## Background

The history of signal transmission, whether for data or voice, is replete with successive attempts to transmit the signal faster or extend the bandwidth to include more data at a given rate. Since the first copper wire was installed in the late 1800's to the advent of using optical fiber to transmit data in the mid 1960's engineers and scientists have searched for ways to extend both the length and the speed.

In the early 1980's, because of the then belief that the physical limitation of the properties of copper, studies were being funded (through government grants and university research) to establish the guidelines for defining the data rates when incorporating fiber optic transmission would be required. Historically the crossover point was thought to be in the 1GHz range where the copper loss due to resistive and skin effects would become exponentially large, precluding higher frequency and higher data rate signals.

Early studies showed the many benefits of fiber optic transmission:

- High bandwidth of fiber optic cables
- Extremely long signal propagation distances
- Immunity to electronic noise
- Immunity to Electromagnetic pulse (EMP)
- No EMI generation
- Lightweight
- Low loss per 10's km

However, concomitant with those early advantages came some equally worrisome disadvantages which included:

- High power consumption
- High heat generation
- High cost per transmit and receive device
- Susceptibility to dust/dirt
- Large component footprint
- Not easily repaired

## Today

Fast forward 25 years and we still have an abundance of very high speed copper interconnects being designed into systems and numerous standards committees working on the next generation of yet higher speed copper interfaces and protocols. Laminate advances, driving the dielectric loss tangents lower and lower, along with advances in signal processing chip technology and advanced manufacturing processing have contributed to extending the ability of copper to be used in designs in the 10Gbps rate at lengths of 7 meters and more. As well today's fiber optic components have brought the early issues of size, power dissipation and cost into reach.

## Premise

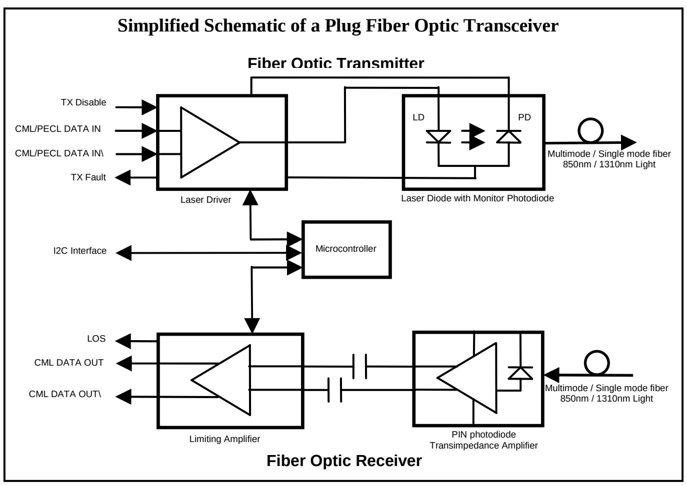
Here at Sabritec we have been tracking the industry needs for both these technologies. On the copper side we have developed an industry leading collection of ultra miniature, ultra high speed, coax; differential twinax and quadrax contacts. Our fiber optic termini bring the best of butt joint and expanded beam technology to precisely fit the design requirements required.

We also have customized and adapted the packaging of these high speed copper products to meet the appropriate electrical characteristics in special configurations and have introduced leading edge fiber optic components for those designs where robust separable fiber optic interconnects are needed.

In anticipation of our industries demands we identified a segment of the market that required the robustness of a copper interface (pin-socket connection) with the transmission properties (length, weight and bandwidth) of a fiber optic cable. To meet this need we have engineered an active connector that takes a high speed electrical differential signal and converts it to a high speed optical signal for transmission down a ruggedized optical cable. This technology brings many advantages to the user including a robust copper separable interface, nearly unlimited bandwidth and reach and more printed circuit board space because the fiber optic transmitter and receiver (along with their supporting IC's) have been moved inside the connector.

**Technology**

Our initial goal was to integrate the standard, robust and familiar MIL-C-39029 pin and socket interface with a small profile MIL-DTL-38999 connector body that would house a low power, ruggedized fiber optic transceiver.




