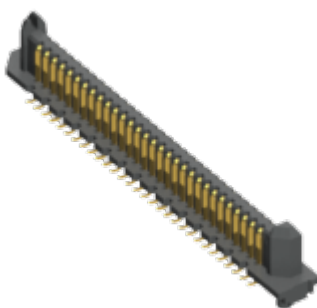




## High Speed Characterization Report

**ERM6-30-01.5-L-DV-A**



**ERF6-30-03.5-L-DV-A**



**Description:**  
**0.635 mm Edge Rate® Rugged High Speed,**  
**ERM6 mating to ERF6, 5 mm Stack Height**

**Series:** ERM6 / ERF6**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

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**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

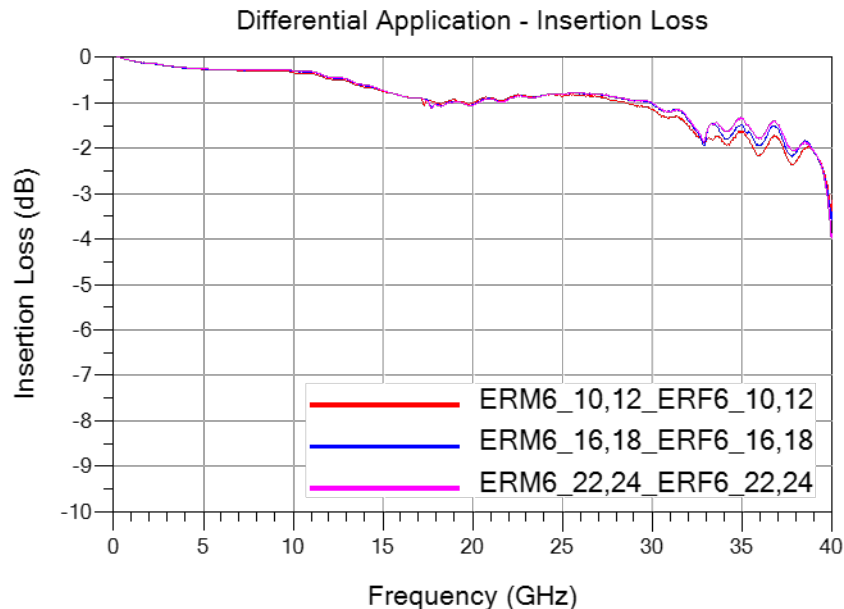
## Connector Overview

The ERM6/ERF6 is a board-mounted header/socket designed for use in high-speed systems. The ERM6/ERF6 uses the Edge Rate® contact system optimized for signal integrity performance; supporting 56Gbps PAM4 applications. The ERM6/ERF6 family comes available in 10, 20, 30, 40, 45 and 60 positions per row. The data in this report is applicable to the 5mm (0.197") board-to-board mated connector stack height.

## Frequency Domain Data Summary

### Bandwidth Chart – Differential Insertion Loss

ERx6 Connector Series



**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

## Time Domain Data Summary

| Table 1 - Differential Impedance ( $\Omega$ ) |                   |       |       |       |
|-----------------------------------------------|-------------------|-------|-------|-------|
| Driver                                        | Signal Rise-time  | 30ps  | 50ps  | 100ps |
| ERM6_10,12                                    | Maximum Impedance | 101.4 | 101.3 | 101.2 |
|                                               | Minimum Impedance | 88.5  | 91.4  | 94.4  |
| ERM6_16,18                                    | Maximum Impedance | 101.5 | 101.4 | 101.3 |
|                                               | Minimum Impedance | 88.0  | 90.8  | 94.0  |
| ERM6_22,24                                    | Maximum Impedance | 101.4 | 101.3 | 101.2 |
|                                               | Minimum Impedance | 87.9  | 90.7  | 93.9  |

