Row

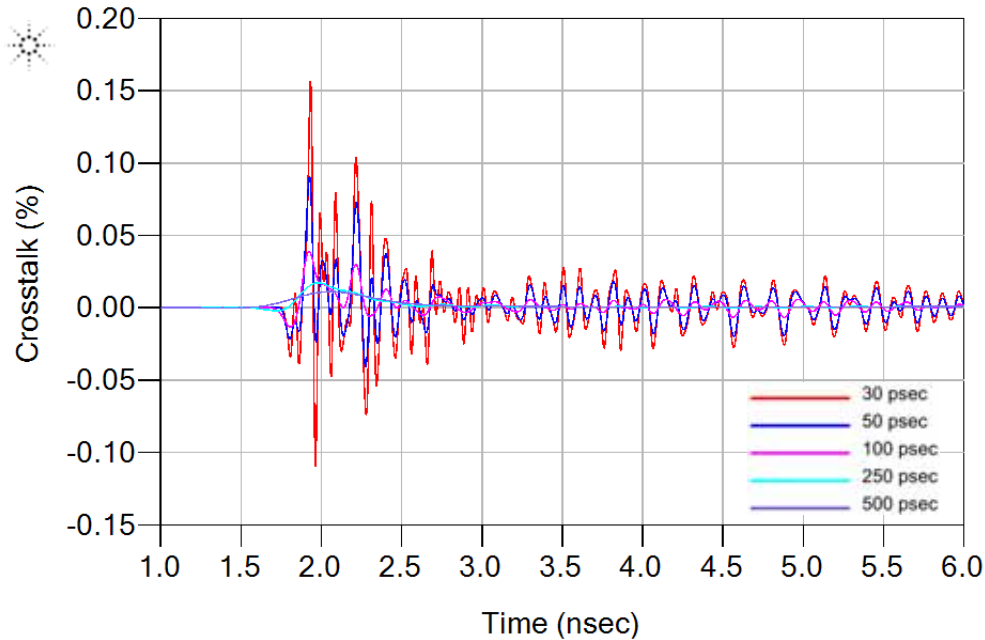


**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

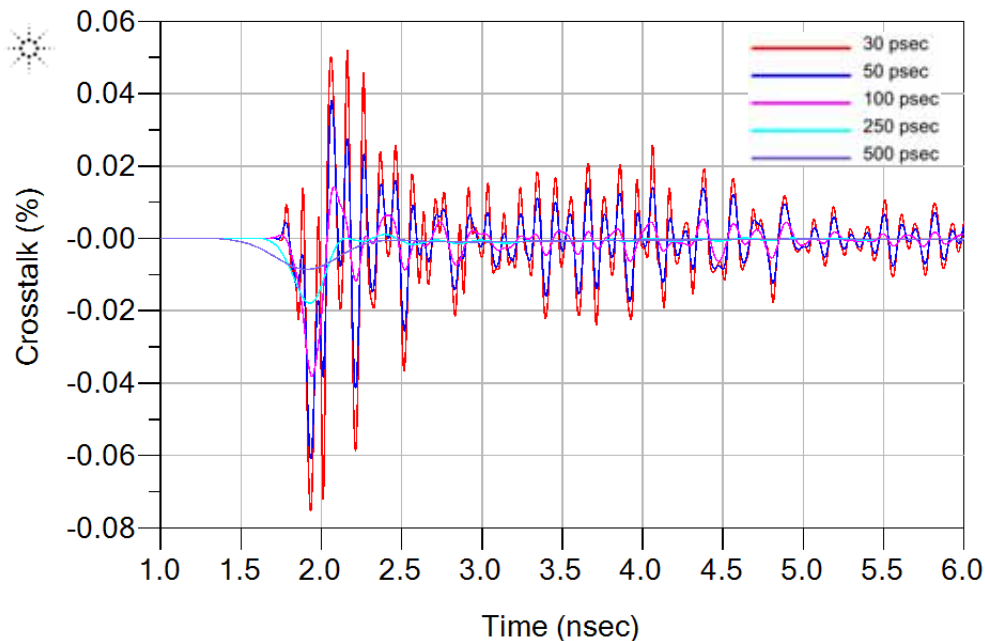
## Single-Ended Application – NEXT, Across Row Configuration

Single-Ended Application - NEXT



## Single-Ended Application – FEXT, Across Row Configuration

Single-Ended Application - FEXT

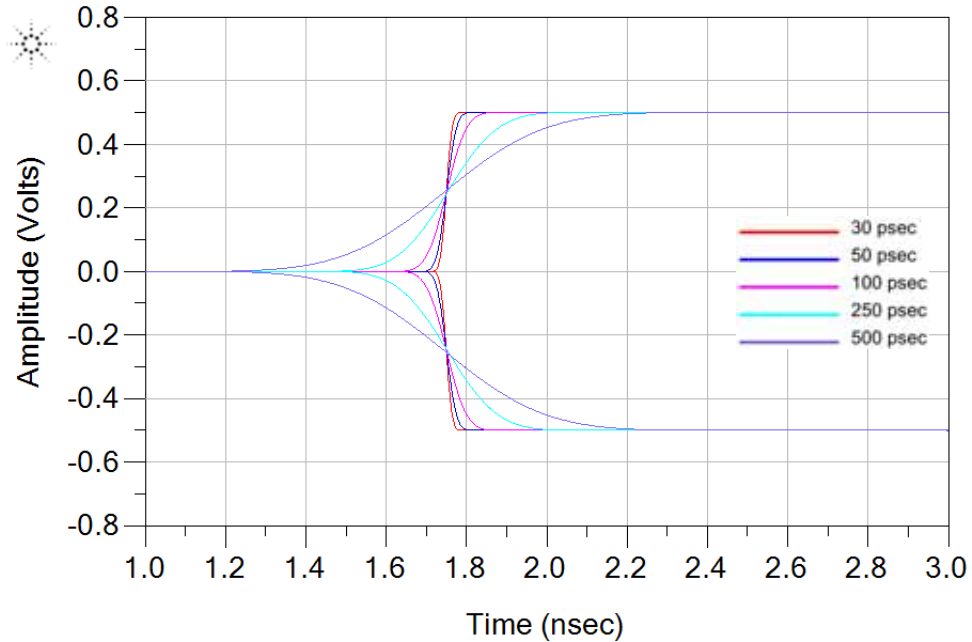


**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

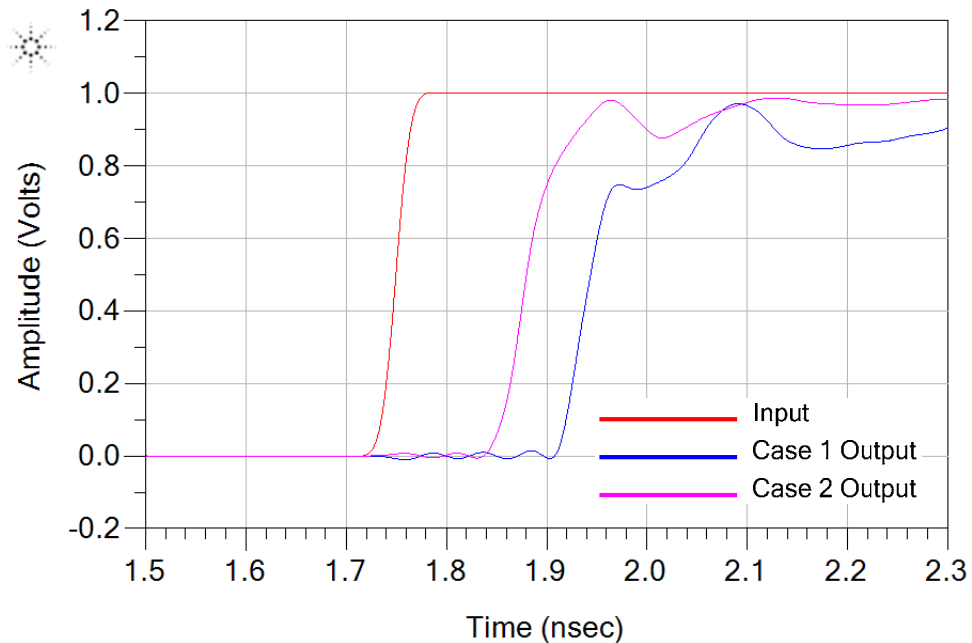
## Differential Application – Input Pulse

