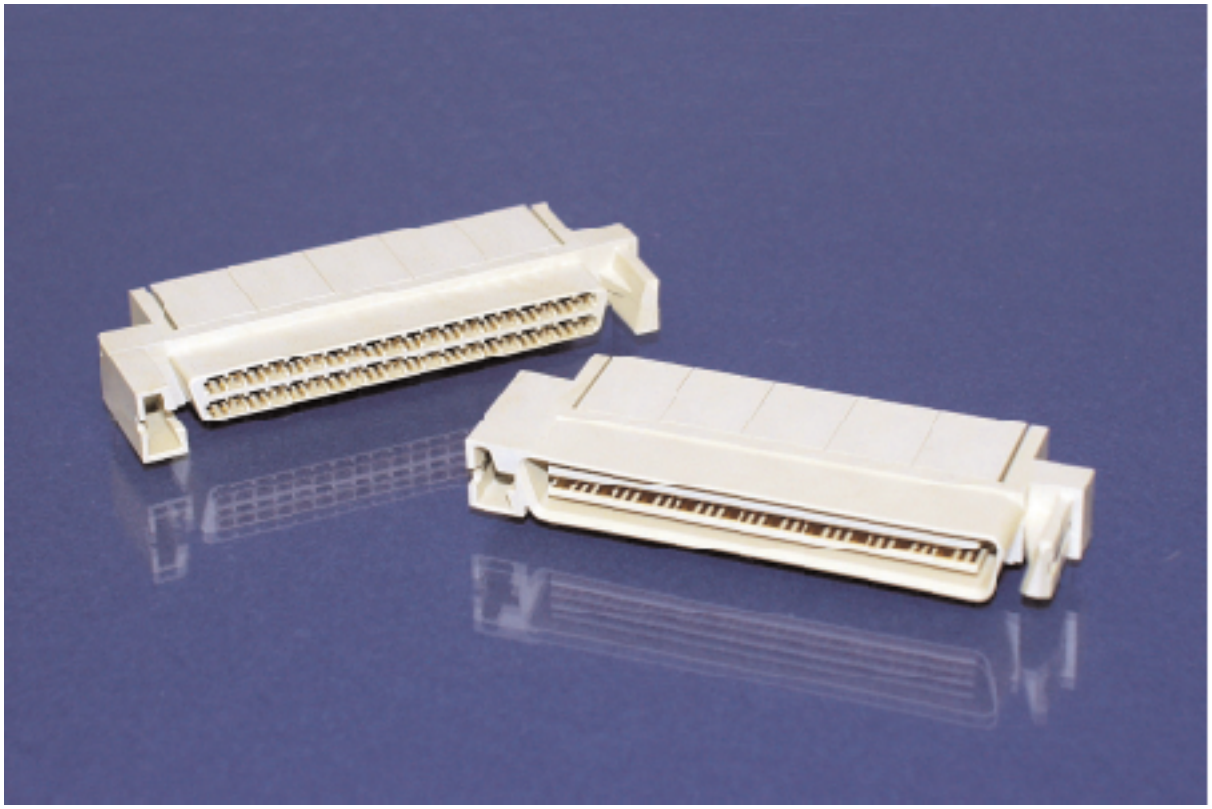
tyco Electronics

Z-Dok High-Performance Connector



Electrical Performance Report

- . . . . . Connector With Typical Footprint
- . . . . . Connector in a System

Report #22GC007, Revision A — May 2002

The information contained herein and the models used in this analysis are applicable solely to the specified Tyco Electronics connector. Alternative connectors may be footprint-compatible, but their electrical performance may vary significantly, due to construction or material characteristics. Usage of the information, models, or analysis for any other connector is improper, and Tyco Electronics disclaims any and all liability or potential liability with respect to such usage.

Report Contents

Welcome to the Z-Dok Connector Series

The Z-Dok connector is a skewless high-speed coplanar differential signal connector with a low-profile design. With this family of connectors, **Tyco Electronics** continues to deliver on the commitment to innovative, leading-edge connector design for high-speed customer applications.

Product Highlights

The Z-Dok connector handles data rates from 6.25 to ten gigabits per second (Gbps) using standard board materials and routing methods. The Z-Dok connector's use of the revolutionary **Tri-Q Differential Pair Contact System** supports very high data transfer rates while limiting pair-to-pair crosstalk and impedance discontinuities. In addition, Z-Dok is a skewless connector.

Leading-edge connection standards supported include InfiniBand(IB) and 10-Gigabit Ethernet. The Z-Dok connector innovative design allows it to perform at twice the data rate of the 10-Gigabit Attachment Unit Interface (XAUI) standard.

The robust blindmate connection mechanism derives from the popular **CHAMP** .050 Series family of connectors. Blindmate guides incorporate a unique make-first, break-last electrostatic discharge (ESD) contact system. Sequenced mating of ESD, ground, and signal circuits ensures proper initialization of the mated cards.

Sizes available are in increments of eight differential pairs, ranging from eight to 72 pairs. Standard offerings are 40 and 64 pairs.

The Z-Dok connector high-performance connector is the ideal choice for applications like high-speed telecommunications equipment, midrange and high-end servers, and storage area networks.

For further information and late-breaking news, visit the Z-Dok connector Web site at http://www.z-dok.com.

Report Orientation

This report contains the following sections:

- **Section 1—General Information** describes the Z-Dok connector and options and identifies target applications. This section also summarizes the connector's mechanical design and general electrical properties.
- **Section 2—Connector With Typical Footprint** presents measured performance attached to a typical plug card and receptacle card. Also included is a guide to routing traces through the connector's footprint.
- **Section 3—Connector in a System** presents insertion loss and eye pattern data for the Z-Dok connector in a range of test systems.

As this **Electrical Performance Report** illustrates, Tyco Electronics Z-Dok connector is truly enabling technology to implement high-speed, high-performance systems.

Overview

Target Applications

- Enterprise switching equipment
- High-speed telecommunications equipment
- Midrange and high-end servers
- Storage area networks
- High-speed custom platforms

Product Features

- Designed for multigigabit applications: excellent performance to 10 Gbps
- Compatible with leading-edge standards such as XAUI, InfiniBand, and 10-Gigabit Ethernet
- Skewless connector
- Tri-Q Differential Pair Contact System:
  - Each pair near dedicated ground
  - True symmetrical impedance
  - Low noise
  - Ground contacts isolated in two rows
- Robust blindmate guides incorporating ESD contacts with make-first, break-last sequencing
- Available in increments of 8 differential pairs, from 8–72, with 40 and 64 pairs as standard offerings

The **Z-Dok** high-performance blindmate connector is the first in a series of high-speed differential connectors meeting customer demand for multigigabit coplanar two-piece interconnects. This **Z-Dok** connector is designed for data rates up to ten gigabits per second (Gbps), using standard board materials and trace routing methods. Release plans for the **Z-Dok** connector family include vertical receptacles and plugs, inverted receptacles and plugs, outboard power modules, press-fit compliant pin tails, and single-ended high-density modules.

Z-Dok connector incorporates the revolutionary **Tri-Q Differential Pair Contact System**, a design that provides a dedicated nearby ground for each contact pair and a 25% reduction in the number of board terminations. These features combine to deliver multigigabit data rates with true symmetrical impedance and limited noise from pair-to-pair crosstalk. Tri-Q also confines ground contacts to two host board rows, simplifying trace routing.

Z-Dok connector mechanical design uses a robust blindmate connection method derived from the popular **CHAMP** .050 Series of connectors. The connector incorporates a unique electrostatic discharge (ESD) system using a make-first, break-last mating sequence for reliable ESD dissipation. Sequenced mating for ESD, ground, and signal contacts in blindmate guides ensures full seating before initialization of host boards.

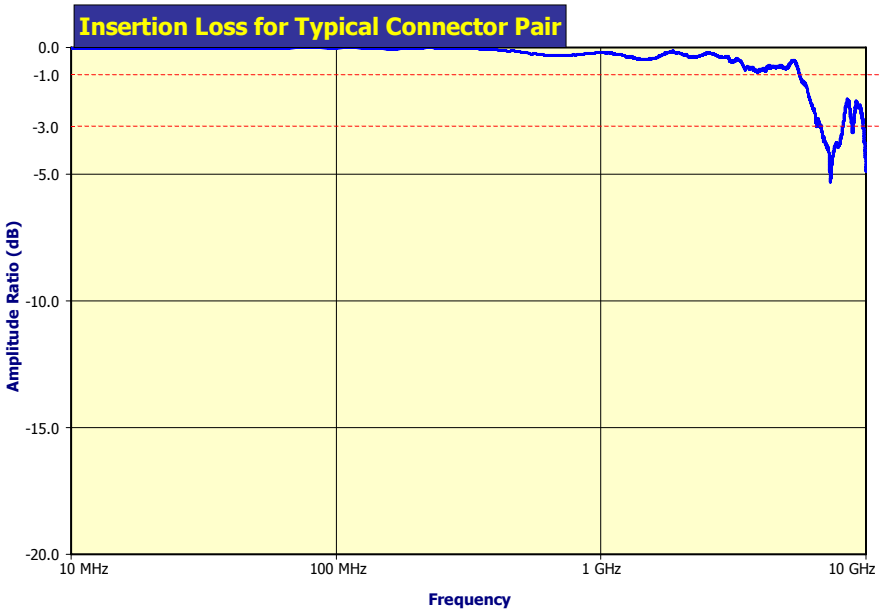
The connector is available in increments of eight differential pairs, from eight to 72, with 40 and 64 pairs as standard offerings.