| Table 2 - Differential Crosstalk (%) |            |            |      |      |       |
|--------------------------------------|------------|------------|------|------|-------|
| Input(tr)                            | Driver     | Receiver   | 30ps | 50ps | 100ps |
| NEXT                                 | ERM6_10,12 | ERM6_16,18 | 0.34 | 0.25 | 0.12  |
|                                      | ERM6_28,30 | ERM6_16,18 | <0.1 | <0.1 | <0.1  |
|                                      | ERM6_9,11  | ERM6_16,18 | 0.11 | <0.1 | <0.1  |
|                                      | ERM6_15,17 | ERM6_16,18 | 1.00 | 0.71 | 0.40  |
|                                      | ERM6_27,29 | ERM6_16,18 | <0.1 | <0.1 | <0.1  |
| FEXT                                 | ERF6_10,12 | ERM6_16,18 | <0.1 | <0.1 | <0.1  |
|                                      | ERF6_28,30 | ERM6_16,18 | <0.1 | <0.1 | <0.1  |
|                                      | ERF6_9,11  | ERM6_16,18 | <0.1 | <0.1 | <0.1  |
|                                      | ERF6_15,17 | ERM6_16,18 | <0.1 | <0.1 | <0.1  |
|                                      | ERF6_21,23 | ERM6_16,18 | <0.1 | <0.1 | <0.1  |

| Table 3 - Propagation Delay (Mated Connector) |       |
|-----------------------------------------------|-------|
| ERM6_10,12 ERF6_10,12                         | 48 ps |
| ERM6_16,18 ERF6_16,18                         | 48 ps |
| ERM6_22,24 ERF6_22,24                         | 47 ps |

**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

### 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 differentially and single-ended driven 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. But 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.

**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

For this connector, the following configurations were evaluated:

|   |    |    |   |    |    |   |    |    |   |    |    |   |   |   |   |
|---|----|----|---|----|----|---|----|----|---|----|----|---|---|---|---|
| G | 29 | 27 | G | 23 | 21 | G | 17 | 15 | G | 11 | 9  | G | T | T | G |
| G | 30 | 28 | G | 24 | 22 | G | 18 | 16 | G | 12 | 10 | G | T | T | G |

Differential Impedance (denoted by blue circles):

- GSSG (Ground-positive Signal-negative Signal-Ground)

Differential Crosstalk (denoted by red circles):

- In row: from the terminals to the other terminals on the same row.
- Across row: from one row of terminals to the other row of terminals.

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. But 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 30 ps and 100 ps.

For this report, measured rise times were at 20%-80% signal levels.

### Frequency Domain Data

Frequency Domain parameters are helpful in evaluating the 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,

**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

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 Keysight 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 1.2 mm of PCB trace on both the ERM6 and ERF6 each. Delay is measured at 100 picoseconds signal risetime. 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. 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](mailto:sig@samtec.com).

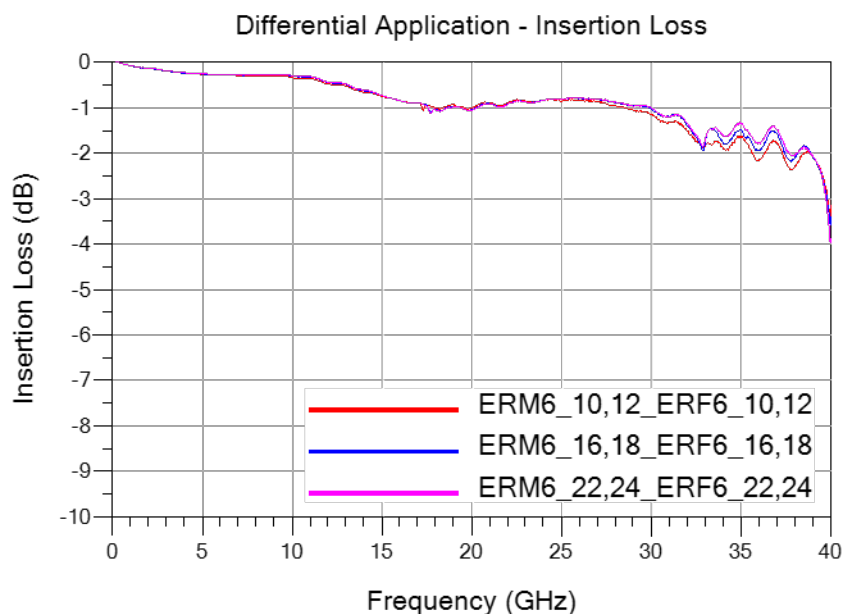
Additional information concerning test conditions and procedures is located in the appendices of this report. Further information may be obtained by contacting our Signal Integrity Group at [sig@samtec.com](mailto:sig@samtec.com).