Differential Application - Input Pulse



## Differential Application – Propagation Delay

Differential Application - Propagation Delay

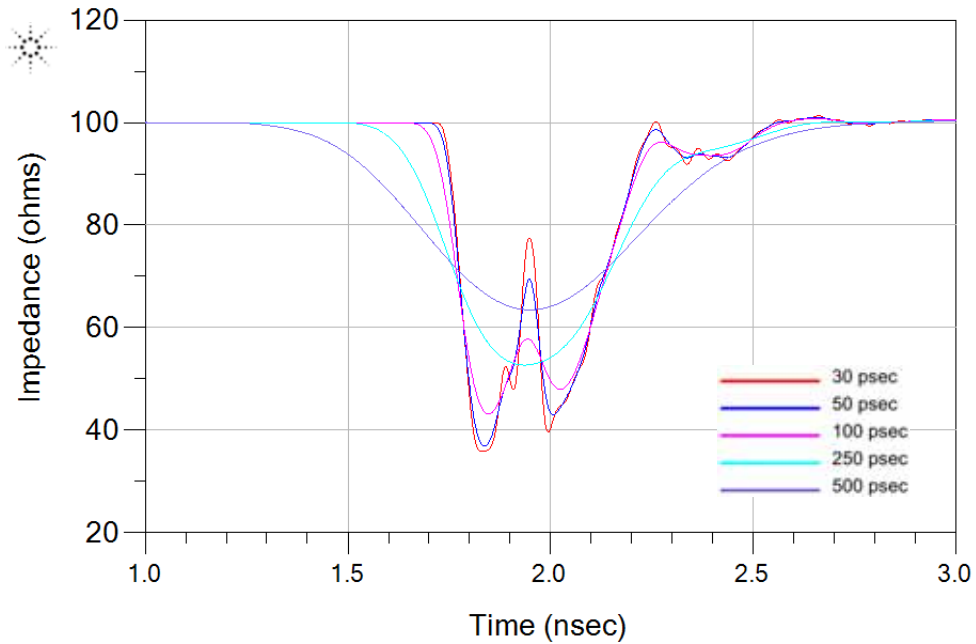


**Series:** QTH-RA/QSH-RA

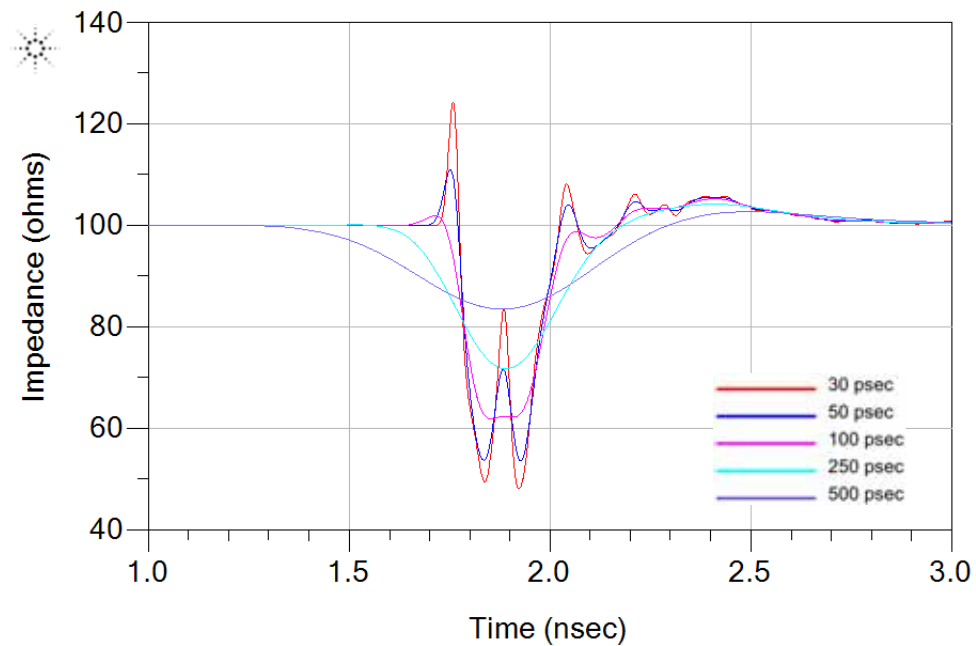
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Differential Application – Impedance

Differential Application - Impedance - Long Row



Differential Application - Impedance - Short Row

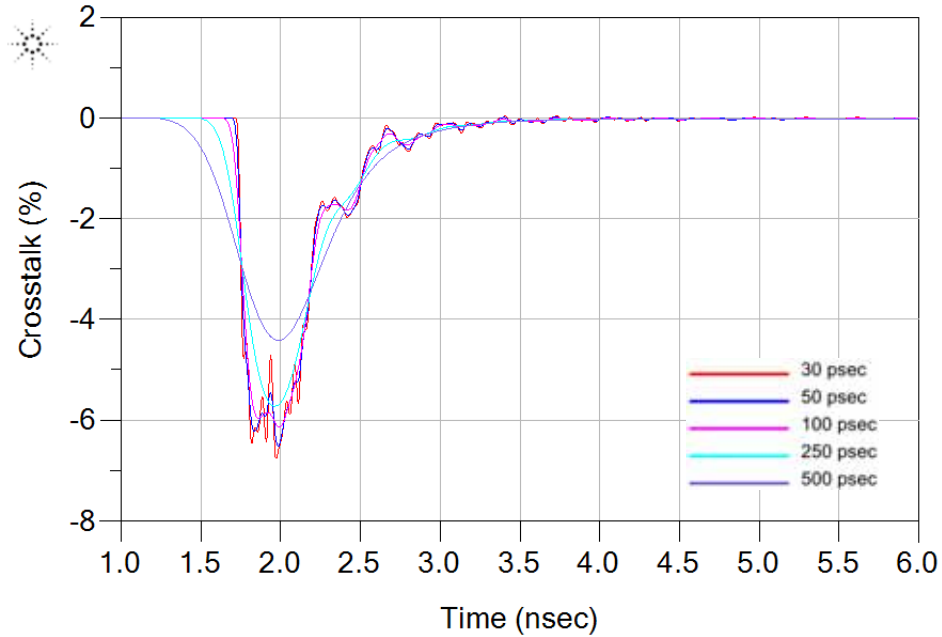


**Series:** QTH-RA/QSH-RA

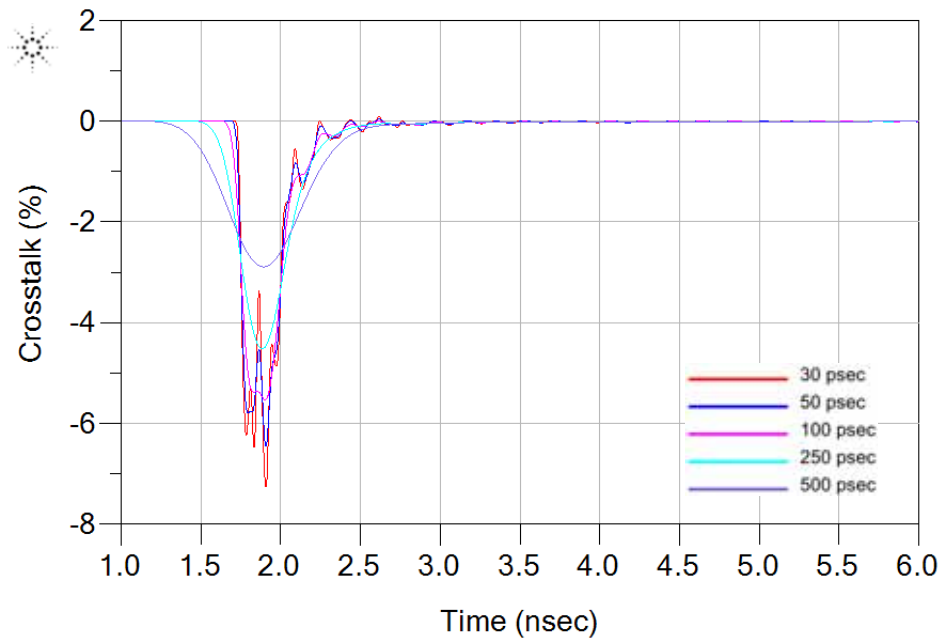
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Differential Application – NEXT, Worst Case Configuration