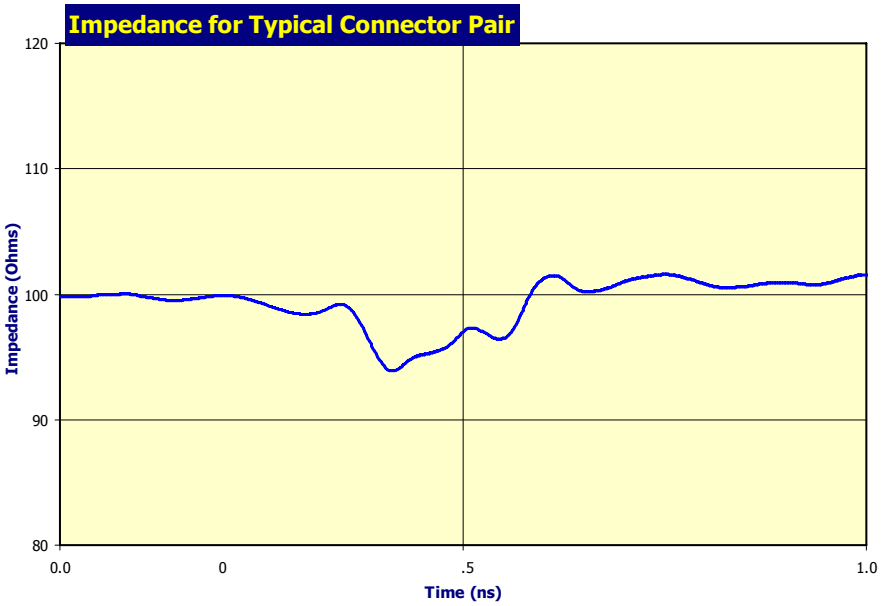
The **Z-Dok** connector is the ideal choice for today's demanding high-speed, high-performance applications, such as enterprise switching equipment, midrange and high-end servers, and storage area networks.

Technical Support	
Telephone support	**Tyco Electronics Product Information Center** Monday-Friday, 8:00 A.M.-8:00 P.M. EST (800) 522-6752 or (717) 986-7777
E-mail contact information	http://www.tycoelectronics.com/help for test samples, models (SPICE, Pro/E, or IGES), or drawings
Connector Web site	http://www.z-dok.com

Electrical Performance Summary

This section gives a few examples of the **Z-Dok** connector's electrical performance. For more detailed information, see **Section 2—Connector With Typical Footprint** and **Section 3—Connector in a System**.





Connector Performance

- Data presented for connector with typical footprint (see explanation in **Section 2**)
- Less than 1 dB insertion loss up to 3 GHz
- Less than 3 dB insertion loss up to 6 GHz
- Connector impedance between 94 and 98 ohms (100 ps signal rise time, 20–80%)
- Differential propagation delay ranges from 145–265 ps
- Intrapair skew, 0 ps; row-to-row skew no greater than 52 ps
- Worst-case noise less than 2.7% (simultaneous attack by all adjacent pairs; 100 ps rise time, 20–80%)

The **Electrical Performance Summary** continues on the following page.

Electrical Performance Summary (cont'd)

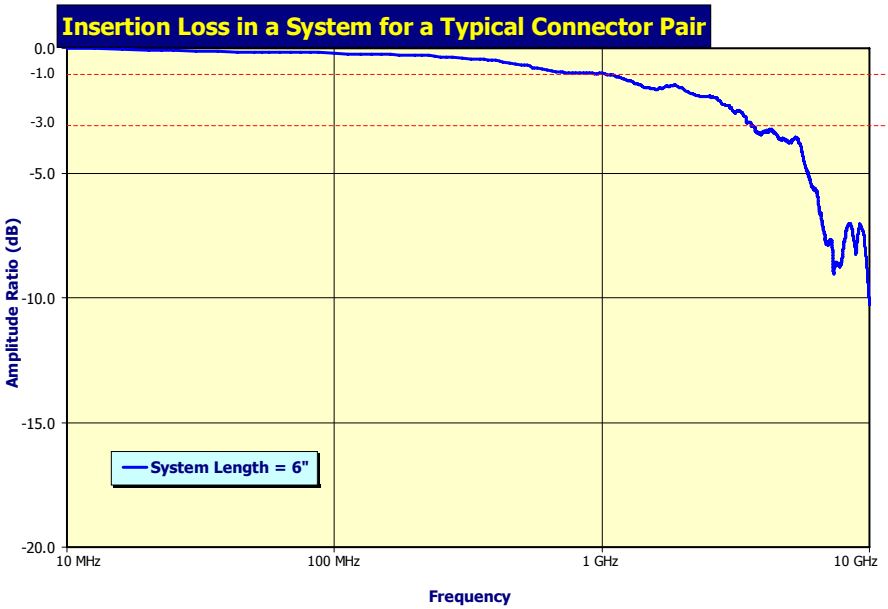
System Performance

With 6" system length, FR-4 dielectric:

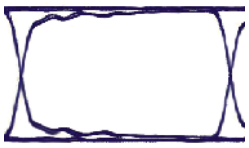
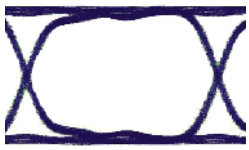
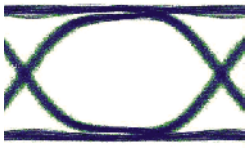
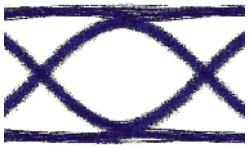
- At 3.125 GHz: 2.5 dB insertion loss
- At 5 GHz: 3.79 dB insertion loss
- At 6.25 Gbps: eye pattern 81% open
- At 10 Gbps: eye pattern 69% open

See **Section 3** for complete test system specifications.

The following graphics summarize the **Z-Dok** connector's performance in a system. For a complete description of the test system and an account of system performance, see **Section 3—Connector in a System**.

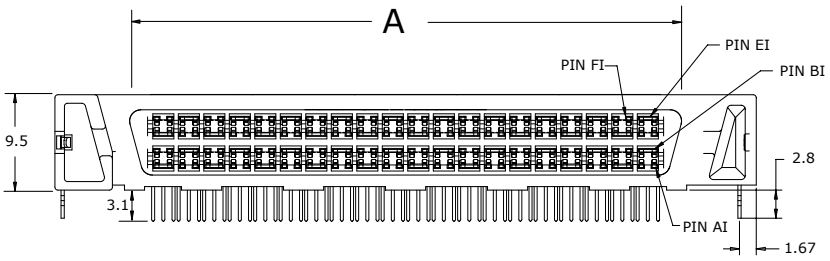


Typical Signal Pair Eye Patterns for System Performance With FR-4

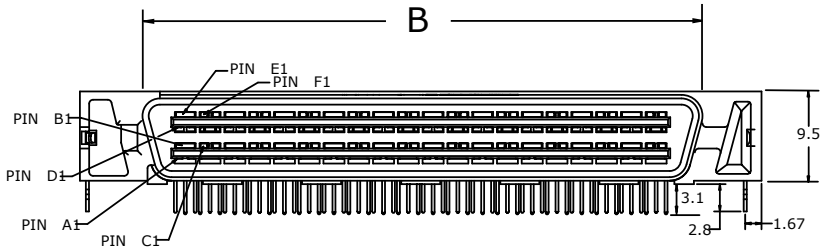
System Length	Data Rate: 1.25 Gbps	3.125 Gbps	6.25 Gbps	10 Gbps
6"				
	Maximum Opening: 95.9% **Jitter:** 0.4%	**Maximum Opening:** 91.6% **Jitter:** 1.9%	**Maximum Opening:** 81.3% **Jitter:** 5.6%	**Maximum Opening:** 69.4% **Jitter:** 10.5%

Mechanical Design Summary

Receptacle, Front View



Plug, Front View



Mechanical Features

- Design based on 8-differential pair model. 8 to 72 pair connectors available, with 40- and 64-pair versions standard.
- Inherently polarized; accidental inversion of mating connectors impossible
- Two types of boardlock:
  - **ESD version**—Engages prior to ground contacts for electrostatic discharge
  - **Sensing version**—Engages after signal contacts to sense full engagement

Part Numbers and Nominal Dimensions

With ESD Boardlocks				
Pairs	**Dimension A**	**Dimension B**	**Receptacle**	**Plug**
32	44.82 mm	45.60 mm	1367130-6	1367198-6
24	34.66 mm	35.44 mm	1367130-5	1367198-5
64	85.46 mm	86.24 mm	1367130-4	1367198-4
56	75.30 mm	76.08 mm	1367130-3	1367198-3
48	65.14 mm	65.92 mm	1367130-2	1367198-2
40	54.98 mm	55.76 mm	1367130-1	1367198-1

With Sensing Boardlocks				
Pairs	**Dimension A**	**Dimension B**	**Receptacle**	**Plug**
64	85.46 mm	86.24 mm	1367445-4	1367444-4
56	75.30 mm	76.08 mm	1367445-3	1367444-3
48	65.14 mm	65.92 mm	1367445-2	1367444-2
40	54.98 mm	55.76 mm	1367445-1	1367444-1

Introduction

Connector Performance

- All data are measured.
- Section contents:
  - Electrical Performance:
    - Insertion Loss
    - Impedance
    - Propagation Delay
    - Noise
  - Routing Guide
- For connector electrical performance in a system, see **Section 3**

No connector is ever used alone; thus the effects of a connector's footprint (its attachment to the printed circuit boards (PCBs)) are always present. Nonetheless, engineers often turn to "connector-only" electrical performance data when evaluating connectors. Since it is not possible to measure a connector's performance without attaching it to PCBs, most reported connector-only data have had the footprint effects mathematically subtracted. While this is an entirely appropriate technique, the mathematical transformations can be complex. When comparing performance data among connectors, engineers must recognize that footprint effects always degrade a connector's performance — sometimes substantially — and they must be alert to these effects for their applications.

