Signal Integrity Performance of the Teledyne Relays GRF300/GRF303 Relay Series

By An Trinh, Minh Tran
Teledyne Relays

Abstract

As requirements for higher-speed data rate increase, questions have arisen about whether Teledyne Relays RF relays can support transmission of digital signals in the 10Gbps data rate. To answer such questions, Teledyne Relays collaborated with two customers to evaluate the performances of the GRF relay series. At the recommendation of both customers and with their assistance, Teledyne simulated an eye diagram using S-parameter data and measurements by an Agilent Digital Communication Analyzer. This paper shows the supporting measurements to conclude that Teledyne RF relays perform very well with 10Gbps signals.

1. Introduction

Today, mainstream data transmission converges on high-speed digital communication technology. Whether to direct digital data from multiple sources to receiving targets or vice versa, switching relay and carrier transmission lines commonly perform these tasks economically and effectively. Standard Teledyne Relays products such as the 114 and 412 relay series already support applications that are less than the gigabit data stream, such as USB and video. When multi-gigabit applications up to 10Gbps and above are required, as in the case of PCI Express and ATE applications, among the most reliable and cost-effective candidates are the Teledyne Relays high-performance GRF300/GRF303 relay series mounted on impedance matched transmission lines. This paper presents objective data to demonstrate the performances of these relays in the multi-gigabit data transmission.

The most simple and useful tool to demonstrate the capabilities of the Teledyne Relays GRF300/GRF303 relay series is the eye diagram. The eye diagram is an informative tool for evaluating the digital signal transmission because it can provide visual information of the system performances plus possible imperfections. The eye diagram is an oscilloscope display of a digital signal, repetitively sampled to display the behavior of the device under test (DUT). The basic information contained in the eye diagram is the amount of distortion (set by signal-to-noise ratio), time variation of zero crossing, and the signal-to-noise at the sampling point. According to the article “Analyzing Signal Using the Eye Diagram” by Gary Breed, the most important features of the eye diagram are the size of the eye opening (signal-to-noise during sampling) and the magnitude of the amplitude and timing errors.

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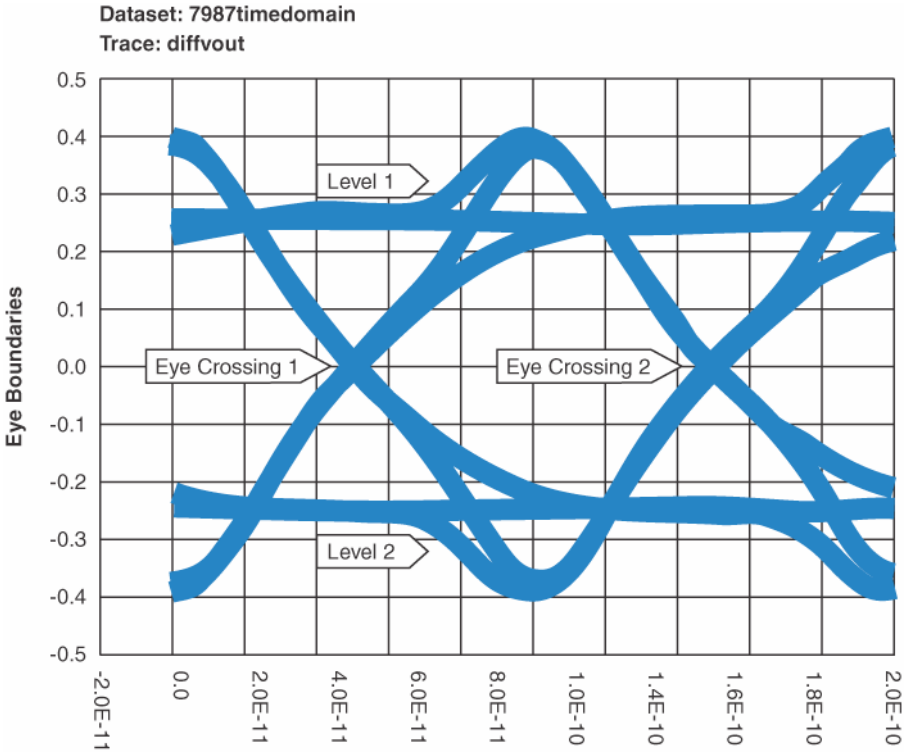
2. Simulation Data of Teledyne RF Relays

Simulated data of the GRF300-12 DPDT relay were provided by Customer 1, using two different S-parameter data sources – as measured by Teledyne Relays using Agilent VNA and data measured by the customer using Anritsu 40G VNA.