Differential Application - NEXT - Long Row



Differential Application - NEXT - Short Row

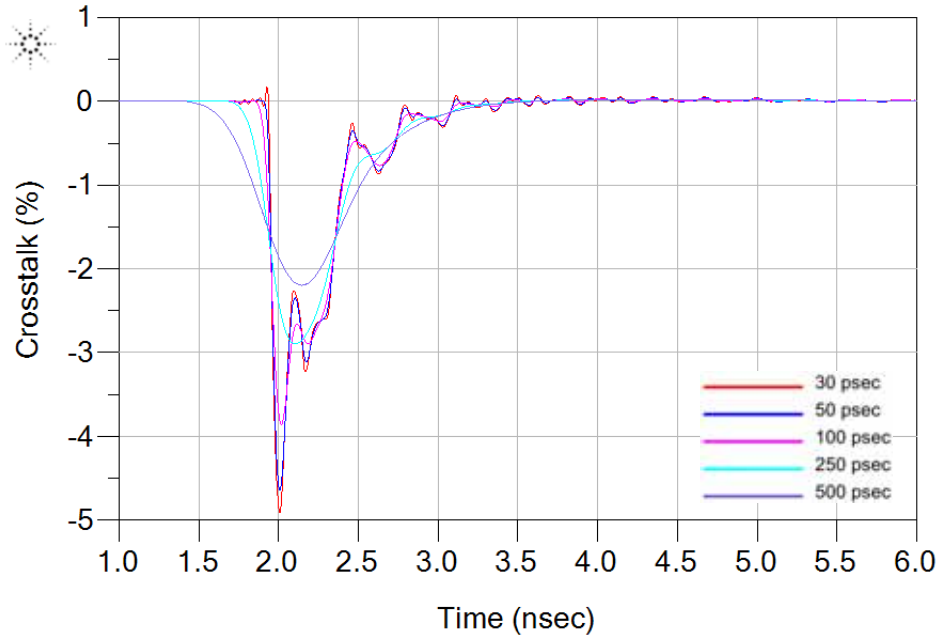


**Series:** QTH-RA/QSH-RA

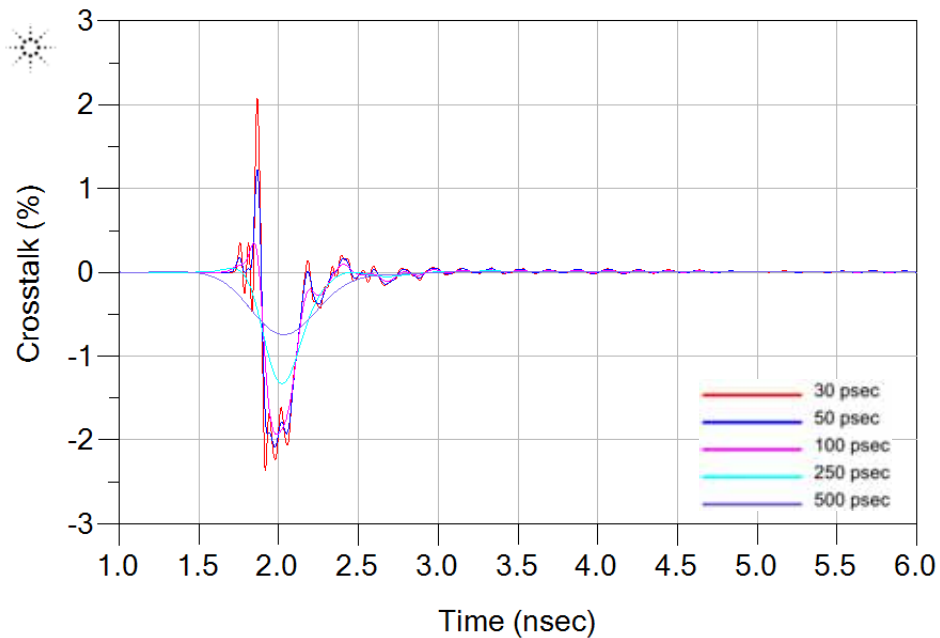
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Differential Application – FEXT, Worst Case Configuration

Differential Application - FEXT - Long Row



Differential Application - FEXT - Short Row

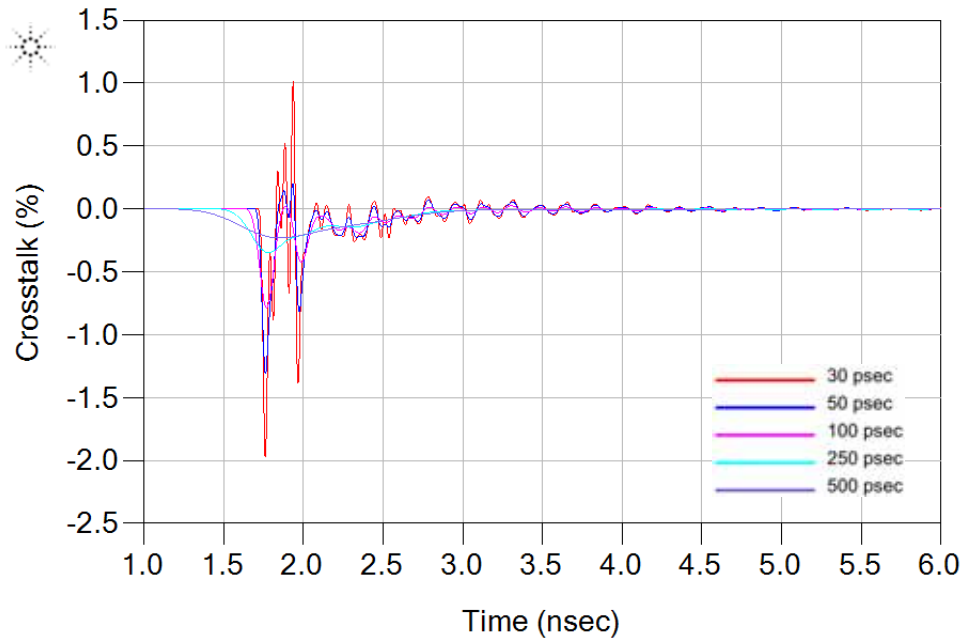


**Series:** QTH-RA/QSH-RA

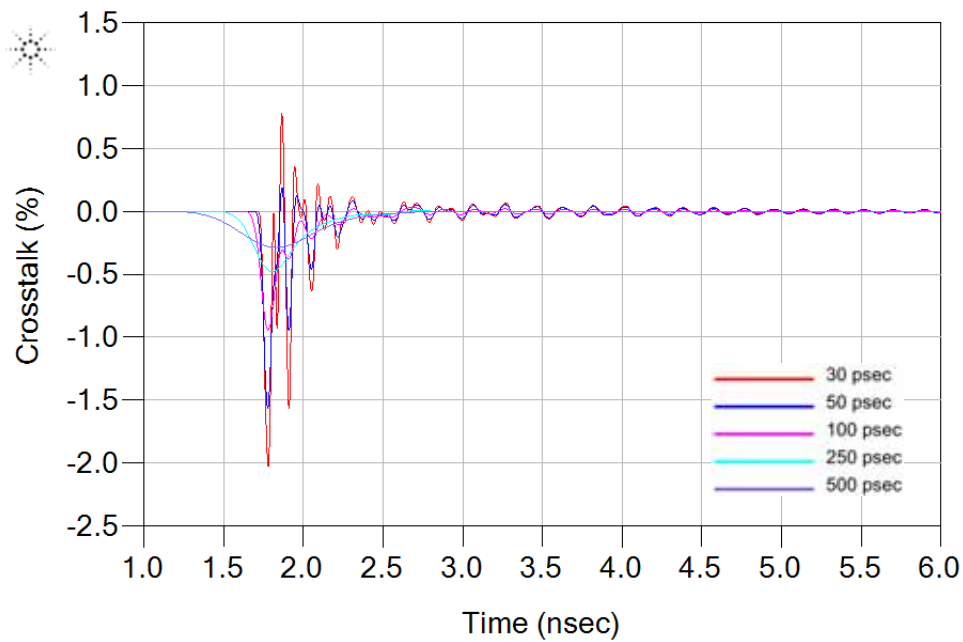
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