Many aspects of the footprint influence electrical performance, including the following:

- Plug card and receptacle card thickness and material
- Plated through-hole diameter and pitch
- Ground plated through-hole diameter and proximity to signal holes
- End effects arising from the nonsymmetrical design of the pins at the edge of the connector
- Pad and antipad size
- Via depth (as dictated by the connector's pin length)
- Layer connection (top or bottom of the PCB)

Because no connector is used alone and the effects of its footprint are always present, connector engineers need to put as much emphasis on optimizing the footprint as they do on all the other elements of design. This section quantifies the **Z-Dok** connector's performance in a typical footprint. Specifically, it presents data for each half of the connector attached to a 0.093-inch thick PCB. The table below shows the footprint specifications.

Printed Circuit Board Specifications	
Dielectric	FR-4
Board Thickness	0.093" (Plug and Receptacle)
Number of Copper Layers	6 (Plug and Receptacle)
Layer Connection	Bottom

This section presents data for insertion loss, impedance, propagation delay, and noise when attached to these typical circuit boards. As the data illustrate, Tyco Electronics engineers have balanced connector and footprint design to give the **Z-Dok** connector excellent performance in the most critical and demanding applications.

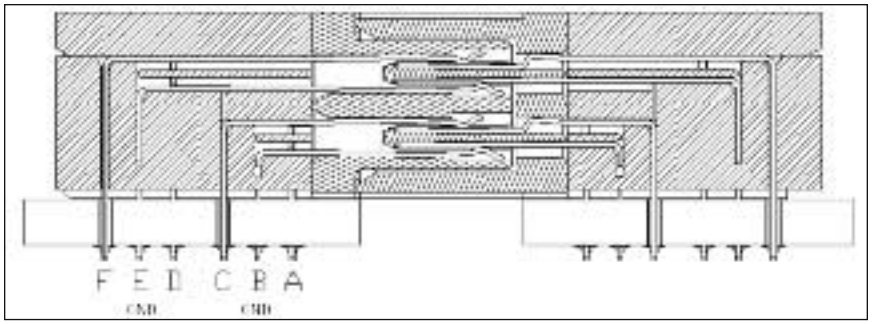
Following the electrical performance data in this section is a **Routing Guide** with recommendations for routing signals through the connector's footprints.

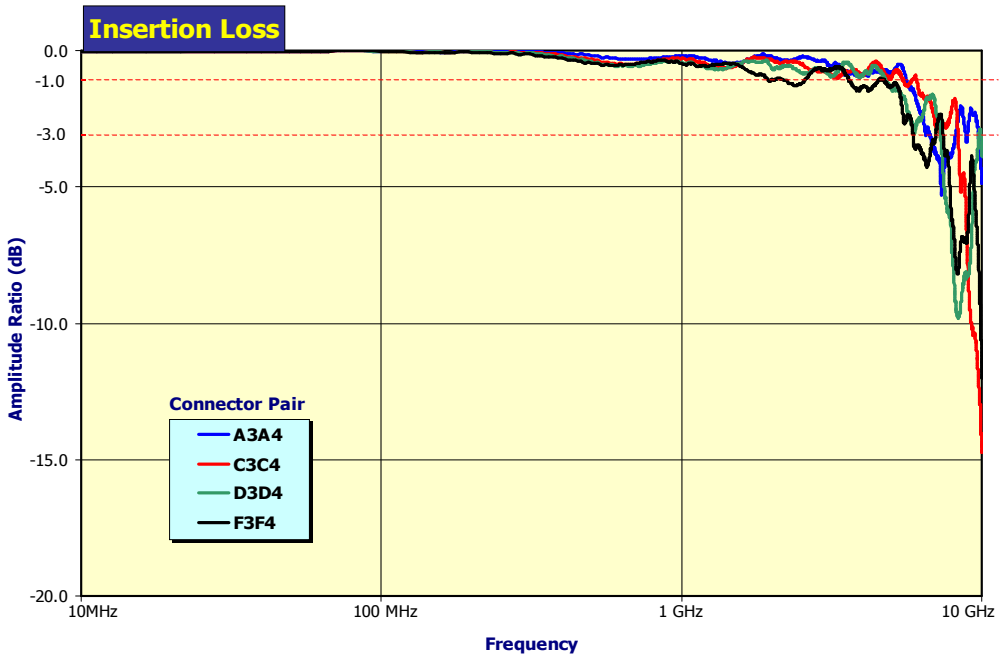
Insertion Loss

Insertion Loss Data for Connector With Typical Footprint (Plug Card and Receptacle Card, 0.093" FR-4)

Pair	Bandwidth at -1 dB	Bandwidth at -3 dB
A3-A4	5.58 GHz	6.54 GHz
C3-C4	4.98 GHz	7.25 GHz
D3-D4	4.76 GHz	6.00 GHz
F3-F4	1.94 GHz	5.90 GHz

Connector Rows, Side View



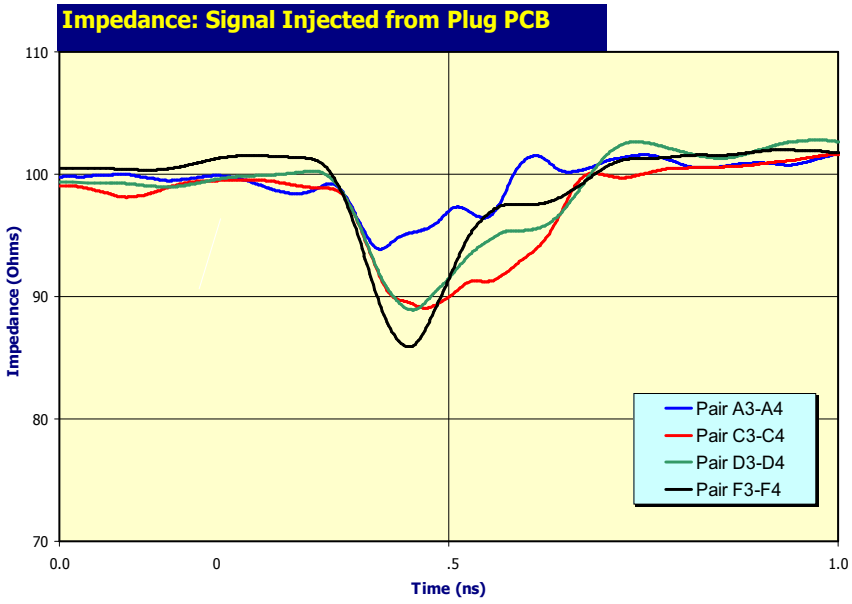


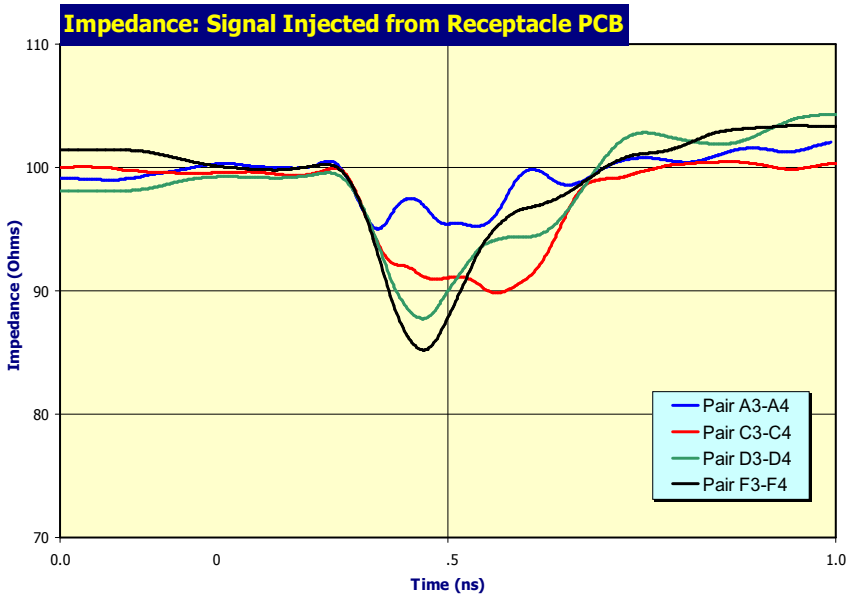
Impedance

Impedance Data for Connector With Typical Footprint (0.093" FR-4)

- All data are measured.
- Tabular data on following page for impedance values at 40, 100, and 250 ps rise times (20–80%)

The data in this section result from measuring the **Z-Dok** connector's impedance over a range of signal rise times, with the signal originating from both the plug and receptacle sides of the connector. These impedance measurements are for the connector attached to a typical plug card and receptacle card (0.093" FR-4). All charts show footprint-connector-footprint data.





Impedance (cont'd)

For all data in the following tables, printed circuit boards are 0.093" thick FR-4.