**Series:** ERM6 / ERF6

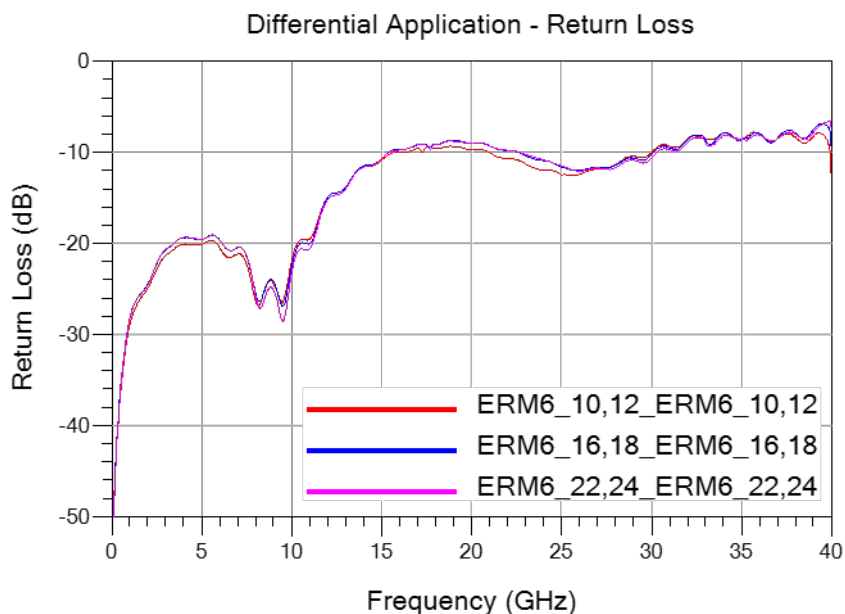
**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

## Appendix A – Frequency Domain Responses

### Differential Application – Insertion Loss



### Differential Application – Return Loss

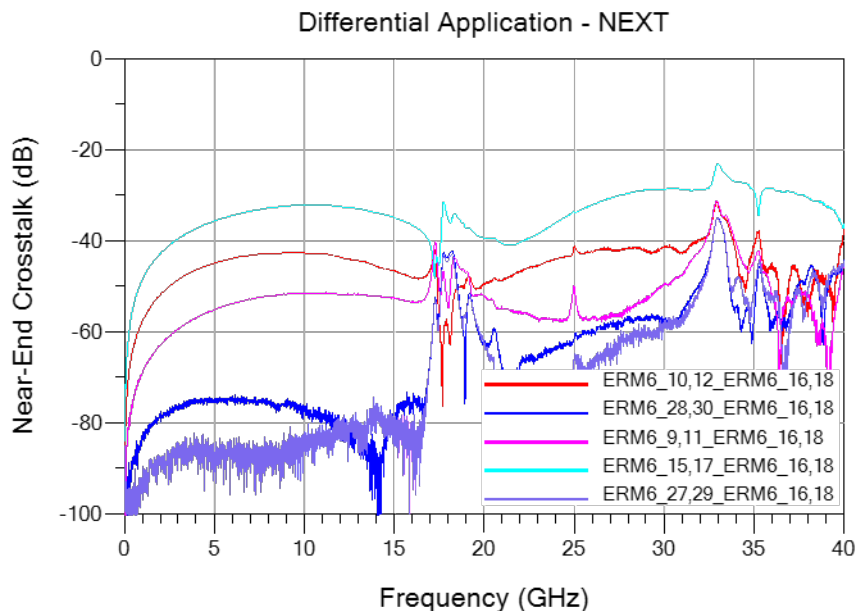




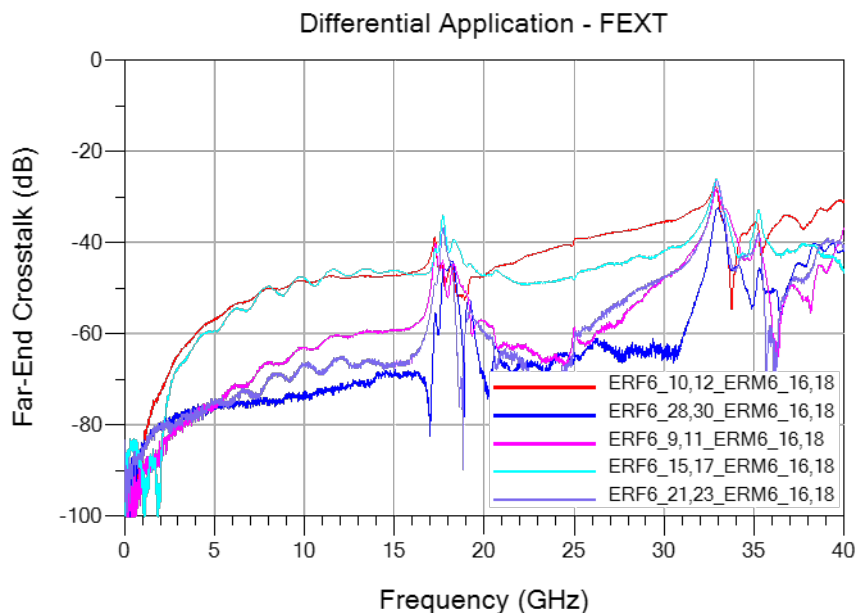
**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