### Differential Application – NEXT, Best Case Configuration

Differential Application - NEXT - Long Row



Differential Application - NEXT - Short Row

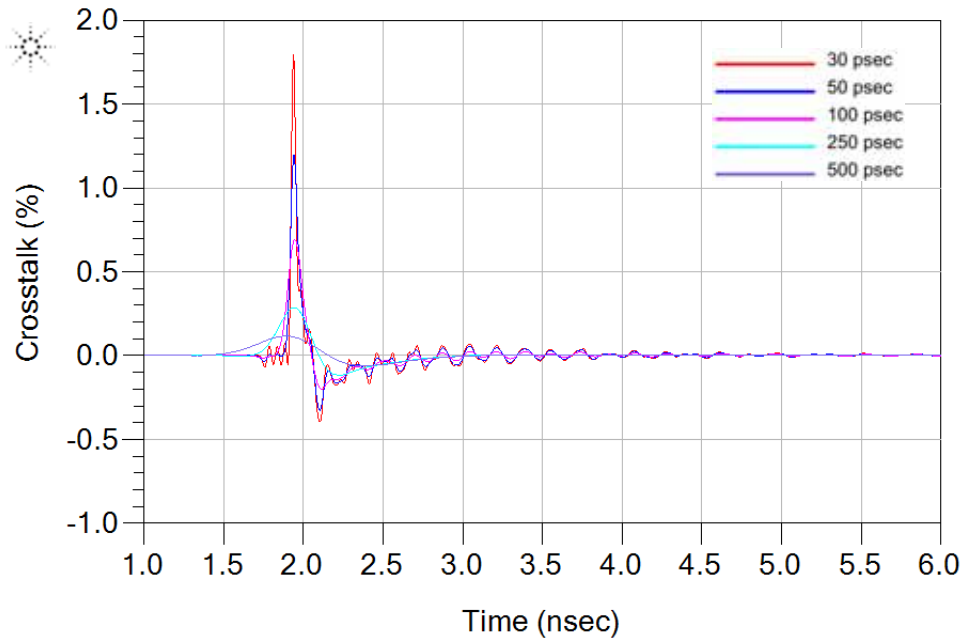


**Series:** QTH-RA/QSH-RA

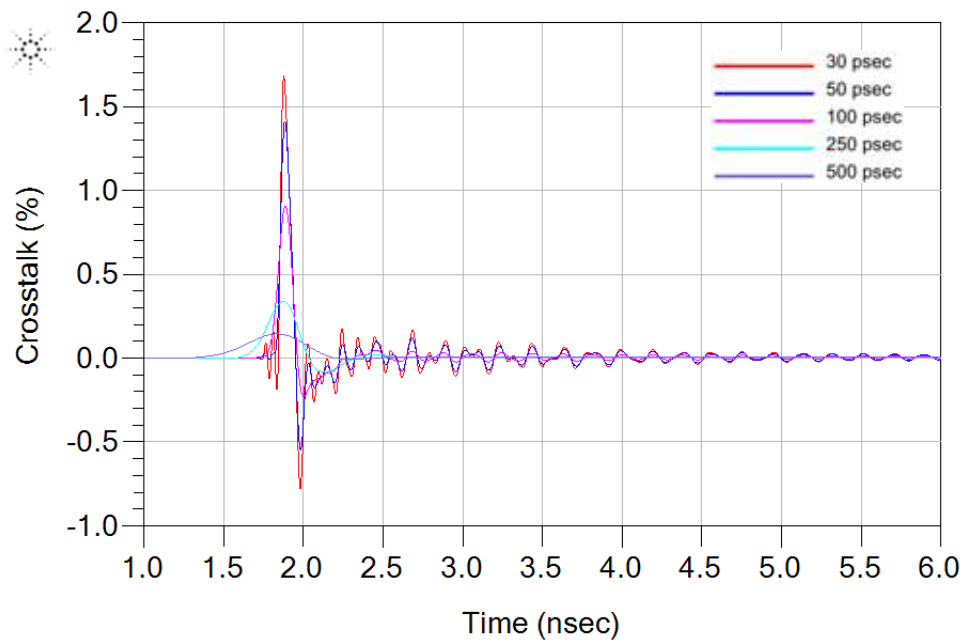
**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Differential Application – FEXT, Best Case Configuration