Completing the marriage of these two technologies we designed a custom backshell that protects and allows repairability of the cable within a low profile, robust design. We determined these components would allow the system designers to achieve electric data rates in excess of 2 Gbps and for those designs that required higher data rates, up to 4.25 Gbps, we would incorporate our high speed Twinax contacts all the while using the same ruggedized transceiver.

The pictures below shows the pinface and side view of the finished product

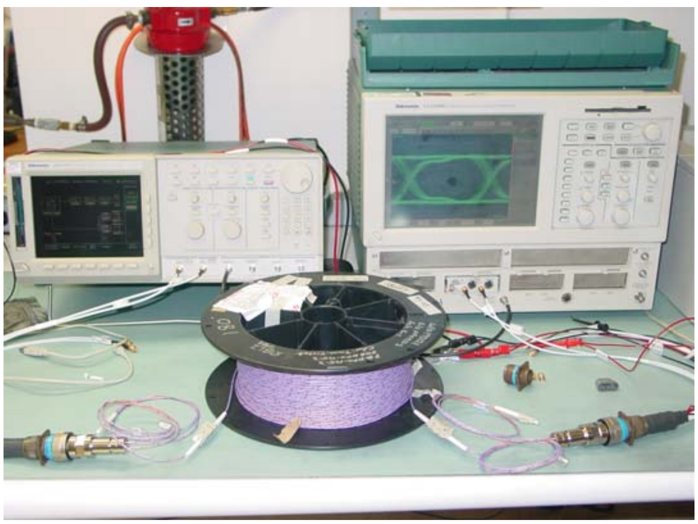
To transition the high speed signals from the standard mil copper contacts to the transceiver inputs, we designed an impedance controlled rigid flex with the options for access to the various control and monitoring signals available to the fiber optic system designer. Signal Examples:

- LOS
- Squelch
- Signal detect
- Power monitoring
- I2C monitoring

Please consult the factory for more information.

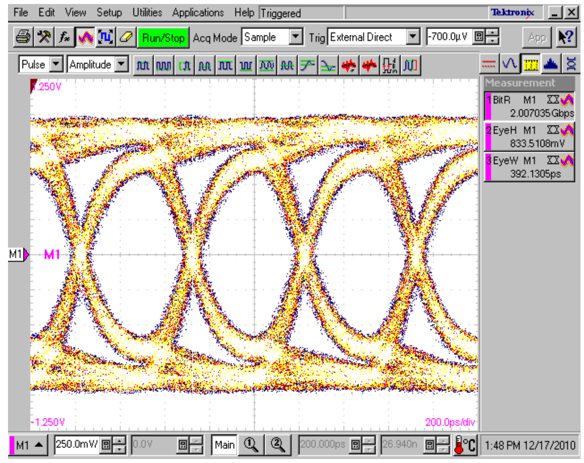
To test the resulting design at Fibre Channel protocol rates of 1 and 2 Gbps (1.0625 Gbps and 2.125 Gbps actual rates respectively), we had to design and assemble a custom test interface so that we could deliver the high speed electrical signals from our signal generator to our E/O connector then transmit the fiber optic signals across 180 feet of fiber optic cable and convert them back to electrical signals to view the received signals at our high speed Digital Storage Scope (DSO).