### Differential Application – NEXT Configurations



### Differential Application – FEXT Configurations



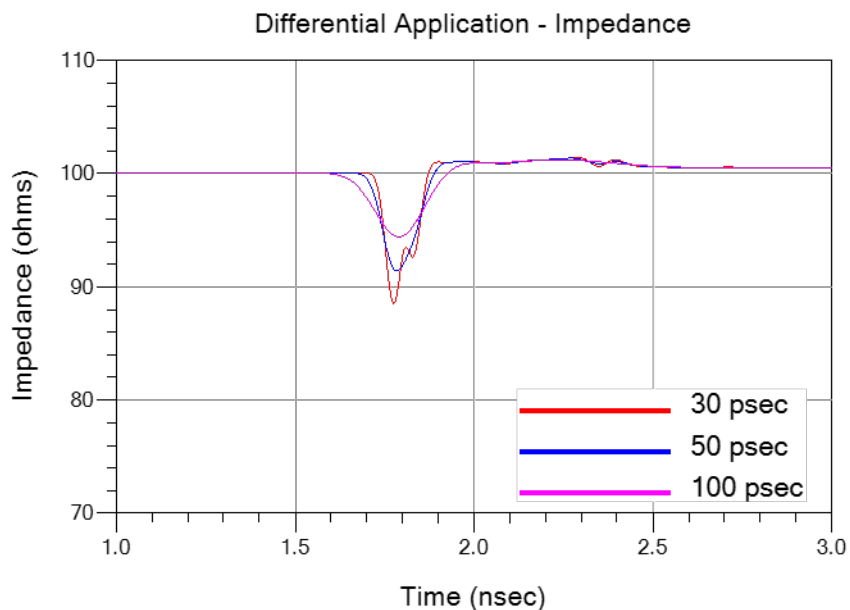
**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

