Technical Note

FIREFLY™
Micro Flyover System
Patent Pending

ECUE Series in 28 Gbps (OIF CEI-28G-VSR) Applications

Mated with UEC5 Series

Revision Date: January 17, 2013

Series: ECUE mated with UEC5
Standard: Optical Internetworking Forum's (OIF) CEI-28G-VSR Working Clause Proposal

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Abstract

As data rates approach 28 Gbps, some of the most complex challenges that designers face are the signal integrity issues associated with routing data signals over circuit boards and through vias and connectors. One solution to this problem is to take the data connections "off-board" thereby leaving the designer free to go chip-to-chip, board-to-board or even system-to-system without having to deal with the signal issues of routing signals over the PCB, vias and connectors.

Introduction

Samtec has recently developed the patent pending FireFly™ Micro Flyover System which is a complete interconnect system that uses either micro footprint optical or copper interconnects. The FireFly™ system enables chip-to-chip, board-to-board and system-to-system connectivity with the ability to run data rates up to 28 Gbps and beyond. FireFly™ is a high-performance interconnect system, which utilizes low-cost copper cable assemblies that can be used to take data connections "off board"; thus removing the signal integrity issues related to PCB layout complexities.

The Samtec FireFly™ ECUE Series copper cable assembly is comprised of 38 AWG, 50 ohm micro ribbon coax cable terminated at both ends with Samtec's UEC5 Series connectors.

In this paper, we will show how a fully mated copper FireFly™ cable assembly performs in a simulation environment by looking at the eye height as we sweep the channel length using Agilent's Advanced Design System software; we will also show an eye pattern of the channel at the maximum length. The transmitter and receiver parameters for these simulations are found in the *Optical Internetworking Forum's* (OIF) *CEI-28G-VSR Working Clause Proposal*, Dated May 14, 2012.

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The Simulation Model

The simulation circuit is modeled as:

Agilent's Advanced Design System Tx and Rx modules that are configured to the *CEI-28-VSR Working Clause Proposal, CEI Implementation agreement Draft 7.0*, dated May 14, 2012.

- Tx parameters are specified in Section 1.3.3, *Module-to-Host Specifications*, Table 1-4, Page 7.
- Rx parameters defined in Section 1.3.2 *Host-to-Module Electrical Specifications*, Table 1-1, Page 5.
- A 1.0 inch length of Tx interconnect trace segment at the transmitter.
- A 1.0 inch length of Rx interconnect trace segment at the receiver.
- Two mated Samtec 0.5mm ECUE connectors Touchstone S-parameter models.
- A 38 AWG 50 ohm W-element cable model

All traces were modeled as microstrip on FR4 with the following parameters:

- The FR4 parameters are modeled using:
  - Er = 4.2 @ 1 GHz
  - Loss Tangent = 0.02 @ 1 GHz

- Copper is modeled as:
  - Conductivity = 4.5E+7 S-m
  - Surface roughness = 0.6 micron

- Traces are differential microstrip with the following geometry:
  - 100 ohm differential impedance
  - 4.25 mil trace width
  - 2 mil trace copper thickness
  - 5.75 mil center-to-center spacing
  - 4.4 mil FR4 dielectric thickness
    No differential coupling to neighboring differential channels

Crosstalk aggressors were configured using the parameters in Table 1-3, *Crosstalk Parameters for Host Output Test and Module Input Test Calibration at TP1a*, Page 6, and are positioned according to Figure 1-10*, Module Input Stressed Receiver Test Setup*, Page 18.

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The Continuous Time Linear Equalizer (CTLE) coefficients were set using the following settings:

- Peaking (dB) = 1
- Pole 1 = 18.6 GHz
- Pole 2 = 14.1 GHz
- Zero 1 = 8.3 GHz

The CTLE settings are found in Section *1.3.10.3 Reference Receiver,* Table 1-8, *Reference Equalizer Coefficients for Rate of 28 Gbaud* Page 21.

Eye Mask

The specifications for an eye mask at a bit error rate of 10^{-15} are in Table 1-1: *Host-to-Module Electrical Specifications at TP1a (Host Output) on Page 5.*

Simulation Results

To obtain a feel for the overall range of operation of the copper ECUE Series FireFly™ at 14 Gbps and 28 Gbps, channel simulation models were created with equal length Tx and Rx trace segments, and the cable W-Element model was swept from 2" to 30", and 2" to 20", respectively.

Figure 1 and Figure 7 both show the un-equalized eye height, at the specified BER, versus the overall channel length (the cable length plus 2.0") at 14 Gbps and 28 Gbps, respectively. The red line at 100mV is the minimum eye height at the specified BER per Table 1-8. Figure 1, shows that at 14 Gbps in an un-equalized system, a total channel length of 23" is possible; Figure 7 shows that at 28 Gbps a total channel length of 7.5" is possible. The output eye patterns for these un-equalized channels are shown in Figures 2 and 8.

Using the CTLE with 3dB of de-emphasis, the overall channel length can be extended to 26" and 14.5" at 14 Gbps and 28 Gbps, respectively, Figures 3 and 9. The eye patterns for these equalized channels are shown in Figures 4 and 10.