Signal Rise Time	250 ps			
Signal Injected From	Plug Card		Receptacle Card	
	Minimum	Maximum	Minimum	Maximum
Pair A3-A4	96.0 ohms	96.0 ohms	96.3 ohms	96.3 ohms
Pair C3-C4	90.8 ohms	90.8 ohms	91.1 ohms	91.1 ohms
Pair D3-D4	92.3 ohms	97.1 ohms	91.6 ohms	94.9 ohms
Pair F3-F4	91.3 ohms	98.9 ohms	90.5 ohms	97.9 ohms

Signal Rise Time	100 ps			
Signal Injected From	Plug Card		Receptacle Card	
	Minimum	Maximum	Minimum	Maximum
Pair A3-A4	93.9 ohms	97.3 ohms	95.0 ohms	97.4 ohms
Pair C3-C4	89.1 ohms	91.5 ohms	91.3 ohms	91.9 ohms
Pair D3-D4	88.9 ohms	95.7 ohms	87.8 ohms	94.7 ohms
Pair F3-F4	85.9 ohms	97.5 ohms	85.2 ohms	96.9 ohms

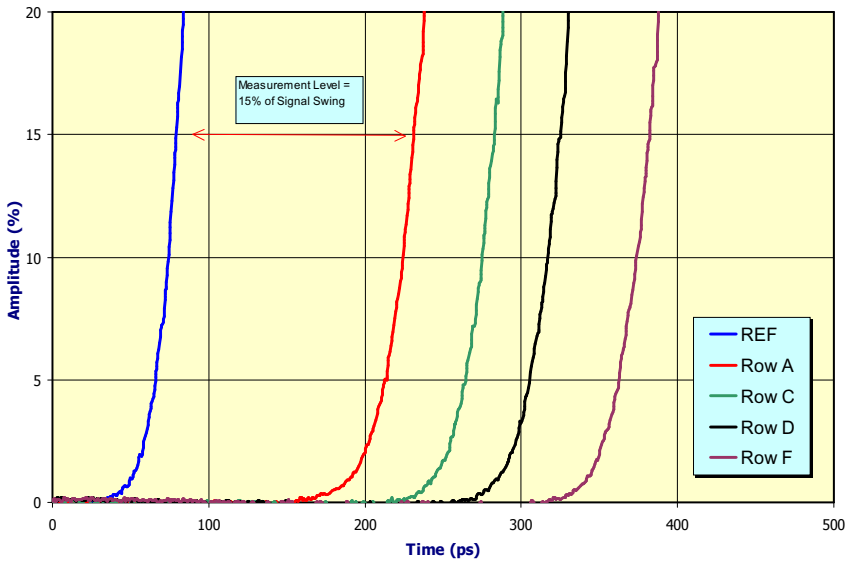
Signal Rise Time	40 ps			
Signal Injected From	Plug Card		Receptacle Card	
	Minimum	Maximum	Minimum	Maximum
Pair A3-A4	85.0 ohms	103.0 ohms	85.3 ohms	103.0 ohms
Pair C3-C4	83.0 ohms	97.0 ohms	83.8 ohms	101.0 ohms
Pair D3-D4	83.0 ohms	95.9 ohms	81.1 ohms	95.5 ohms
Pair F3-F4	79.3 ohms	98.9 ohms	79.1 ohms	97.2 ohms

NOTE: Minimum impedance due to footprint effects.

Propagation Delay

Propagation Delay Data for Connector With Typical Footprint (0.093" FR-4)

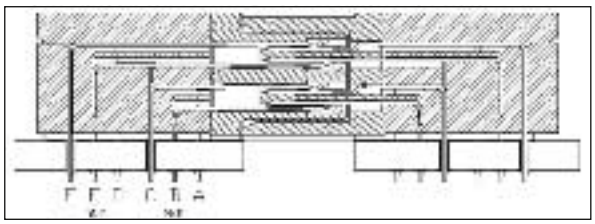
- Measurements at 15% of signal amplitude for true propagation delay without edge degradation effects
- Signal rise time less than 50 ps (20–80%)
- All propagation delay measurements in picoseconds (ps)
- Table includes both inter pair and pair to pair measurements



Propagation Delay and Skew (ps), Connector With Typical PCBs Attached

	Differential Propagation Delay	Pair-to-Pair Skew
Pair A3-A4	145.2 ps	
		51.6 ps
Pair C3-C4	196.8 ps	
		16.5 ps
Pair D3-D4	213.3 ps	
		51.5 ps
Pair F3-F4	264.8 ps	

Connector Rows, Side View

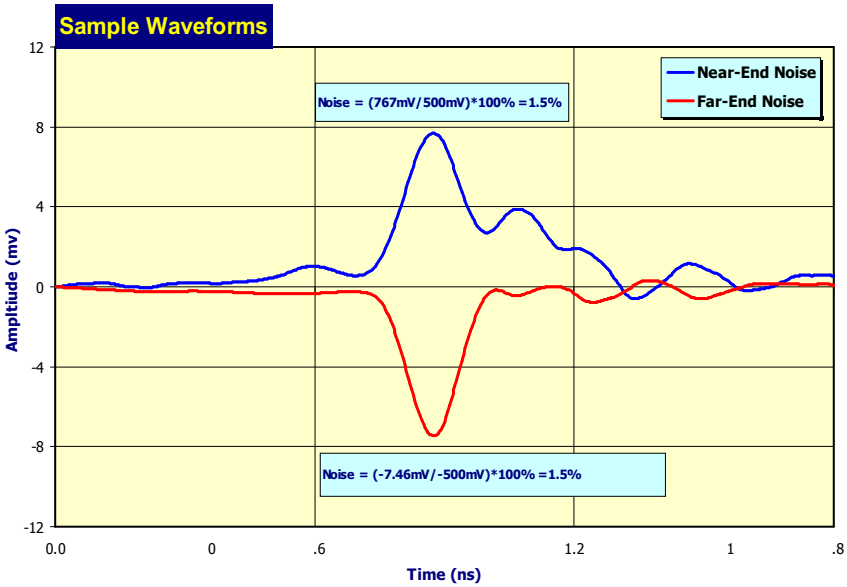


Noise

Noise (or crosstalk) is voltage measured at one pair in the connector when a signal is injected into a second pair. In general, there are two types of noise. **Near-end noise** (sometimes called **backward crosstalk**) is the noise measured at the same end of the connector as the injected signal. **Far-end noise** (sometimes called **forward crosstalk**) is the noise measured at the end opposite the injected signal.

Noise Data for Connector With Typical Footprint (0.093" FR-4)

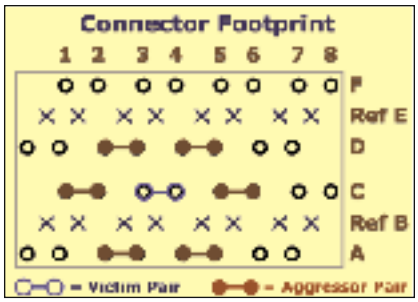
- Near-end and far-end noise
- Noise for single-aggressor and multiple-aggressor pairs
- All data are measured.



The differential noise measurements here report noise as the maximum value of the noise waveform (in millivolts (mV)) divided by the differential input signal (in mV), expressed as a percentage. Because noise by this definition can be either positive or negative, the measurement value reported is the absolute value. In these tests the divisor is 500 mV, arising from the two 250 mV edges of the differential input signal. The graphic above illustrates a typical waveform and the noise values measured.

Also important is the difference between single-aggressor and multiple-aggressor noise. That is, the noise created at a connector pair when a signal is injected into one nearby pair (single-aggressor) is different from the noise created when signals are injected into all nearby pairs simultaneously (multiple-aggressor). For the design engineer, these different types of noise are important because they represent two commonly accepted ways of reporting connector crosstalk.

In general, noise declines significantly as the location of the injected signal moves away from the pair under test. Thus, this section reports only noise arising from signals injected into near-neighbor locations. The graphic at the right illustrates this. It shows the Z-Dok connector's footprint and a typical victim pair surrounded by aggressor pairs. The single-aggressor test measures noise at the victim pair with a signal injected into only one adjacent aggressor. The multiple-aggressor test measures victim-pair noise with all aggressors firing simultaneously.



Note: Picture for reference only see customer print for actual dimension

Noise (cont'd)

Noise Data for Connector With Typical Footprint

- Near-end and far-end noise
- Noise for single-aggressor and multiple-aggressor pairs
- All data are measured.

The tables below present noise measurements for the four **Z-Dok** connector signal pairs (see graphic on the previous page):

- **Pair A3-A4:** At the connector's edge with reference (ground) row on one side
- **Pair C3-C4:** Inside row adjacent to reference row and signal row
- **Pair D3-D4:** Inside row adjacent to reference row and signal row
- **Pair F3-F4:** At the connector's edge with reference row on one side

These tables show measured noise values for a range of signal rise times. Tables include near-end noise from signals originating on the backplane; far-end noise is indifferent to signal origin. As explained in the **Introduction** to **Section 2**, these measurements are with the **Z-Dok** connector attached to a typical plug card and receptacle card (FR-4, 0.093" thick).

Single-Aggressor Noise

		Backplane Side Near-End Noise			Far-End Noise		
Victim Pair	Aggressor Pair	40 ps	100 ps	250 ps	40 ps	100 ps	250 ps
A3-A4	A1-A2	0.60 %	0.40 %	0.24 %	1.33 %	0.70 %	0.26 %
	A5-A6	0.60 %	0.40 %	0.24 %	1.33 %	0.70 %	0.26 %
	C3-C4	0.97 %	0.74 %	0.40 %	0.49 %	0.20 %	0.08 %
C3-C4	C1-C2	0.70 %	0.40 %	0.20 %	1.23 %	0.60 %	0.24 %
	C5-C6	0.70 %	0.40 %	0.20 %	1.23 %	0.60 %	0.24 %
	A3-A4	0.97 %	0.74 %	0.40 %	0.49 %	0.20 %	0.10 %
	D3-D4	0.68 %	0.56 %	0.40 %	0.38 %	0.20 %	0.10 %
D3-D4	C3-C4	0.68 %	0.56 %	0.40 %	0.38 %	0.20 %	0.10 %
	D1-D2	0.63 %	0.34 %	0.16 %	0.77 %	0.40 %	0.18 %
	D5-D6	0.63 %	0.34 %	0.16 %	0.77 %	0.40 %	0.18 %
	F3-F4	0.86 %	0.76 %	0.52 %	0.28 %	0.16 %	0.06 %
F3-F4	F1-F2	0.81 %	0.40 %	0.20 %	0.7 %	0.20 %	0.16 %
	F5-F6	0.81 %	0.40 %	0.20 %	0.7 %	0.20 %	0.16 %
	D3-D4	0.86 %	0.76 %	0.52 %	0.28 %	0.16 %	0.06 %

Multiple-aggressor noise data appears on the following page.