2.1 Simulated results using Teledyne Relays data; simulated with 10Gbps signal



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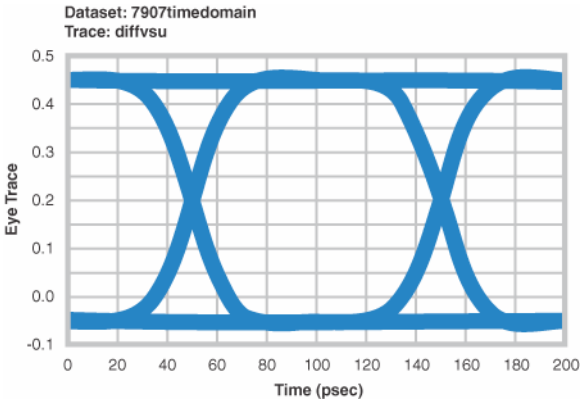
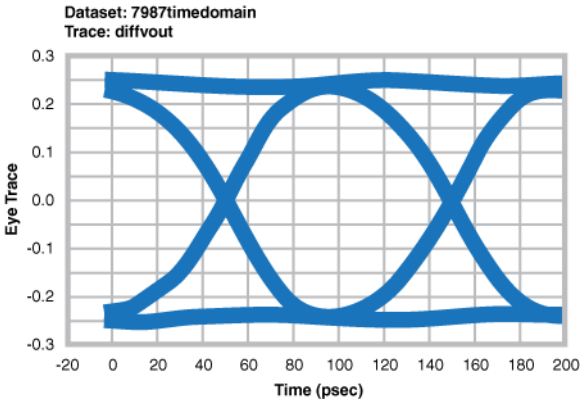
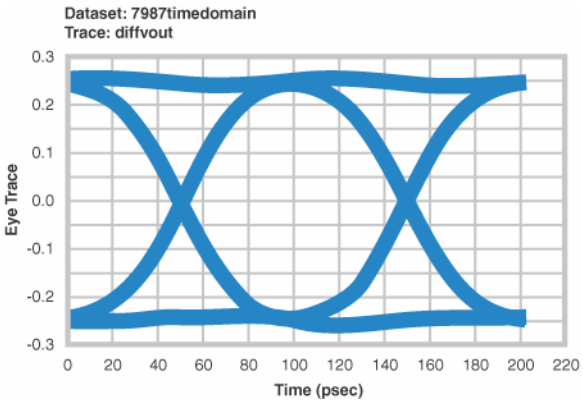
2.2 Simulated results using Customer 1 measurements; simulated with 10Gbps signal simulation source



2.3 Relay at “ON” state (with PCB)



2.4 Relay only



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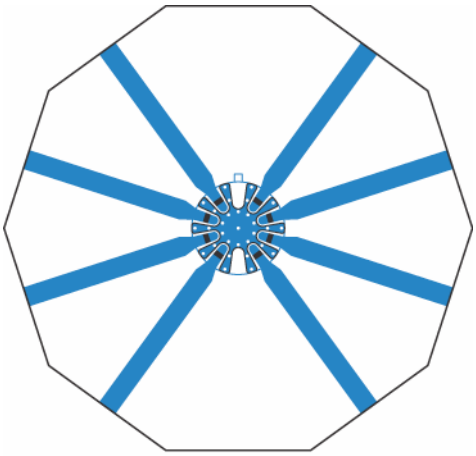
3. Measured Data of Teledyne RF Relays

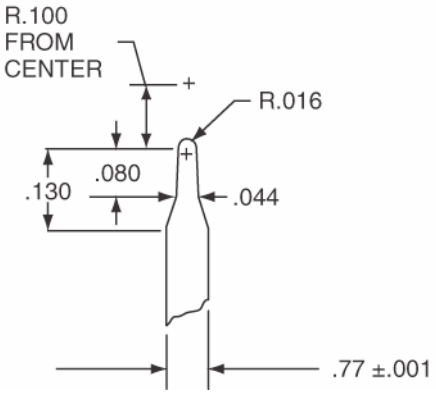
Simulated results were validated by measurements using the Agilent AG86100 Digital Communication Analyzer with 12GHz pattern generator and 10GHz clock source by Customer 1. The relay was mounted on an evaluation board with the following descriptions. Two RF 3-foot-long cables were used for measurements.

Pattern Generator Settings
- $2^{31}-1$ PRBS signal
- 10Gbps data rate
- Data amplitude of 500mVpp

Oscilloscope Settings
- Measurement threshold set to 20%-80%
- NRZ Eye/Mask mode measurements: rise time, fall time, eye ramp and bit rate



a. Material: RT/duroid 6002 [Rogers]
b. Thickness: 0.030"
c. Copper foil thickness: 0.00134"
d. Trace layout:



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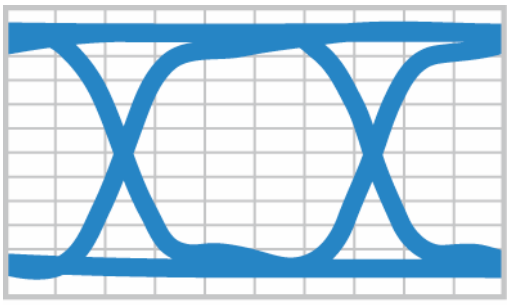
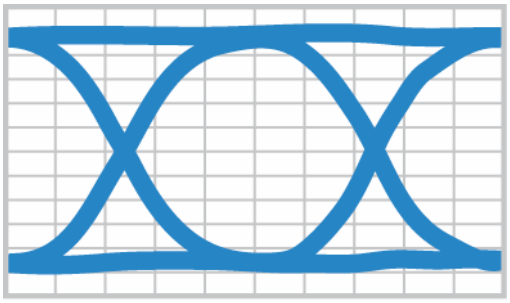
3.1 Eye diagram for source and cables



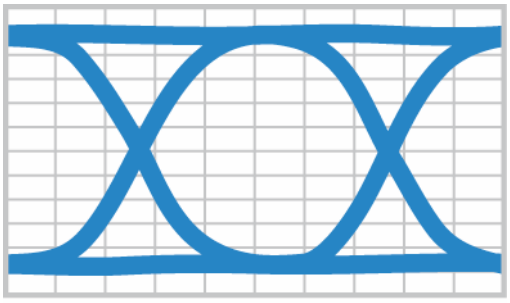
i. Rt_S = 21.3 pS.
ii. Ft_S = 22.2 pS.
iii. V_S = 501.6 mVpp.

3.2 Eye diagram of relay at normally closed position (coil off)



i. Rt_{OFF} = 31.1 pS.
ii. Ft_{OFF} = 32 pS.
iii. V_{OFF} = 511.95 mVpp.

3.3 Eye Diagram of relay at normally open position (coil on)



i. Rt_{ON} = 30.2 pS.
ii. Ft_{ON} = 30.7 pS.
iii. V_{ON} = 512.54 mV

Customer 2 provided eye diagrams for four different relay mounting configurations – formed leads (RF303), formed leads with ground pins (RF303-1), surface mounted with RF shield (GRF303), surface-mounted with RF shield and formed leads (SGRF303).

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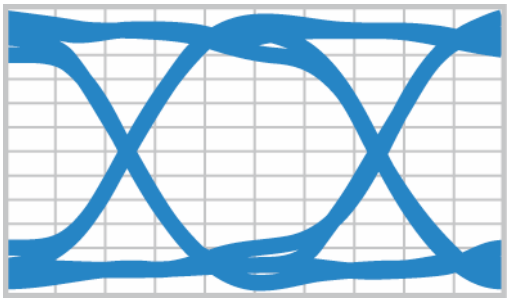
Pattern Generator Settings

• 2^9 –1 PRBS signal

• 10Gbps data rate

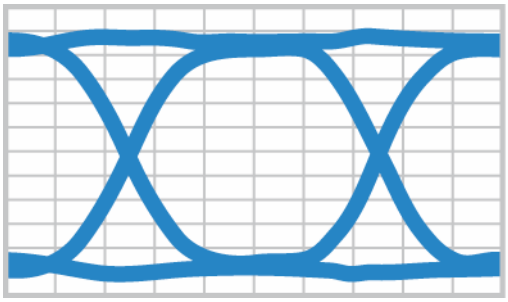
• Data amplitude of 400mVpp

3.4 Eye diagram of RF303 relay (formed leads configuration)

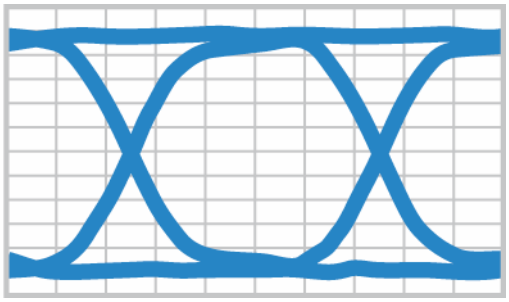


3.5 Eye diagram of GRF303 relay (surface-mounted with RF shield configuration)

Normally open position (coil on)

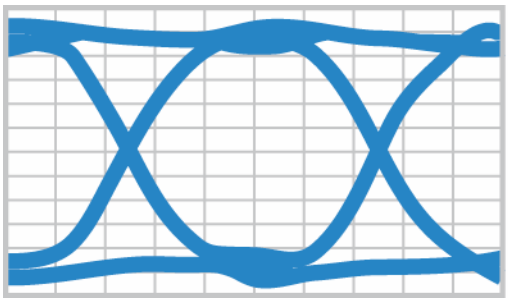


Normally closed position (coil off)