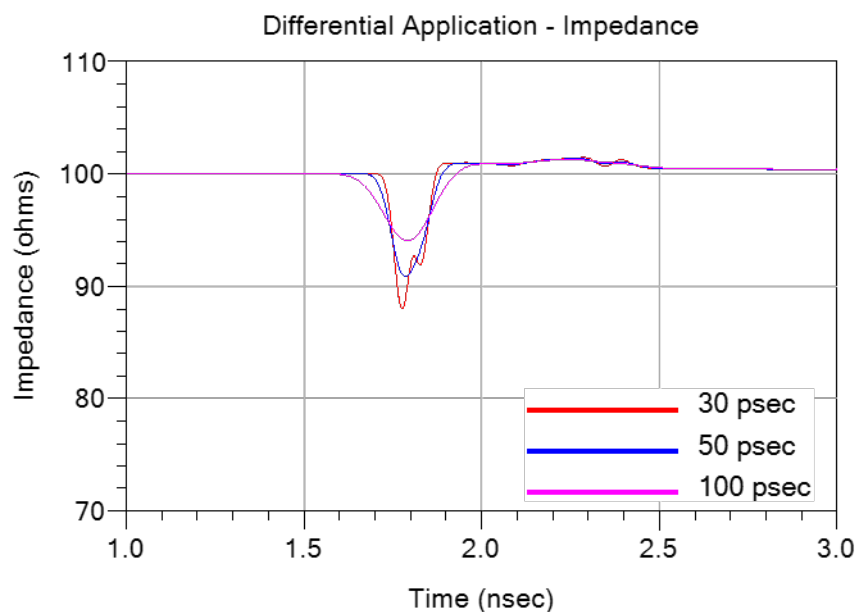
## Appendix B – Time Domain Responses

### Differential Application – Impedance

ERM6\_10,12\_ ERF6\_10,12



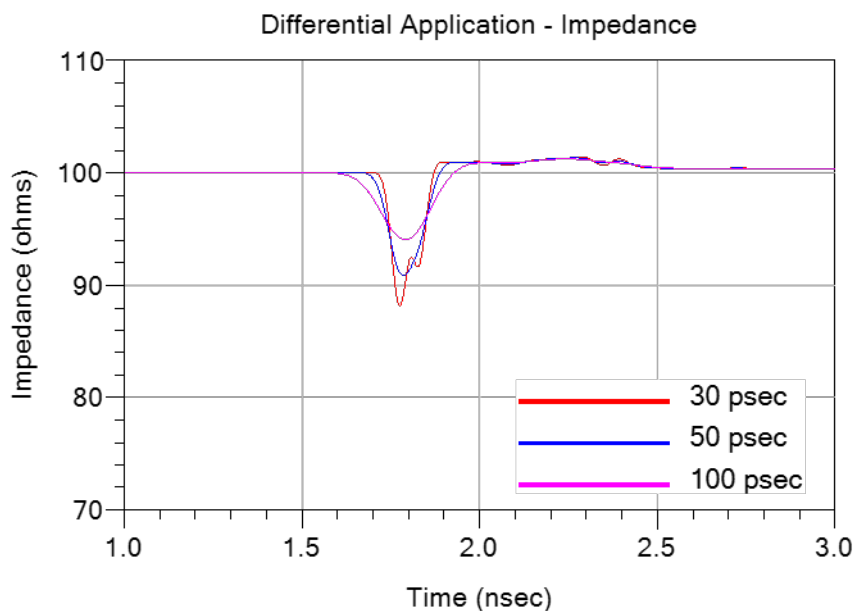
ERM6\_16,18\_ ERF6\_16,18



**Series:** ERM6 / ERF6

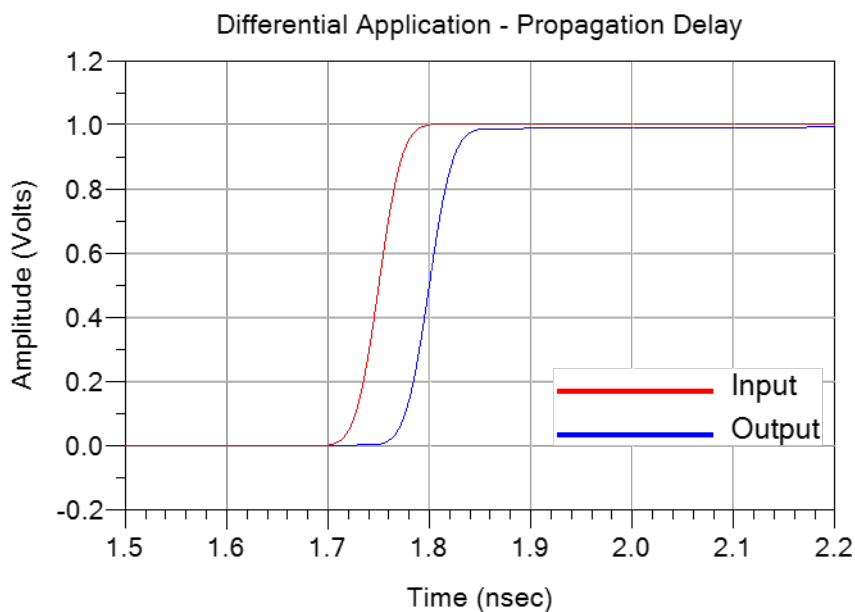
**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

ERM6\_22,24\_ ERF6\_22,24



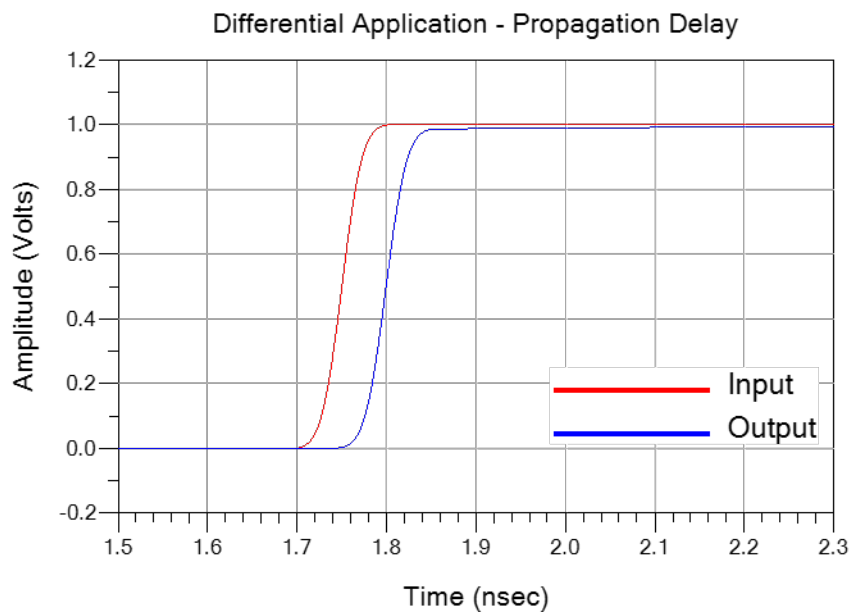
### Differential Application – Propagation Delay