Noise (cont'd)

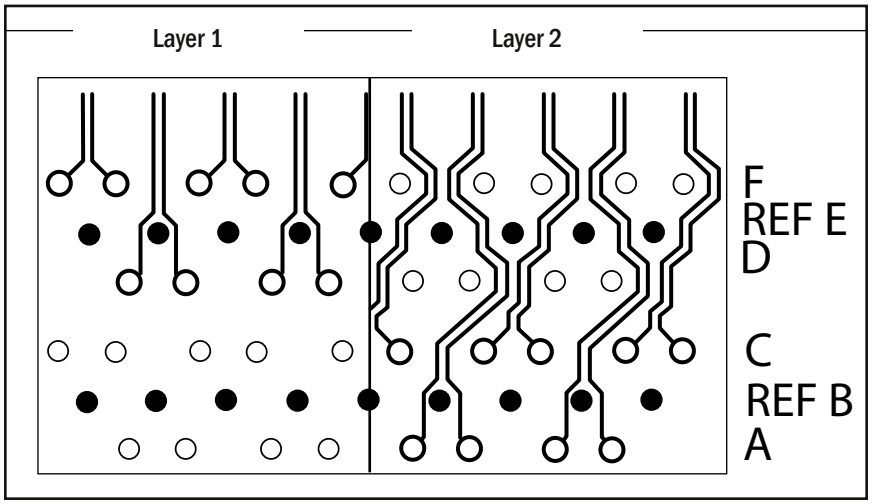
Multiple-Aggressor Noise

		Backplane Near-End Noise			Far-End Noise		
Victim Pair	Aggressor Pair	40 ps	100 ps	250 ps	40 ps	100 ps	250 ps
A3-A4	A1-A2 A5-A6 C3-C4 C5-C6	2.1%	1.50%	0.88%	2.92%	1.50%	0.60%
C3-C4	C1-C2 C5-C6 A3-A4 A5-A6 D3-D4 D5-D6	2.9%	2.0%	1.22%	2.84%	1.50%	0.65%
D3-D4	C3-C4 C5-C6 D1-D2 D5-D6 F3-F4 F5-F6	1.9%	1.45%	1.23%	2.07%	1.30%	0.50%
F3-F4	F1-F2 F5-F6 D3-D4 D5-D6	1.62%	1.21%	0.91%	1.58%	0.90%	0.40%

Routing Guide

The graphic below shows the routing of edge-coupled differential pair traces from the **Z-Dok** connector. On the receptacle card side and on the plug card side, traces are 7 mils wide with 15 mil spacing between them. The **Z-Dok** connector requires two layers to route all signals.

Printed Circuit Board Footprint



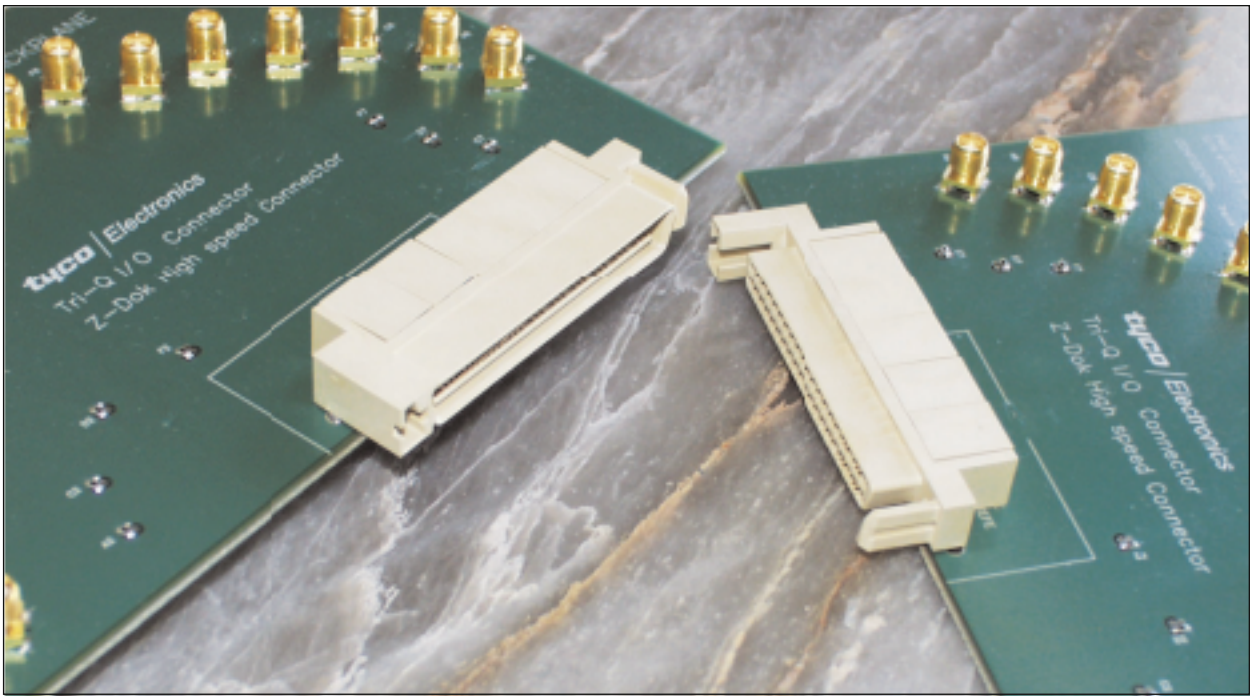
Routing Guide

- For differential pair routing, traces can be 7 mils wide and 15 mils apart.
- CAD routing models are available.

The Test System

This section presents the **Z-Dok** connector's electrical performance in a test system. This first subsection describes the test system and the methods for measuring electrical performance. The next subsection shows the **Z-Dok** system's insertion loss and eye pattern data for a range of system configurations.

The picture below shows the test system. Test signals traverse the plug card through the connector, then onto the receptacle card.



* Test systems available upon request.

The Test System (cont'd)

Selecting specific traces on the plug card and the receptacle card determines the overall test system length, as the following table shows:

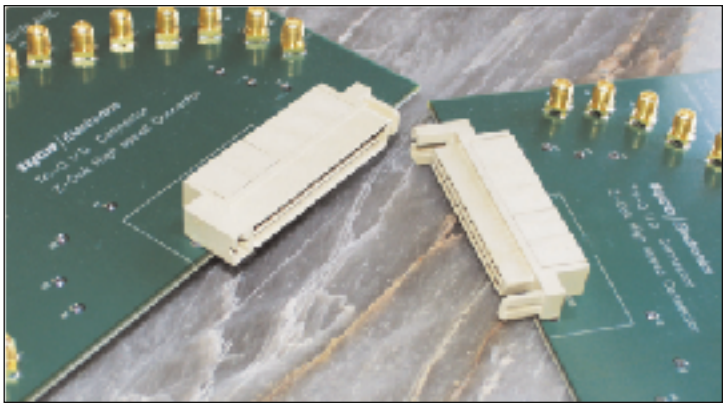
For a total system length of...	Receptacle Card 1 Trace	Plug Card Trace
1"	0.5"	0.5"
3"	1.5"	1.5"
6"	3"	3"

Test System Circuit Board

- High-grade FR-4
- Dielectric Constant:
  - 4.3 at 100 MHz
  - 4.1 at 1 GHz
  - 3.9 at 10 GHz
- Loss Tangent = 0.015

In addition to system length, the other principal test system variable is the printed circuit board (PCB) dielectric material. Electrical performance measurements are made using FR-4, a common dielectric (see sidebar for PCB specifications). The significant design parameters for each element in the test system are as follows:

- Plug card trace parameters:
  - Board: High-grade FR-4
  - Traces: Trace pairs with each trace either 0.5", 1.5", or 3" long
  - Pair dimensions: 7 mils wide, 15 mils apart
  - Pair impedance: 100 ohms
- Connector PCB footprint:
  - Board thickness: PCB 0.093" thick
  - Board layers: 6 copper layers, each one ounce
  - Board vias: Drill diameter 27.6 mils, finished hole diameter 24 mils, 42 mil pads, differential anti-pads
- Connector:
  - Line polarities: For test pair XY (where XY is any connector pair), positive line is Row X and negative line is Row Y



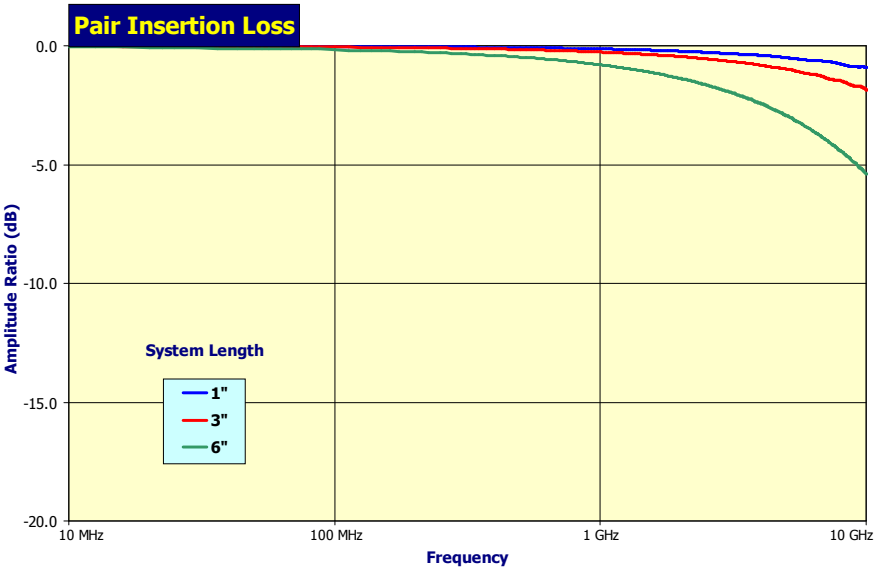
- Receptacle card trace parameters:
  - Board: High-grade FR-4
  - Traces: Trace pairs with each trace either 0.5", 1.5", or 3" long
  - Pair dimensions: 7 mils wide, 15 mils apart
  - Pair impedance: 100 ohms

Electrical Performance Without Connector (Traces Only)

The next two pages illustrate trace-only electrical performance for FR-4 and glass-reinforced ceramic test systems. These insertion loss and eye pattern measurements serve as a baseline, showing the optimal performance of a system length when no connectors are used.