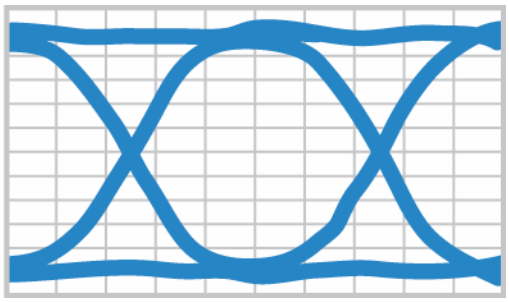


3.6 Eye Diagram of SGRF303 relay (surface-mounted with RF shield and formed leads configuration)

Normally open position (coil on)



Normally closed position (coil off)



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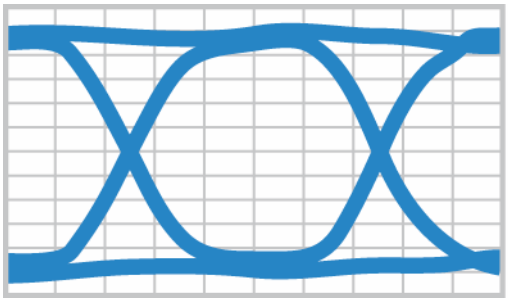
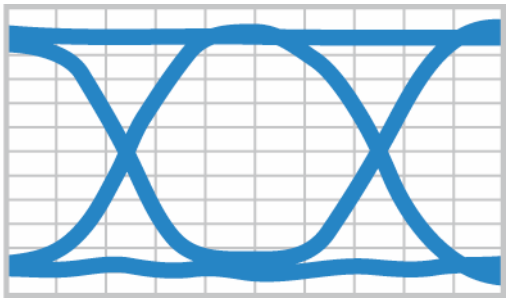
3.7 Eye Diagram of RF303-1 relay (formed leads with ground pins configuration)

Normally open position (coil on)



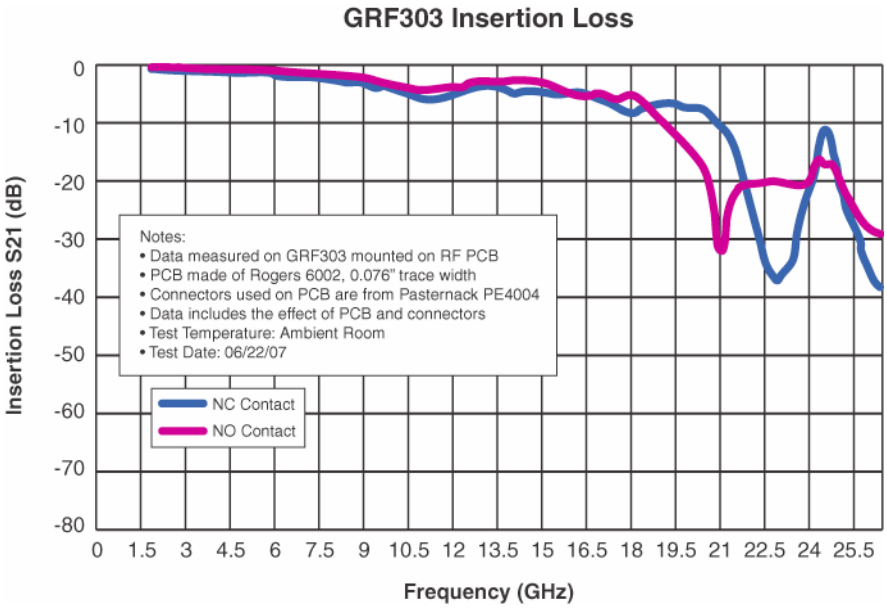
Normally closed position (coil off)



Conclusion

The eye diagrams provided by both customers conclusively demonstrate that the Teledyne Relays GRF300/GRF303 relay series would perform very well with 10Gbps signals. The most valuable characteristic of the GRF300/GRF303 relay series when mounted on impedance matched transmission lines is the monotonic insertion loss (S21) of its signal path to the maximum useful bandwidth, up to 19-21GHz. By comparison, Teledyne Relays observed drastic roll-off in insertion loss in non-impedance controlled relays and in competitor RF relays after 8-9GHz. Other benefits, such as repeatability of the loss characteristic (a trademark of Teledyne Relays products) and cost of ownership, make Teledyne Relays products highly competitive.

The next challenge for Teledyne Relays engineers is to make further improvement, such as uses of new contact materials and/or contact configurations, to support applications at 12Gbps data rates and beyond.



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Reference:

Gary Breed, “Analyzing Signals Using the Eye Diagram,” *High Frequency Electronics*, November 2005. Alex Hirman, “Teledyne GRF300-12 Performance Analysis,” Vitesse Semiconductor Corporation, May 2007. Heidi Barnes, “Analyzing & Addressing the Impact of Text Figure Multi-Gigabit ATE,” I/O Characterization Application, 2007 IEEE International Test Conference, Verigy Inc. Americas Application Development Center.

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