Differential Application - FEXT - Long Row



Differential Application - FEXT - Short Row

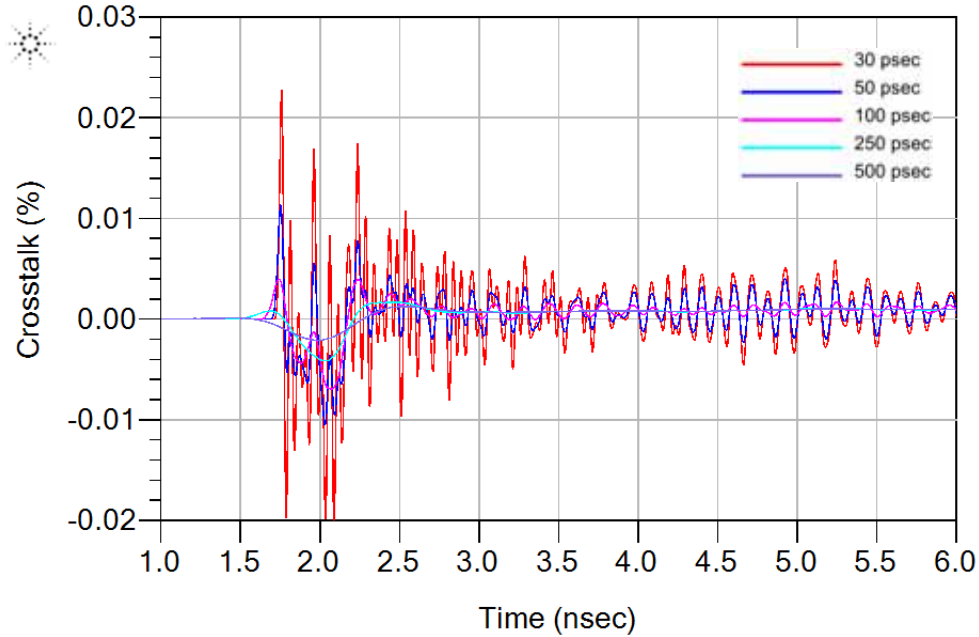


**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

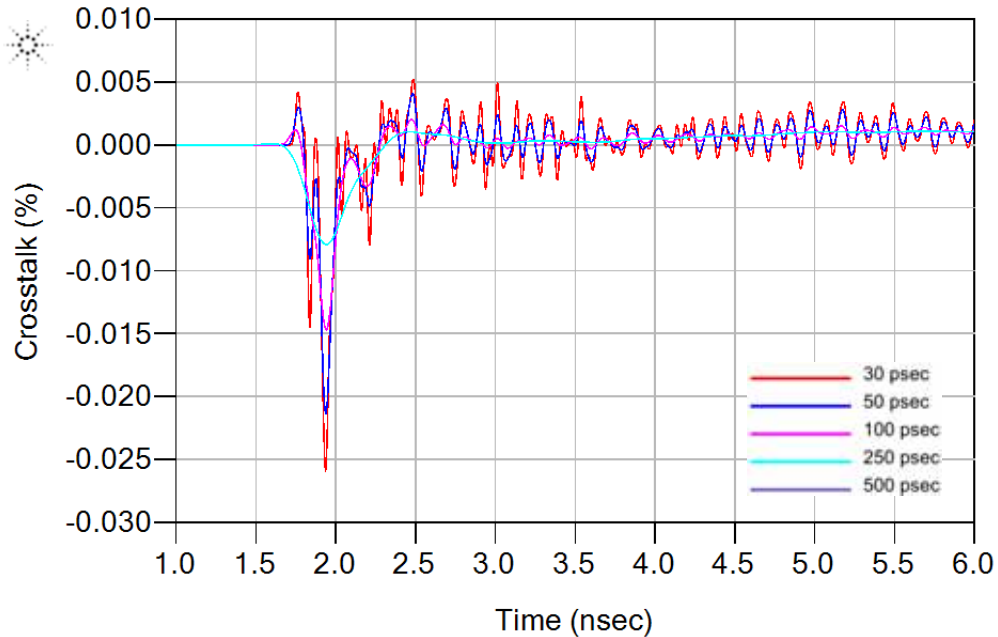
## Differential Application – NEXT, Across Row Case Configuration

Differential Application - NEXT



## Differential Application – FEXT, Across Row Case Configuration

Differential Application - FEXT



**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197”) Pitch

## Appendix C – Product and Test System Descriptions

### Product Description

Product test samples are QTH-RA/QSH-RA Q Rate® High-Speed Right-Angle Ground Plane Header. The part number is QTH-030-01-L-D-RA-WT and it mates to QSH-030-01-L-D-RA-WT. The connector has two rows of 30 contacts evenly spaced on a 0.5 mm (0.0197”) pitch. A photo of the mated test article mounted to SI test boards is shown at right.

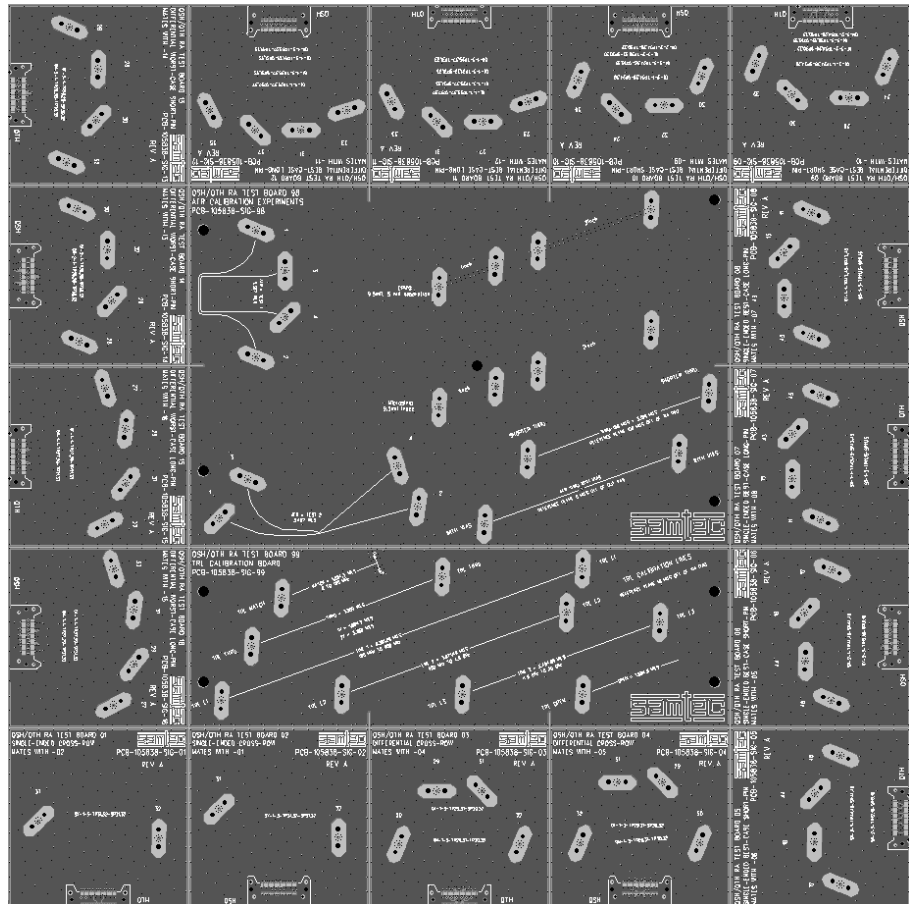


### Test System Description

The test fixtures are composed of four-layer FR-406 material with 50Ω signal trace and pad configurations designed for the electrical characterization of Samtec high speed connector products. A PCB mount SMA connector is used to interface the VNA test cables to the test fixtures. SMA launch optimization is attained using full wave simulation tools to minimize reflections. There are 18 test fixtures specific to the QTH-RA/QSH-RA series connector set.

Sixteen of the 18 fixtures mate to comprise a full hi-speed characterization test. The remaining boards contain the SMA/TRL calibration structures designed specifically for the QTH-RA/QSH-RA series. Displayed on the following pages is information for the SMA/TRL calibration structure and directives for mating QTH-RA/QSH-RA fixtures.

**PCB-105838-SIG-XX**  
**PCB Layout Panel**  
 Panel includes test boards for QTH-RA/QSH-RA.



**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

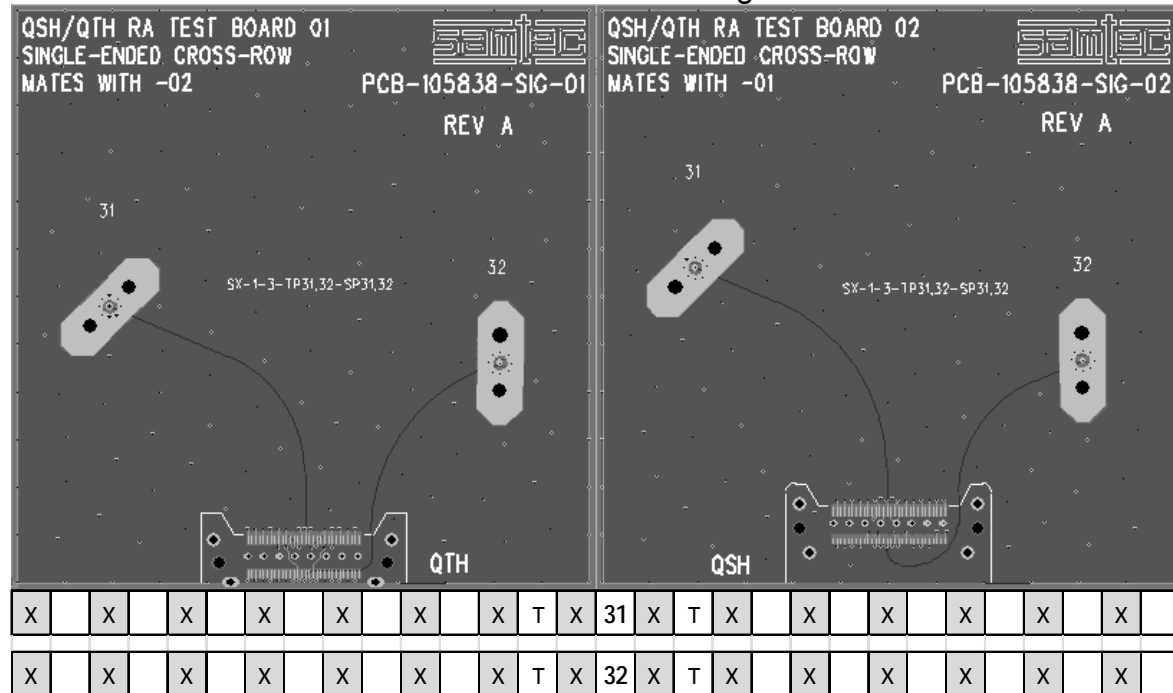
## PCB Fixtures

The test fixtures used are as follows:

Open pin     Ground Pin

P# Signal Pins     T Termination

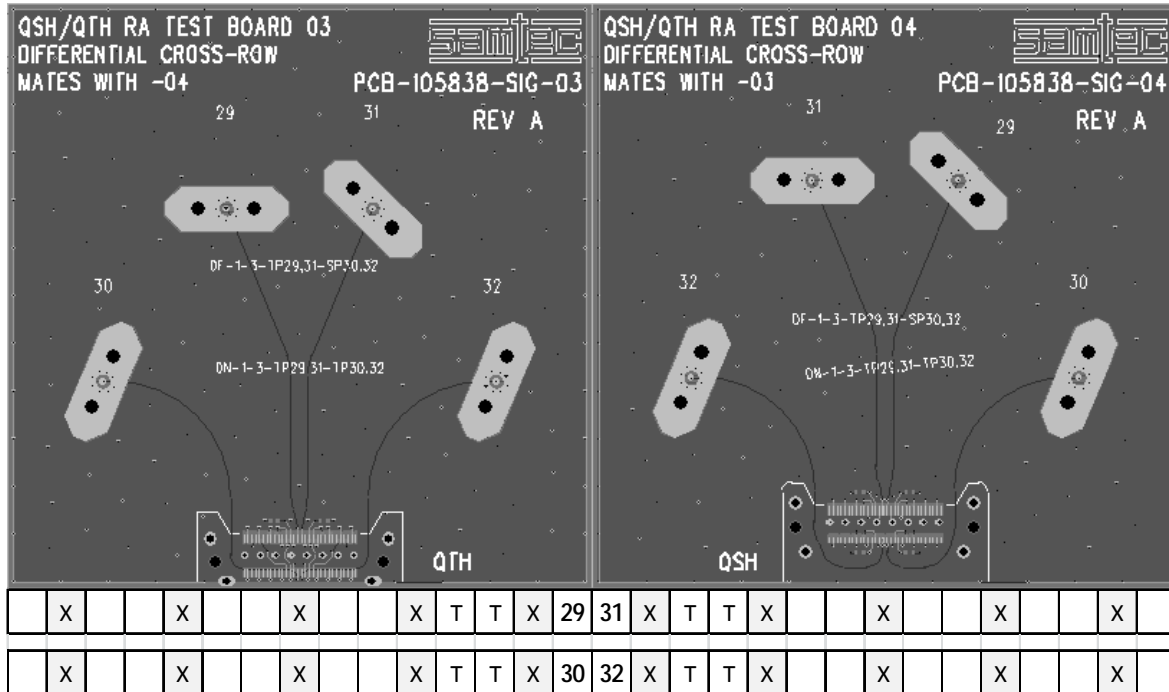
## PCB-105838-SIG-01 and PCB-105838-SIG-02. Single-Ended Cross-Row Crosstalk



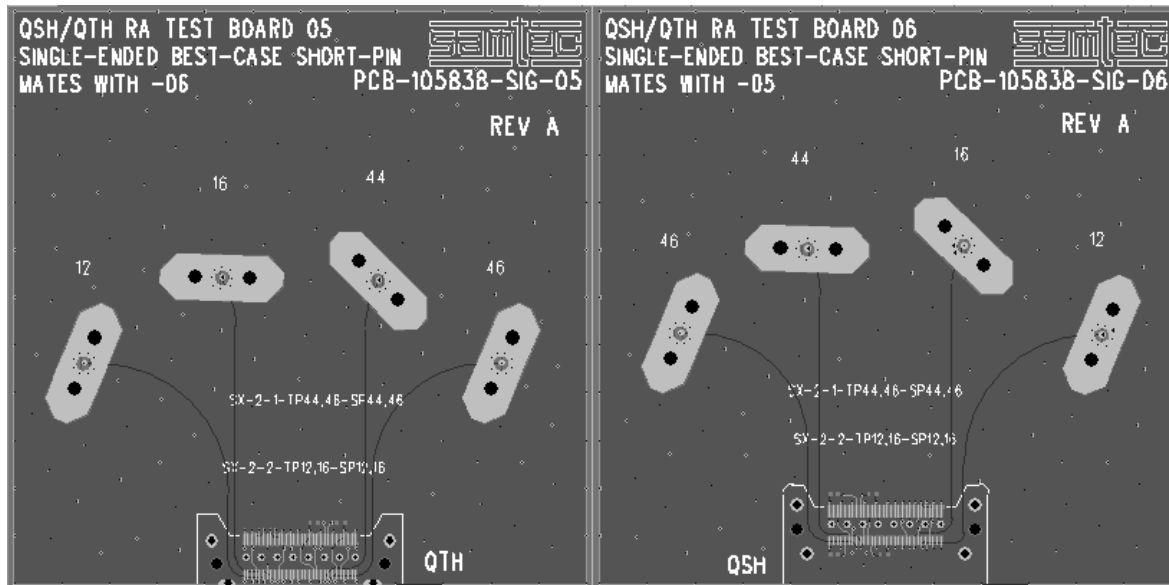
**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

**PCB-105838-SIG-03 and PCB-105838-SIG-04. Differential Cross-Row Crosstalk**



**PCB-105838-SIG-05 and PCB-105838-SIG-06 Single-Ended Worst and Best Case, Short Row**

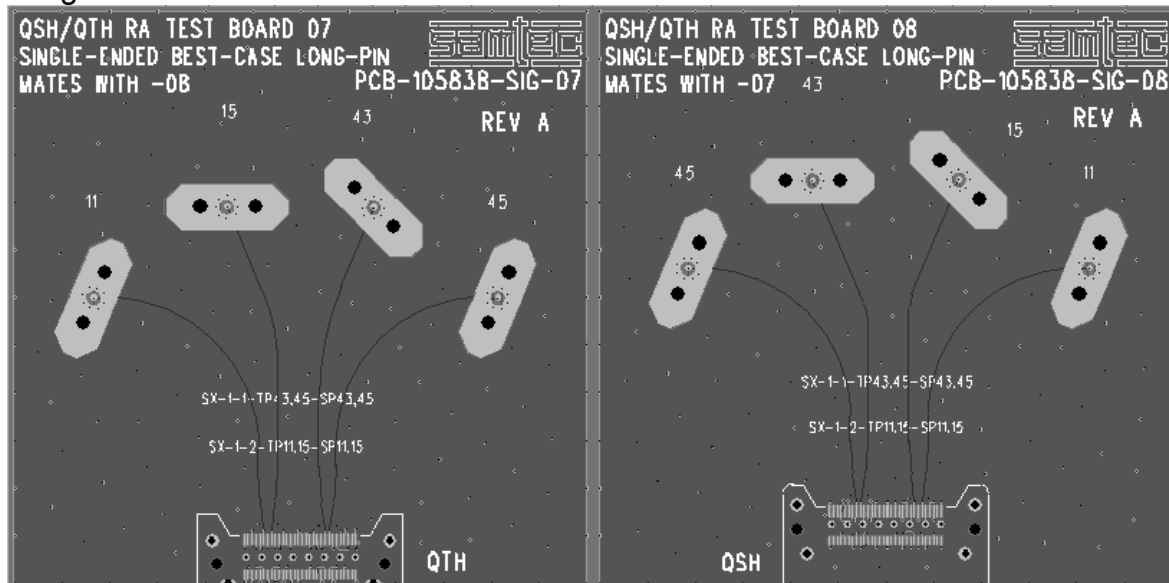


**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

X		X		X	T	X	T	X		X		X		X		X	T	T	X			X			X			
X		X	T	X	12	X	16	X	T	X		X		X		X	T	T	X	44	46	X	T	T	X			X

PCB-105838-SIG-07 and PCB-105838-SIG-08 Single-Ended Worst and Best Case, Long Row