The next subsection shows the system's electrical performance when the **Z-Dok** connector is inserted. Comparing those results with the baseline data shown here helps the application engineer fully understand the **Z-Dok** connector's effects on a system's electrical performance.

Traces Only, FR-4



Trace-Only Configuration

- **Conductors:** Signals and grounds, one-ounce copper
- **Dielectric:** High-grade FR-4
- Eye patterns based on measured data except where noted

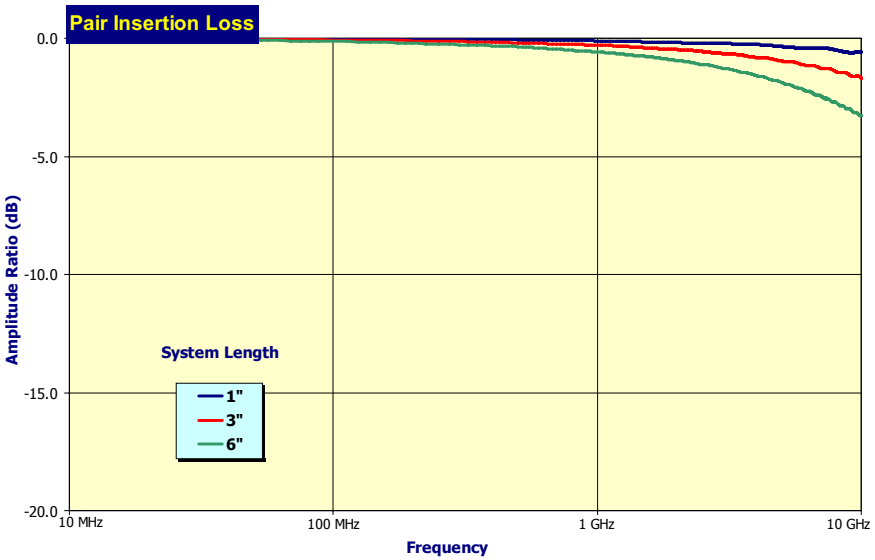
System Length	Data Rate: 1.25 Gbps	3.125 Gbps	6.25 Gbps	10 Gbps
1"	**Maximum Opening:** 99.9% **Jitter:** 0.1% Simulated	**Maximum Opening:** 98.8% **Jitter:** 0.2% Simulated	**Maximum Opening:** 97.7% **Jitter:** 0.6% Simulated	**Maximum Opening:** 94.9% **Jitter:** 1.0% Simulated
3"	**Maximum Opening:** 98.2% **Jitter:** 0.4% Simulated	**Maximum Opening:** 95.9% **Jitter:** 0.6% Simulated	**Maximum Opening:** 94.3% **Jitter:** 0.8% Simulated	**Maximum Opening:** 86.8% **Jitter:** 1.2% Simulated
6"	**Maximum Opening:** 98.2% **Jitter:** 0.6%	**Maximum Opening:** 91.9% **Jitter:** 0.8%	**Maximum Opening:** 88.4% **Jitter:** 1.9%	**Maximum Opening:** 79.2% **Jitter:** 4.5%

High-Grade FR-4: Dielectric Constant = 4.3 at 100 MHz, 4.1 at 1 GHz, 3.9 at 10 GHz; Loss Tangent = 0.015

Traces Only, Glass-Reinforced Ceramic

Trace-Only Configuration

- **Conductors:** Signals and grounds, one-ounce copper
- **Dielectric:** Glass-reinforced ceramic
- Eye patterns based on simulated data



System Length	Data Rate: 1.25 Gbps	3.125 Gbps	6.25 Gbps	10 Gbps
1"	Maximum Opening: 99.9% Jitter: 0.01% Simulated	Maximum Opening: 98.9% Jitter: 0.03% Simulated	Maximum Opening: 97.1% Jitter: 0.6% Simulated	Maximum Opening: 95.0% Jitter: 1.0% Simulated
3"	Maximum Opening: 98.6% Jitter: 0.04% Simulated	Maximum Opening: 97.2% Jitter: 0.5% Simulated	Maximum Opening: 93.1% Jitter: 0.6% Simulated	Maximum Opening: 90.5% Jitter: 1.2% Simulated
6"	Maximum Opening: 97.6% Jitter: 0.1% Simulated	Maximum Opening: 93.9% Jitter: 0.6% Simulated	Maximum Opening: 87.5% Jitter: 1.9% Simulated	Maximum Opening: 81.5% Jitter: 2.0% Simulated

Glass-Reinforced Ceramic: Dielectric Constant = 3.65 at 100 MHz, 3.58 at 1 GHz, 3.53 at 10 GHz; Loss Tangent = 0.008

System Performance With Connector

This subsection presents the electrical performance data for the **Z-Dok** connector in the test system. Specifically, it shows insertion loss data and eye patterns as a function of the connector's conductor pair, the type of layer connection, and the type of dielectric.

There are electrical performance data for four connector row pairs: **Pairs A3-A4** and **F3-F4**, at the edge rows of the connector, and **Pairs C3-C4** and **D3-D4**, in the interior rows of the connector. For each of these pairs, there are data for bottom-layer connection, using an FR-4 dielectric, in three system lengths, at four different data rates. In addition, there are data for **Pairs A3-A4** and **F3-F4** top-layer connections with a 6-inch system length.

Most of the electrical performance measurements in this subsection come from a test system using FR-4 for both the plug card and the receptacle card. However, to illustrate the **Z-Dok** connector's optimum throughput, there are data presented using glass-reinforced ceramic printed-circuit boards (PCBs) for **Pairs A3-A4** and **F3-F4**.

At the top of each data page that follows is a chart showing insertion loss against frequency for various system lengths. Beneath the chart are a series of eye patterns for a number of system lengths and speeds or bit rates. Each eye pattern includes the maximum opening (expressed as a percentage of the input swing) and the jitter (expressed as a percentage of the unit interval). For the eye patterns, the input signal is a pseudo-random bit sequence (PRBS) with a bit pattern of 2^7-1 (127 bits) and a one-volt differential swing. The signal rise time is approximately 25 picoseconds (ps).

The following table is an index to specific **Z-Dok** connector test system electrical performance measurements:

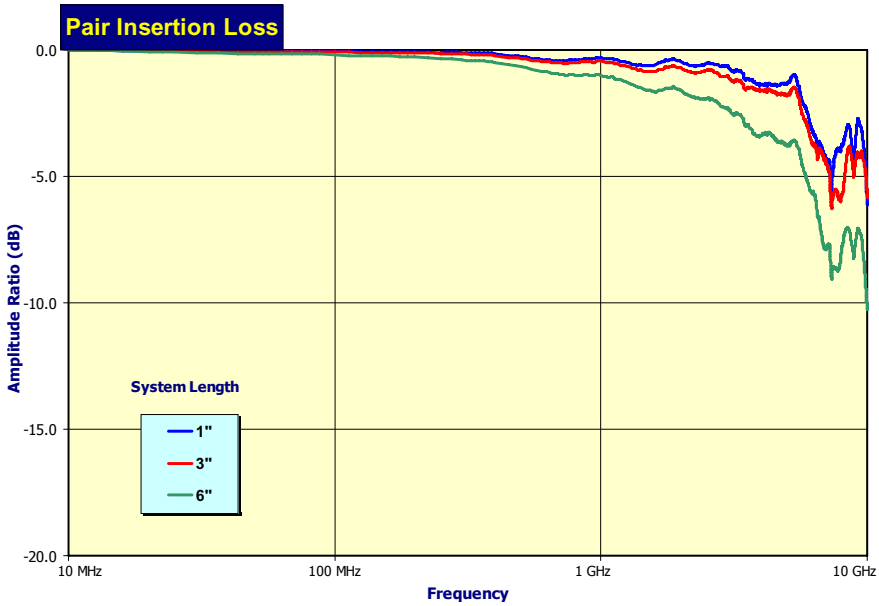
Index to System Performance Data

Connector Row Pair	PCB Material	Via Connection Type	Page Number
A3-A4	FR-4	Bottom-Layer	3-7
C3-C4	FR-4	Bottom-Layer	3-8
D3-D4	FR-4	Bottom-Layer	3-9
F3-F4	FR-4	Bottom-Layer	3-10
A3-A4	FR-4	Top-Layer	3-11
F3-F4			
A3-A4	Glass-Ceramic	Bottom-Layer	3-12
F3-F4			

A3-A4 — FR-4 — Bottom Layer Connection

Test System

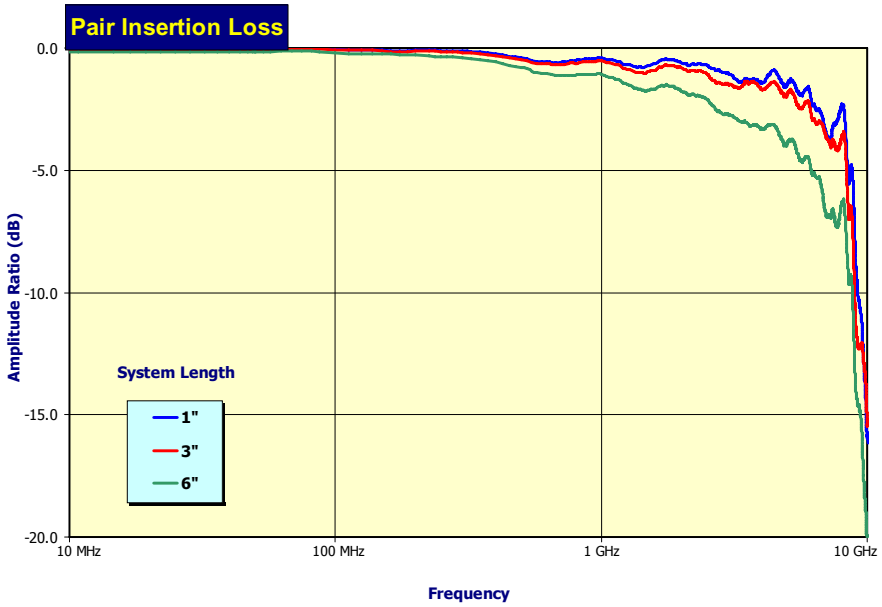
- See **Section 3**, Page 2 for test system specifications
- Based on measured data
- Simulated data based on measurements