ERM6\_10,12\_ ERF6\_10,12

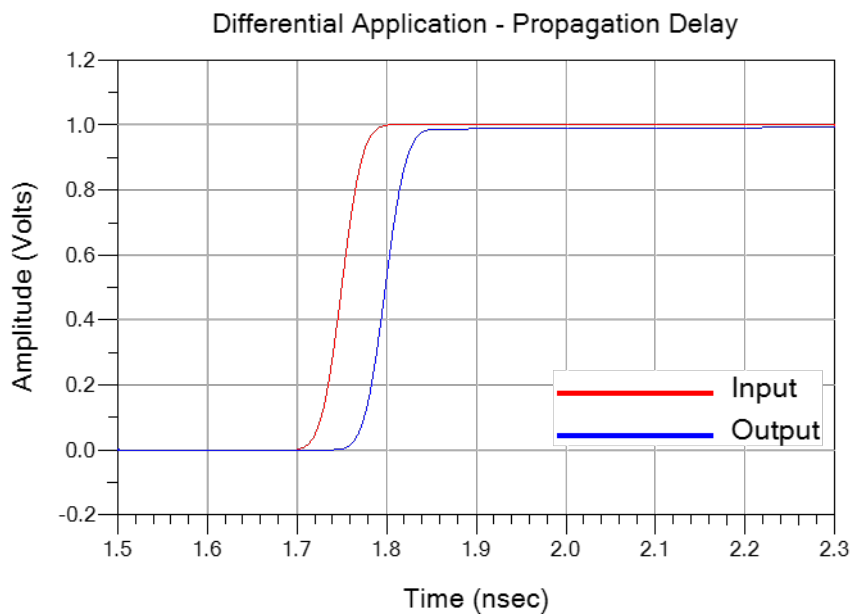


**Series:** ERM6 / ERF6**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

ERM6\_16,18\_ ERF6\_16,18



ERM6\_22,24\_ ERF6\_22,24



**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

## Appendix C – Product and Test System Descriptions

### Product Description

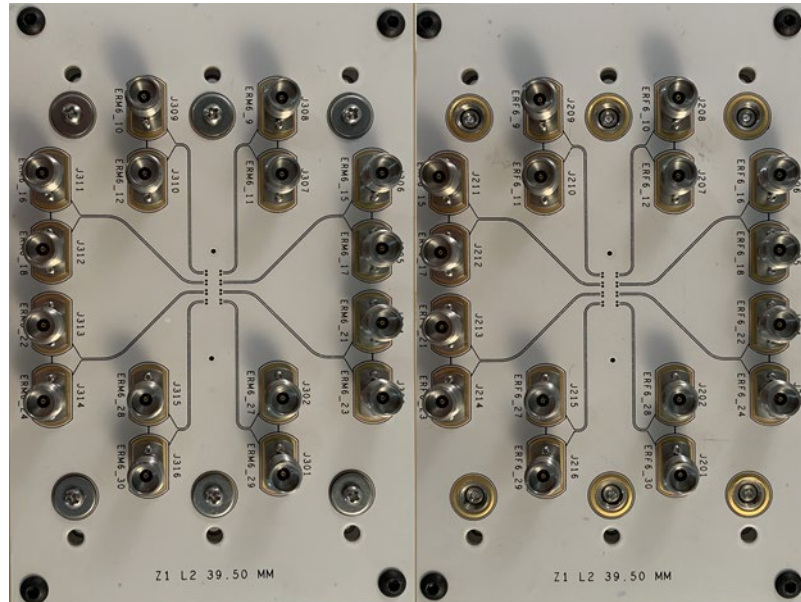
Product test samples are ERx6 Series connectors. The part number is ERM6-30-01.5-L-DV-A and ERF6-30-03.5-L-DV-A. A photo of the test articles mounted to SI test boards is shown below.