Increasing the de-emphasis to 6 dB, the channel reach for 14 Gbps and 28 Gbps can be extended to 30" and 15", Figures 5 and 11, respectively. The corresponding eye patterns are shown in Figures 6 and 12.

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14 Gbps

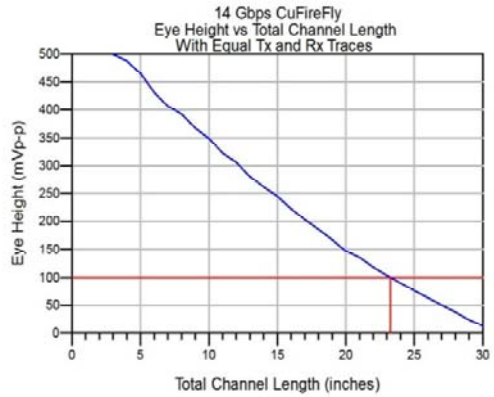

Figure 1: 14 Gbps, Eye Height vs. Length, Un-equalized

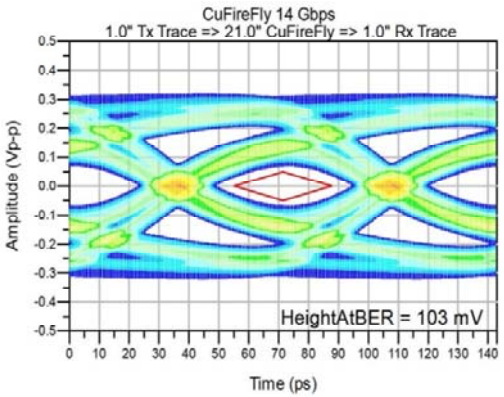

Figure 2: 14 Gbps, Un-equalized Eye, 23.0" Channel

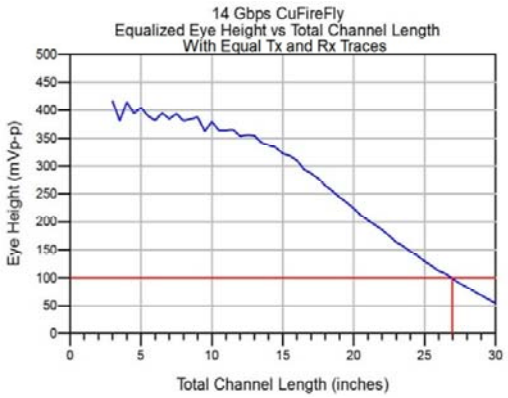

Figure 3: 14 Gbps Eye Height vs Length, 3dB Equalization

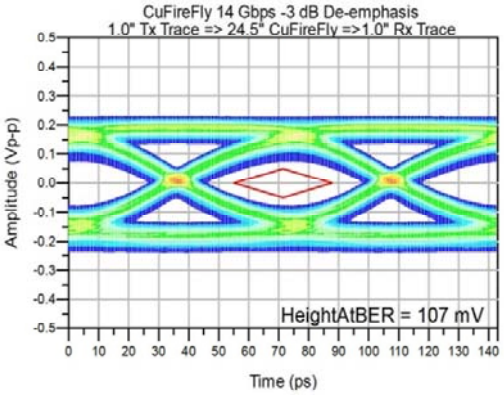

Figure 4: 14 Gbps, 3 dB Equalized Eye, 26.0" Channel

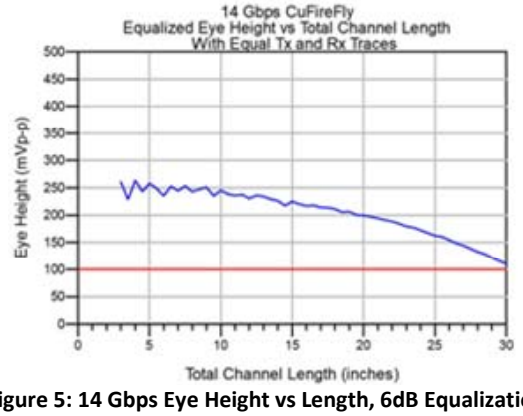

Figure 5: 14 Gbps Eye Height vs Length, 6dB Equalization

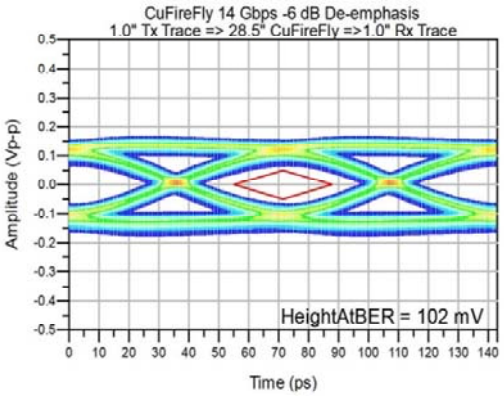

Figure 6: 14 Gbps, 6 dB Equalized Eye, 30.0" Channel

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28 Gbps

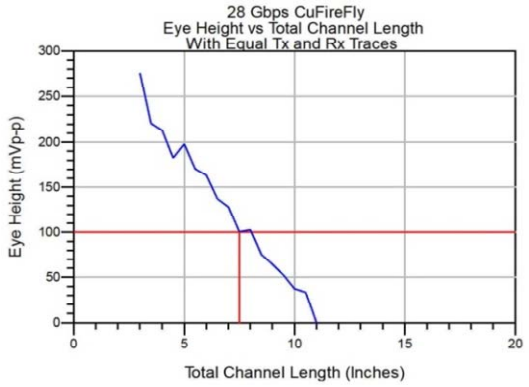

Figure 7: 28 Gbps, Eye Height vs. Length, Un-equalized