System Length	Data Rate: 1.25 Gbps	3.125 Gbps	6.25 Gbps	10 Gbps
1"	**Maximum Opening:** 99.2% **Jitter:** 0.3% Simulated	**Maximum Opening:** 99.4% **Jitter:** 1.3% Simulated	**Maximum Opening:** 98.9% **Jitter:** 3.8% Simulated	**Maximum Opening:** 90.2% **Jitter:** 6.0% Simulated
3"	**Maximum Opening:** 99.7% **Jitter:** 0.4% Simulated	**Maximum Opening:** 98.0% **Jitter:** 1.6% Simulated	**Maximum Opening:** 97.0% **Jitter:** 3.9% Simulated	**Maximum Opening:** 92.5% **Jitter:** 7.0% Simulated
6"	**Maximum Opening:** 96.3% **Jitter:** 0.4%	**Maximum Opening:** 91.6% **Jitter:** 1.9%	**Maximum Opening:** 81.3% **Jitter:** 5.6%	**Maximum Opening:** 69.4% **Jitter:** 10.5%

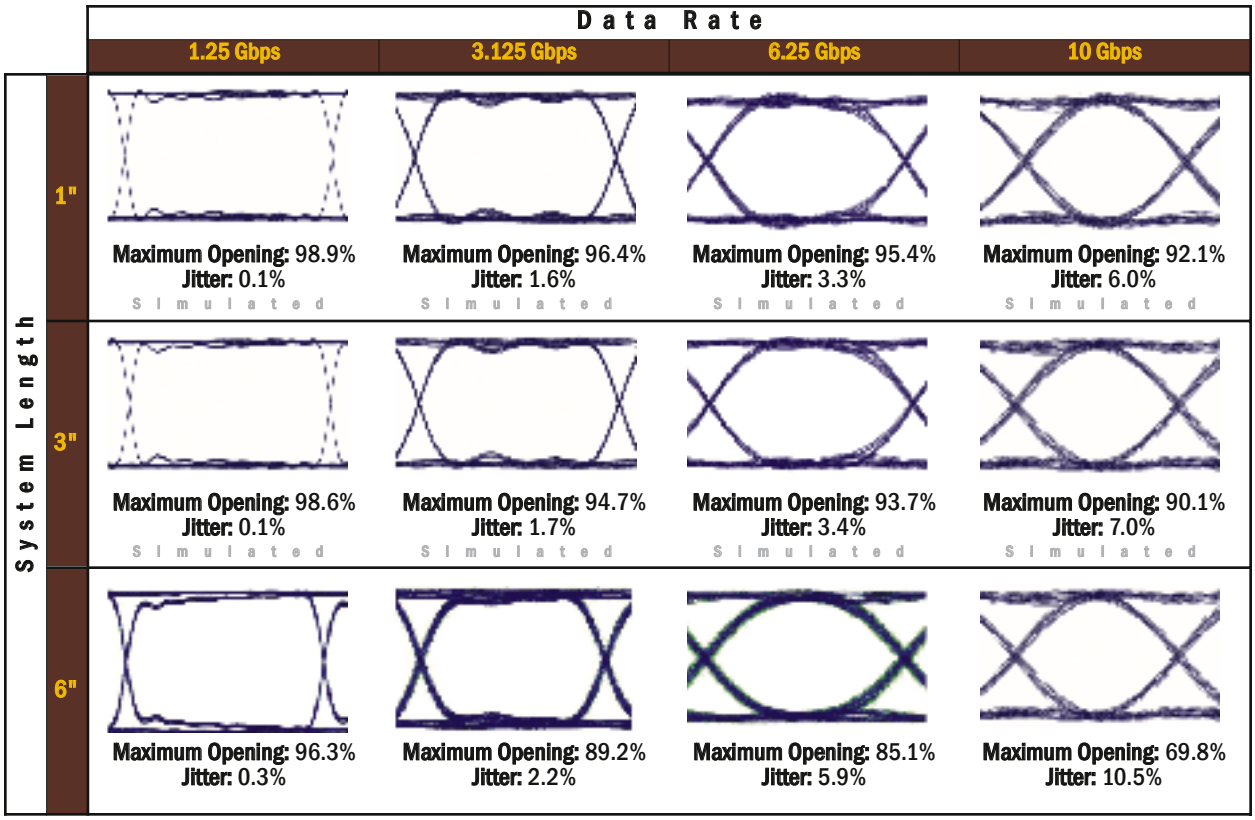
High-Grade FR-4: Dielectric Constant = 4.3 at 100 MHz, 4.1 at 1 GHz, 3.9 at 10 GHz; Loss Tangent = 0.015

C3-C4 — FR-4 — Bottom Layer Connection



Test System

- See **Section 3**, Page 2 for test system specifications
- Based on measured data
- Simulated data based on measurements

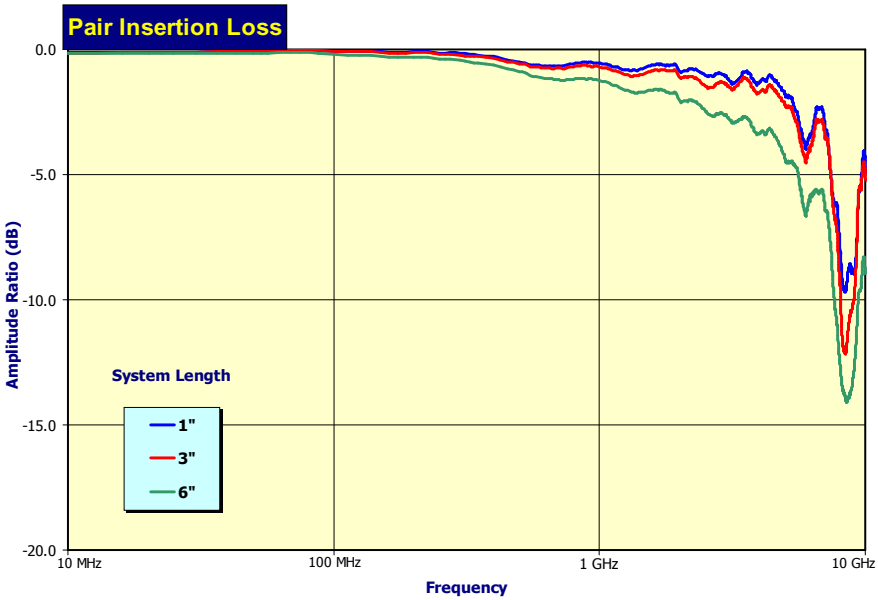


High-Grade FR-4: Dielectric Constant = 4.3 at 100 MHz, 4.1 at 1 GHz, 3.9 at 10 GHz; Loss Tangent = 0.015

D3-D4 — FR-4 — Bottom Layer Connection

Test System

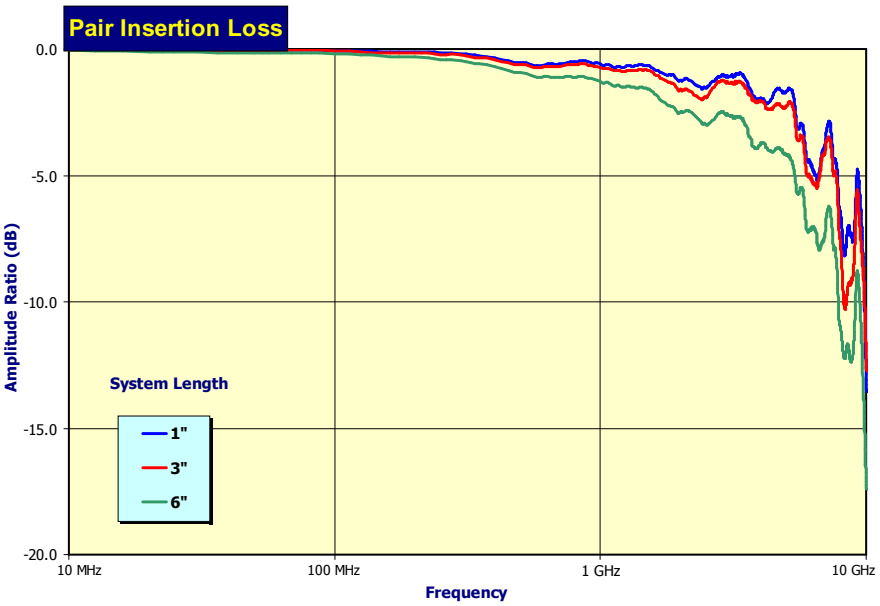
- See **Section 3**, Page 2 for test system specifications
- Simulated data based on measurements



System Length	Data Rate: 1.25 Gbps	3.125 Gbps	6.25 Gbps	10 Gbps
1"	**Maximum Opening:** 98.2% **Jitter:** 0.1% Simulated	**Maximum Opening:** 95.2% **Jitter:** 1.3% Simulated	**Maximum Opening:** 93.8% **Jitter:** 3.8% Simulated	**Maximum Opening:** 87.7% **Jitter:** 7.5% Simulated
3"	**Maximum Opening:** 98.0% **Jitter:** 0.1% Simulated	**Maximum Opening:** 91.3% **Jitter:** 1.6% Simulated	**Maximum Opening:** 88.7% **Jitter:** 5.6% Simulated	**Maximum Opening:** 83.8% **Jitter:** 9.0% Simulated
6"	**Maximum Opening:** 94.8% **Jitter:** 0.5% Simulated	**Maximum Opening:** 85.9% **Jitter:** 2.0% Simulated	**Maximum Opening:** 83.7% **Jitter:** 7.4% Simulated	**Maximum Opening:** 66.9% **Jitter:** 11.0% Simulated