### Test System Description

The test fixtures are composed of six-layer MT40 material with 50Ω signal trace and pad configurations designed for the electrical characterization of Samtec high speed connector products. A PCB mount 2.4mm connector is used to interface the PNA test cables to the test fixtures. Optimization of the 2.4mm launch was performed using full wave simulation tools to minimize reflections. The test fixtures and calibration kit are specific to the ERx6 series connector set and identified by part number PCB-ERM6-111052-SIG-0 and PCB-ERF6-111052-SIG-0.

### PCB-ERx6-111052-SIG-0 Test Fixtures

Shown below is a photograph of the one of the three test board sets.

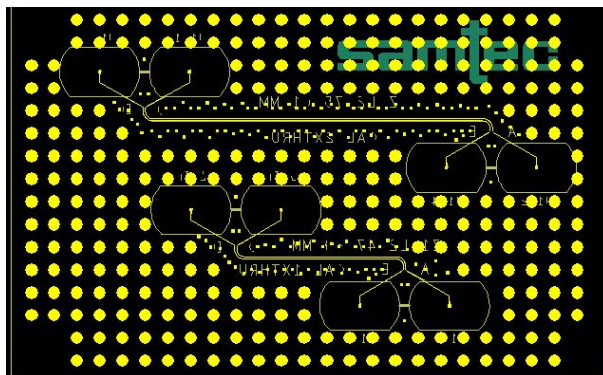
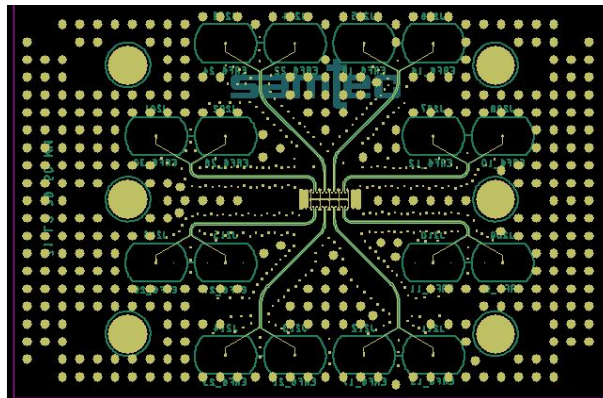
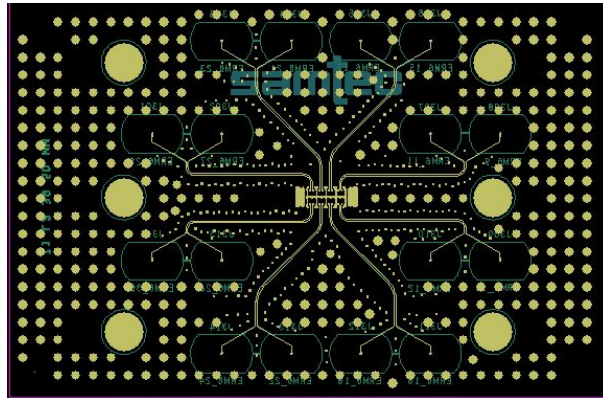


**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

### PCB Fixtures

The test fixtures used are as follows:



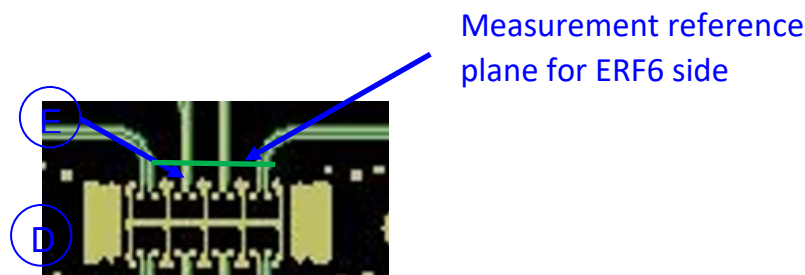
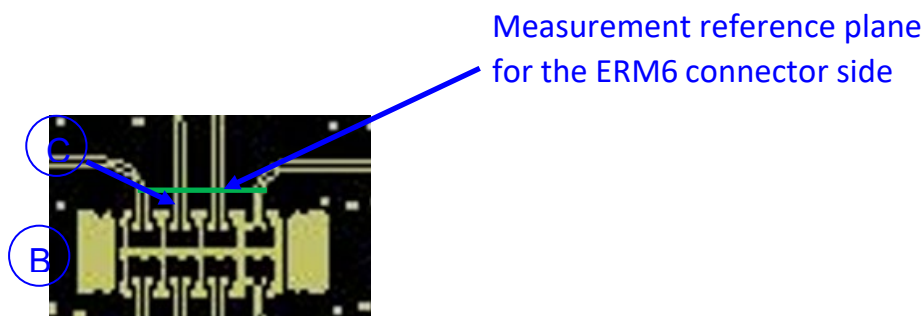
**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