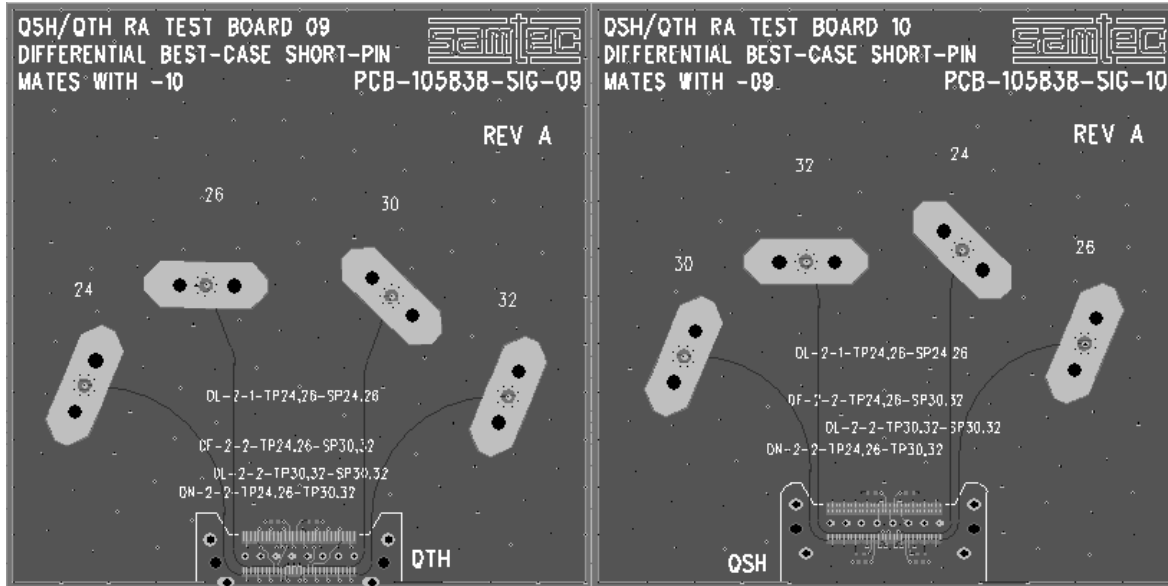


X		X	T	X	11	X	15	X	T	X		X		X		X	T	T	X	43	45	X	T	T	X			X
X		X		X	T	X	T	X		X		X		X		X		X	T	T	X			X			X	

PCB-105838-SIG-09 mates with PCB-105838-SIG-10 Differential Best Case, Short Row

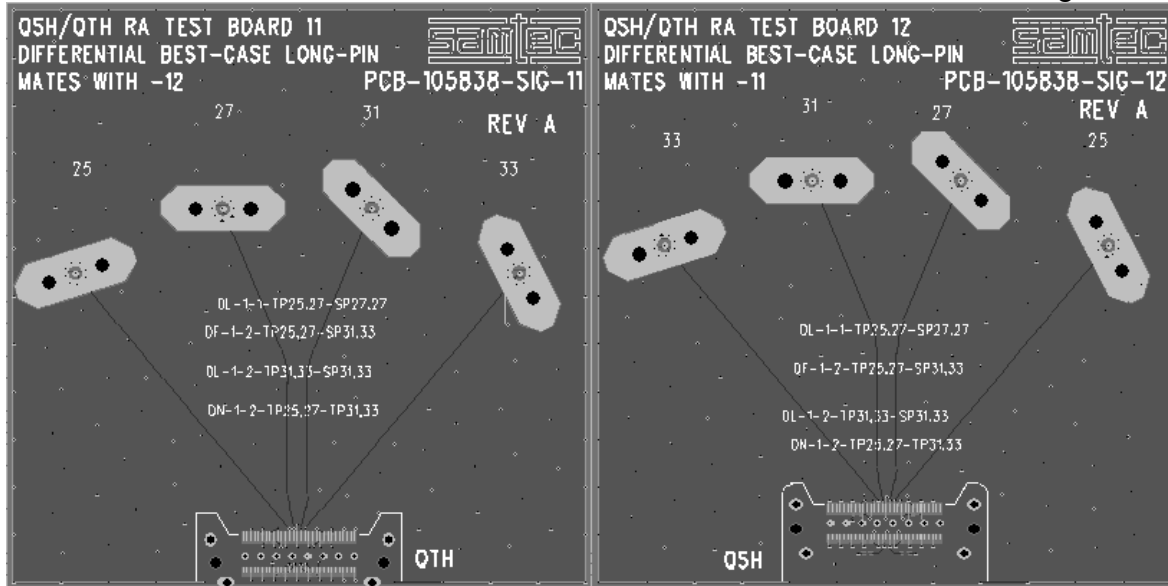
**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch



X		X		X		X	T	T	X	T	T	X		X		X		X		X
X		X		X	T	T	X	24	26	X	30	32	X	T	T	X		X		X

**PCB-105838-SIG-11 and PCB-105838-SIG-12 Differential Best Case, Long Row**



	X		X		X	T	T	X	25	27	X	31	33	X	T	T	X		X		X		X
	X		X		X			X	T	T	X	T	T	X			X		X		X		X

**PCB-105838-SIG-13 and PCB-105838-SIG-14 Differential Worst Case, Short Row**

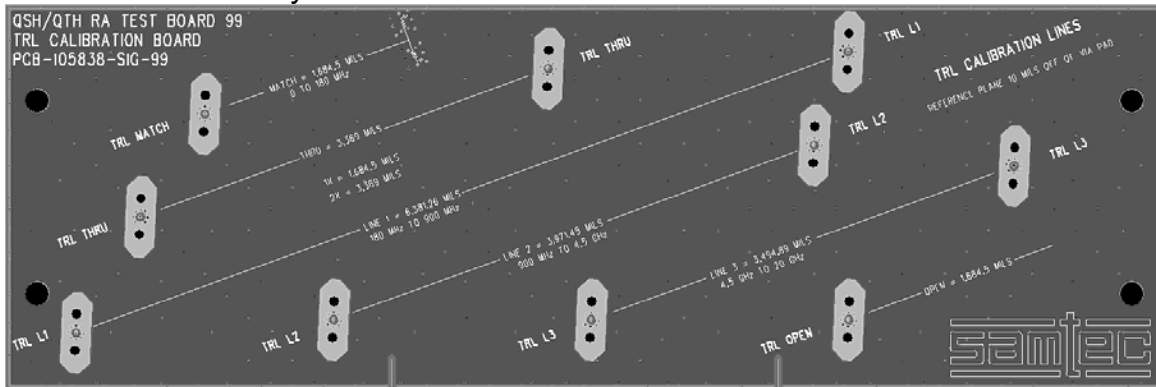


**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## Calibration Board

Test fixture losses and test point reflections were removed from the data by use of TRL calibration. The calibration boards are shown below. Prior to making any measurements, the calibration board is characterized to obtain parameters required to define the calibration kit. Once a cal kit is defined, calibration using the standards on the calibration board can be performed. Finally, the device can be measured and the test board effects are automatically removed.