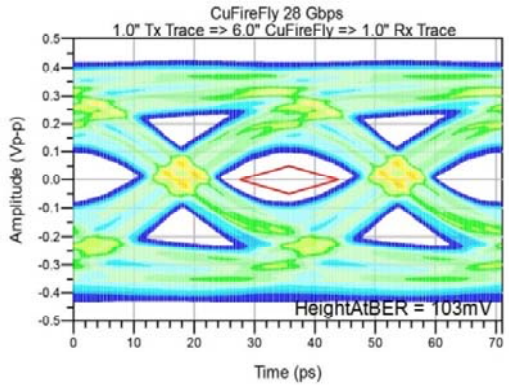

Figure 8: 28 Gbps Un-equalized Eye, 8.0" Channel

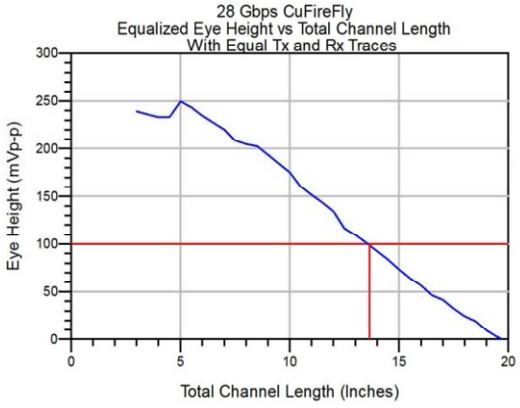

Figure 9: 28 Gbps Eye Height vs Length, 3dB Equalization

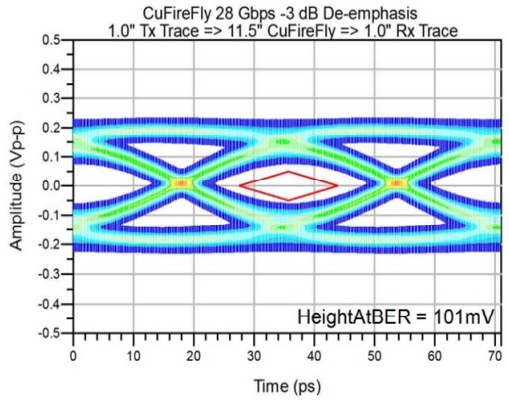

Figure 10: 28 Gbps 3 dB Equalized Eye, 14.5" Channel

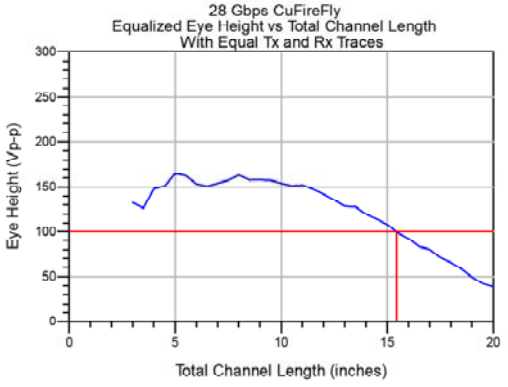

Figure 11: 28 Gbps Eye Height vs Length, 6dB Equalization

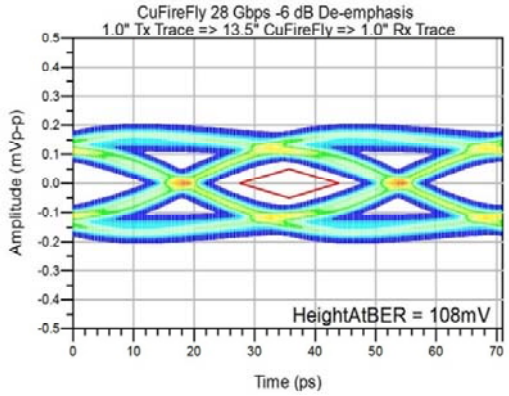

Figure 12: 28 Gbps 6 dB Equalized Eye, 15.5" Channel

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Conclusions

Depending on the equalization settings and the Tx and Rx PCB parameters, a channel reach of 23" to 30" is attainable for 14 Gbps. Likewise, a channel length of 8.0" to 15.5" at 28 Gbps is possible. The results of these simulations show that the copper ECUE Series FireFly™ Micro Flyover cable assembly is a viable solution for taking data "off-board" thereby eliminating the complexities of the circuit board design.