All traces on the test boards are length matched to 39 mm measured from the edge of the pad to the 2.4mm connector. The AFR calibration effectively removes 37.8 mm of test board trace effects. This means that 1.2 mm of test board trace length effects are included in the both sides of test boards in the measurement. The S-Parameter measurement includes:

- A- The ERx6 Series connector set
- B- Test board vias, pads (footprint effects) for the ERM6 connector side.
- C- 1.2 mm of 0.142 mm wide microstrip trace.
- D- Test board vias, pads (footprint effects) for the ERF6 side.
- E- 1.2 mm of 0.142 mm wide microstrip trace.

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





**Series:** ERM6 / ERF6

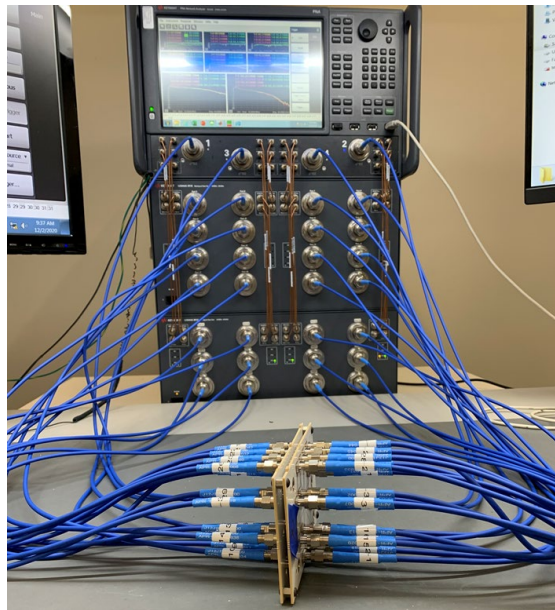
**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

## Appendix D – Test and Measurement Setup

For frequency domain measurements, the test instrument is the Keysight N5227B PNA-L network analyzer. Frequency domain data are obtained directly from the instrument and figures are generated by Keysight ADS. The network analyzer is configured as follows:

Start Frequency – 10 MHz  
Stop Frequency – 40 GHz  
Number of points – 4000  
IFBW – 1 KHz

### N5227B Measurement Setup



### Test Instruments

| <u>QTY</u> | <u>Description</u>                                      |
|------------|---------------------------------------------------------|
| 1          | Keysight N5227B PNA Network Analyzer (10 MHz to 50 GHz) |
| 1          | Keysight 1.85mm 85058B M-Cal (10 MHz to 50 GHz)         |

### Test Cables & Adapters

| <u>QTY</u> | <u>Description</u>                                 |
|------------|----------------------------------------------------|
| 4          | 1m Gore 1.85mm male to female cable (DC to 67 GHz) |



**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

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

A coaxial SOLT calibration is performed using 85058B M-Cal module. Then DUT measurements are performed under SOLT calibration. The measurements include the effect of test fixture. The measurements of the 2X THRU line standards are required to remove the test fixture effect.

### Time Domain Procedures

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 Keysight ADS 2017. 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/Technical\\_Library/reference/articles/pdfs/tech-note\\_using-PLTS-for-time-domain-data\\_web.pdf](http://www.samtec.com/Technical_Library/reference/articles/pdfs/tech-note_using-PLTS-for-time-domain-data_web.pdf)

### 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.

**Series:** ERM6 / ERF6

**Description:** 0.635 mm Edge Rate® Rugged High Speed, ERM6 mating to ERF6,  
5 mm Stack Height

### Appendix F – Glossary of Terms

ADS – Advanced Design Systems

FD – Frequency domain

FEXT – Far-End Crosstalk

GSG – Ground–Signal–Ground; geometric configuration

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

NEXT – Near-End Crosstalk

PCB – Printed Circuit Board

SE – Single-Ended

SI – Signal Integrity

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

Z – Impedance (expressed in ohms)