## Through – Reflect – Match (TRL) Calibration Standards

PCB-105838-SIG-99

Reflect Standard - Open = 1,684.5 mils	Line 3 Length = 3,494.89 mils
Line 1 Length = 6,381.26 mils	Line 2 Length = 3,971.45 mils
Match Standard - Term = 1,684.5 mils	Thru Line (2X) = 3,369 mils
	Reflect Standard - Short = 1,684.5 mils

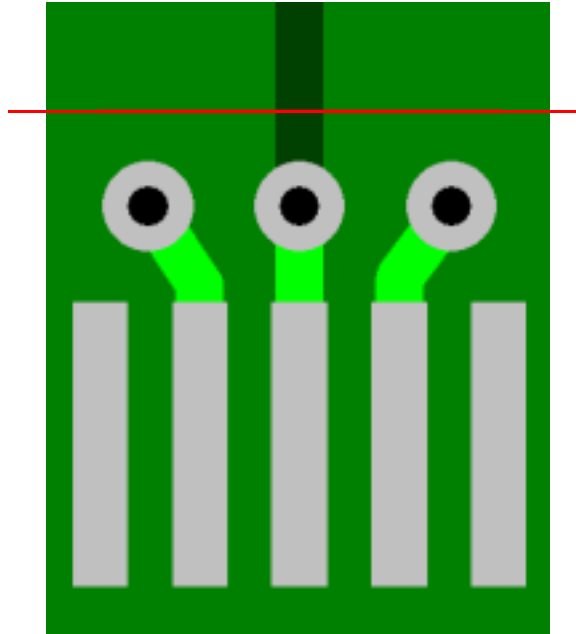
All traces on the test boards are length matched to 1703.52 mils measured from the center of the signal via to the SMA center contact pad. The TRL calibration effectively removes 1,684.5 mils of PCB signal trace effects. The calibrated reference plane is located 10 mils from the signal via connector pad on each side. The S-Parameter measurements include:

- A. 10 mils of 9.5 mil wide microstrip trace (bottom layer)
- B. A signal via; 8 mil drill, 18 mil pad
- C. 10 mils of 9.5 mil wide microstrip trace (top layer)
- D. Test board vias, pads (footprint effects) for the QTH-RA connector
- E. The QXH-RA Series mated connector pair
- F. Test board vias, pads (footprint effects) for the QSH-RA connector
- G. A signal via; 8 mil drill, 18 mil pad
- H. 10 mils of 9.5 mil wide microstrip trace (bottom layer)

**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

The figure below shows the location of the measurement reference plane.



**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

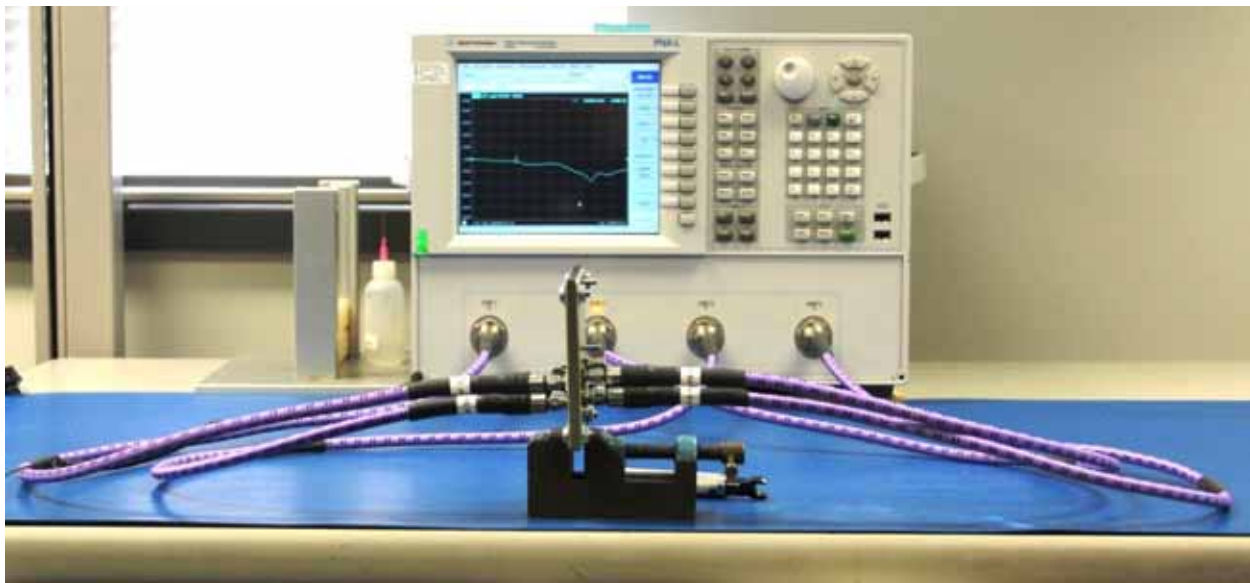
## Appendix D – Test and Measurement Setup

The test instrument is the Agilent N5230C PNA-L network analyzer. Frequency domain data and graphs are obtained directly from the instrument. Post-processed time domain data and graphs are generated using convolution algorithms within Agilent ADS. The network analyzer is configured as follows:

Start Frequency – 300 KHz                      Number of points -1601  
Stop Frequency – 20 GHz                      IFBW – 1 KHz

With these settings, the measurement time is approximately 20 seconds.

### N5230C Measurement Setup



### Test Instruments

<u>QTY</u>	<u>Description</u>
1	Agilent N5230C PNA-L 4-Port Network Analyzer (300 KHz to 20 GHz)
1	Agilent N4433A Ecal module (300 KHz to 20 GHz)

### Test Cables & Adapters

<u>QTY</u>	<u>Description</u>
4	Huber+Suhner Sucoflex 104PEA 3.5 mm(f) to 3.5mm(m) Test Port Cables

**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## 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 TRL calibration standards, the SI test boards, and the selection of the PCB vendor.

The measurement process begins with a measurement of the TRL calibration standards. A coaxial SOLT calibration is performed using an N4433A E-cal module. This measurement is required in order to obtain precise values of the line standard offset delay and frequency bandwidths. Measurements of the reflect and 2x through line standard can be used to determine the maximum frequency for which the calibration standards are valid. For the QTH-RA/QSH-RA Series test boards, this is greater than 20 GHz.

From the TRL calibration standard measurements, a user defined calibration kit is developed and stored in the network analyzer. Calibration is then performed on all 4 ports following the calibration wizard within the Agilent N5230C. This calibration is saved and can be recalled at any time. Calibration takes roughly 30 minutes to perform.

### 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 Agilent ADS 2013 update 6. 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/tech-note\\_using-PLTS-for-time-domain-data\\_web.pdf](http://www.samtec.com/Documents/WebFiles/Technical_Library/tech-note_using-PLTS-for-time-domain-data_web.pdf)

**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

#### Impedance (TDR)

A step pulse is applied to the touchstone model of the connector and the reflected voltage is monitored. The reflected voltage is converted to a reflection coefficient and then transformed into an impedance profile. All ports of the Touchstone model are terminated in 50 ohms.

#### Propagation Delay (TDT)

The Propagation Delay is a measure of the Time Domain delay through the connector and footprint. A step pulse is applied to the touchstone model of the connector 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 graph. The difference in time, measured at the 50% point of the step voltage is the propagation delay.

#### Near-End Crosstalk (TDT) & Far End Crosstalk (TDT)

A step pulse is applied to the touchstone model of the connector and the coupled voltage is monitored. The amplitude of the peak-coupled voltage is recorded and reported as a percentage of the input pulse.

**Series:** QTH-RA/QSH-RA

**Description:** Q Strip® High Speed Ground Plane Terminal/Socket Strip, Coplanar Board-to- Board, 0.5mm (.0197") Pitch

## **Appendix F – Glossary of Terms**

ADS – Advanced Design Systems

BC – Best Case crosstalk configuration

DUT – Device under test, term used for TDA IConnect & Propagation Delay waveforms

FD – Frequency domain

FEXT – Far-End Crosstalk

GSG – Ground–Signal–Ground; geometric configuration

GSSG - Ground–Signal–Signal–Ground; geometric configuration

HDV – High Density Vertical

LRM – Line Reflect Match calibration

NEXT – Near-End Crosstalk

OV – Optimal Vertical

OH – Optimal Horizontal

PCB – Printed Circuit Board

PPO – Pin Population Option

SE – Single-Ended

SI – Signal Integrity

SUT – System Under Test

S – Static (independent of PCB ground)

SOLT – acronym used to define Short, Open, Load & Thru Calibration Standards

TD – Time Domain

TDA – Time Domain Analysis

TDR – Time Domain Reflectometry

TDT – Time Domain Transmission

TRL – Through Reflect Match calibration

WC – Worst Case crosstalk configuration

Z – Impedance (expressed in ohms)