High-Grade FR-4: Dielectric Constant = 4.3 at 100 MHz, 4.1 at 1 GHz, 3.9 at 10 GHz; Loss Tangent = 0.015

F3-F4 — FR-4 — Bottom Layer Connection



Test System

- See **Section 3**, Page 2 for test system specifications
- Simulated data based on measurements

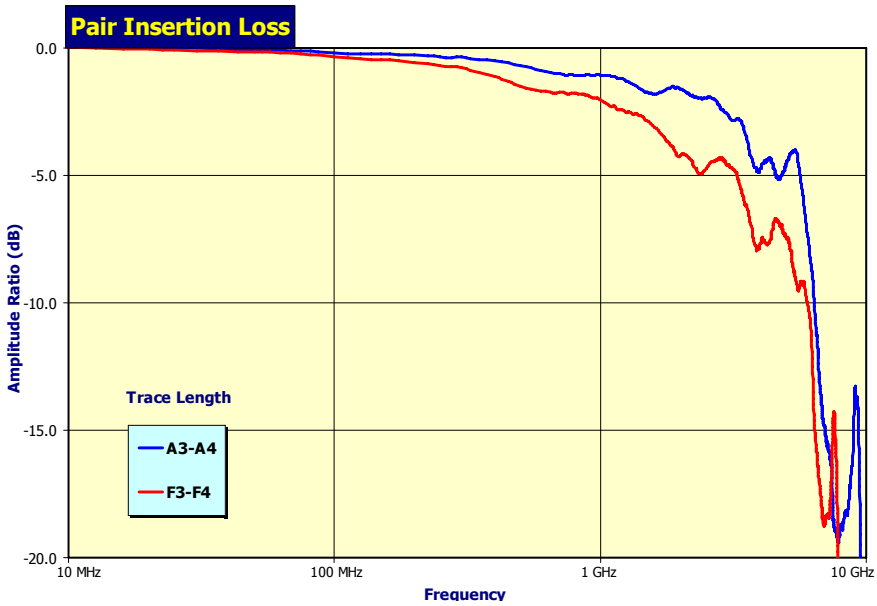
System Length	Data Rate: 1.25 Gbps	3.125 Gbps	6.25 Gbps	10 Gbps
1"	**Maximum Opening:** 97.4% **Jitter:** 0.06% Simulated	**Maximum Opening:** 95.3% **Jitter:** 1.6% Simulated	**Maximum Opening:** 89.2% **Jitter:** 4.4% Simulated	**Maximum Opening:** 87.1% **Jitter:** 6.3% Simulated
3"	**Maximum Opening:** 94.7% **Jitter:** 0.3% Simulated	**Maximum Opening:** 93.8% **Jitter:** 1.7% Simulated	**Maximum Opening:** 88.4% **Jitter:** 5.0% Simulated	**Maximum Opening:** 83.3% **Jitter:** 7.5% Simulated
6"	**Maximum Opening:** 93.8% **Jitter:** 0.6% Simulated	**Maximum Opening:** 87.9% **Jitter:** 2.5% Simulated	**Maximum Opening:** 74.7% **Jitter:** 5.6% Simulated	**Maximum Opening:** 64.7% **Jitter:** 11.0% Simulated

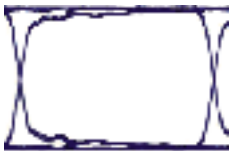
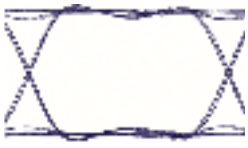
High-Grade FR-4: Dielectric Constant = 4.3 at 100 MHz, 4.1 at 1 GHz, 3.9 at 10 GHz; Loss Tangent = 0.015

A3-A4 and F3-F4 — FR-4 — Top Layer Connection

Test System

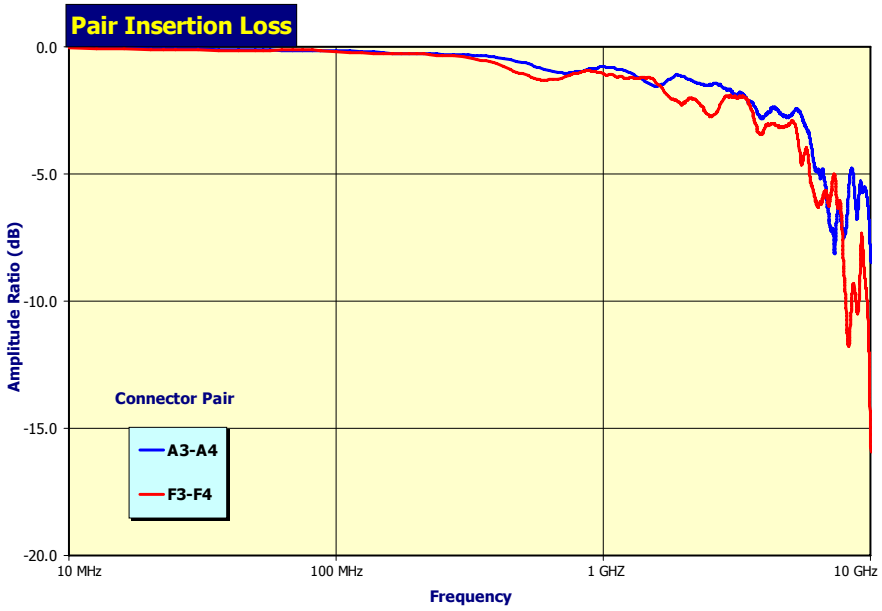
- See **Section 3**, Page 2 for test system specifications
- System length: 6"
- Simulated data based on measurements



Connector Pair	Data Rate: 1.25 Gbps	3.125 Gbps	6.25 Gbps	10 Gbps
A3-A4	 **Maximum Opening:** 98.6% **Jitter:** 0.1% Simulated	 **Maximum Opening:** 94.4% **Jitter:** 2.5% Simulated	 **Maximum Opening:** 76.1% **Jitter:** 6.8% Simulated	 **Maximum Opening:** 75.8% **Jitter:** 13.5% Simulated
F3-F4	 **Maximum Opening:** 95.2% **Jitter:** 0.1% Simulated	 **Maximum Opening:** 89.0% **Jitter:** 2.5% Simulated	 **Maximum Opening:** 76.1% **Jitter:** 6.8% Simulated	 **Maximum Opening:** 61.7% **Jitter:** 13.5% Simulated

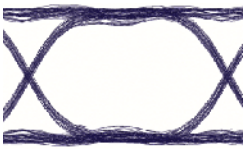
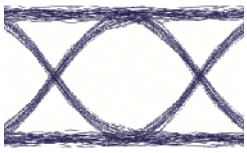
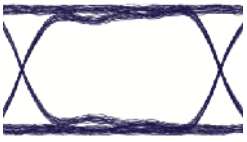
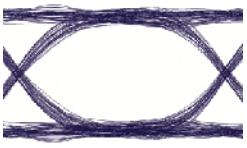
High-Grade FR-4: Dielectric Constant = 4.3 at 100 MHz, 4.1 at 1 GHz, 3.9 at 10 GHz; Loss Tangent = 0.015

A3-A4 and F3-F4 — Glass-Ceramic — Bottom Layer Connection



Test System

- See **Section 3**, Page 2 for test system specifications
- Based on measured data
- Simulated data based on measurements

Connector Pair	Data Rate: 1.25 Gbps	3.125 Gbps	6.25 Gbps	10 Gbps
A3-A4	 **Maximum Opening:** 99.3% **Jitter:** 0.3% Simulated	 **Maximum Opening:** 93.6% **Jitter:** 1.8% Simulated	 **Maximum Opening:** 86.2% **Jitter:** 5.6% Simulated	 **Maximum Opening:** 82.2% **Jitter:** 8.5% Simulated
F3-F4	 **Maximum Opening:** 94.3% **Jitter:** 0.6% Simulated	 **Maximum Opening:** 89.5% **Jitter:** 2.3% Simulated	 **Maximum Opening:** 79.8% **Jitter:** 6.1% Simulated	 **Maximum Opening:** 76.8% **Jitter:** 9.0% Simulated

Glass-Reinforced Ceramic: Dielectric Constant = 3.65 at 100 MHz, 3.58 at 1 GHz, 3.53 at 10 GHz; Loss Tangent = 0.008

Effects of Noise on System Throughput

Signal Characteristics

- Pseudorandom binary sequence with a bit pattern of 2^7-1 (127 bits) and 1 volt differential swing
- Rise time = 25 ps
- All data are measured or transformed

The eye patterns on this page illustrate the effects noise can have on system throughput. Elsewhere in this report, eye patterns assume all nearby lines are held quiet. The eye diagrams below show the effect of switching the lines surrounding the main signal line on a signal's throughput waveform.

The first row shows eye patterns without any system noise; these are included for reference.

The second row shows the effect of synchronous noise. Synchronous noise occurs when all lines in a system transmit and receive simultaneously. The advantage of synchronous noise is that most of the noise occurs in the time during edge transitioning, and not during sampling. This increases the eye opening for measurement during sampling. Typically, synchronous systems match system lengths for all signals and group transmit signals together to take advantage of this phenomenon. Because of this, far-end noise is usually associated with synchronous noise.

The third row of eye patterns shows the effect of asynchronous noise. Asynchronous systems do not have length-matched networks or provide any special data timing. Because of this, asynchronous noise can occur at any time from any or all nearby active lines. Analysis of asynchronous noise must account for the worst case in which the greatest possible near-end and far-end noise occur simultaneously.

Note that the following waveforms are examples only. For versions of eye patterns from this report which include the effect of noise, contact **Tyco Electronics** for custom measurements or simulations.