*Test set up for the fiber optic link with 180 feet of 50/125 um MM fiber*

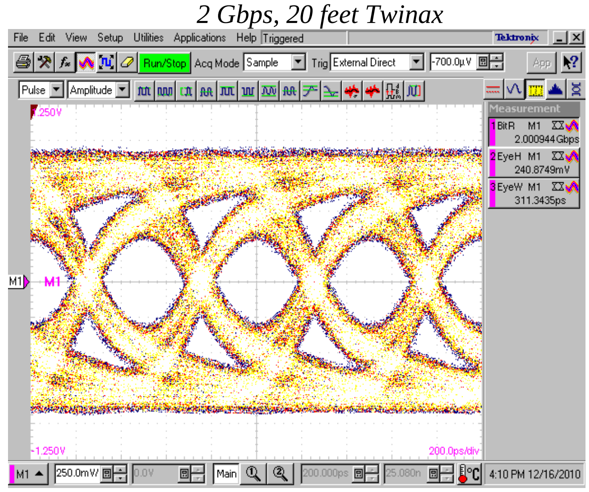


The Eye Pattern Diagrams (EPD) shown below are actual screen captures of the scope showing data transmission at 4 Gbps data rate over 10 feet and 20 feet of a Twinax copper cable.

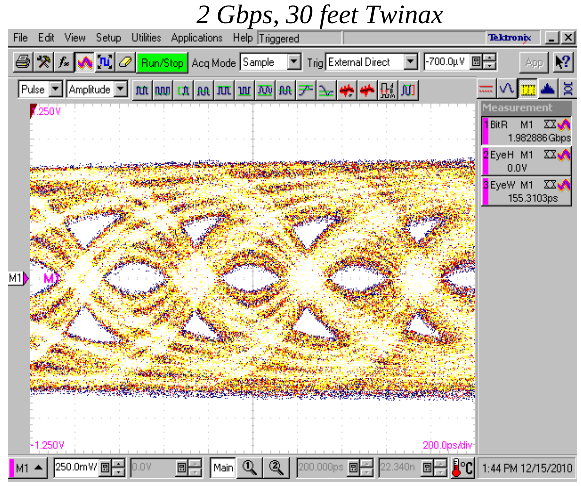
*2 Gbps, 10 feet Twinax*




*2 Gbps, 20 feet Twinax*



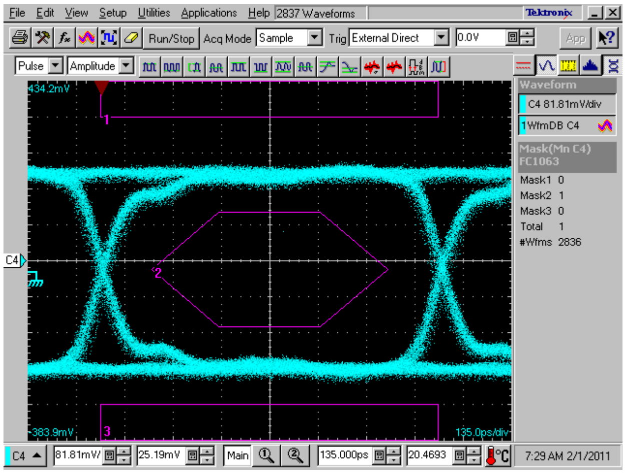

*2 Gbps, 30 feet Twinax*



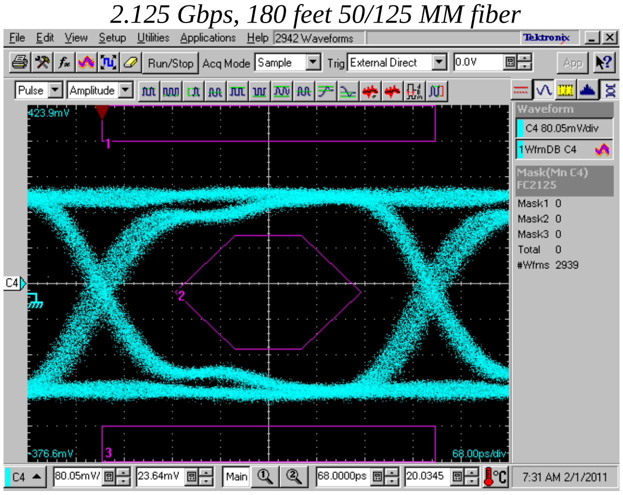

The Eye Pattern Diagrams (EPD) shown below are actual screen captures of the scope, showing successful data transmission at the FC rates over 180 feet of fiber.

*l.0625 Gbps, 180 feet 50/125 MM fiber*

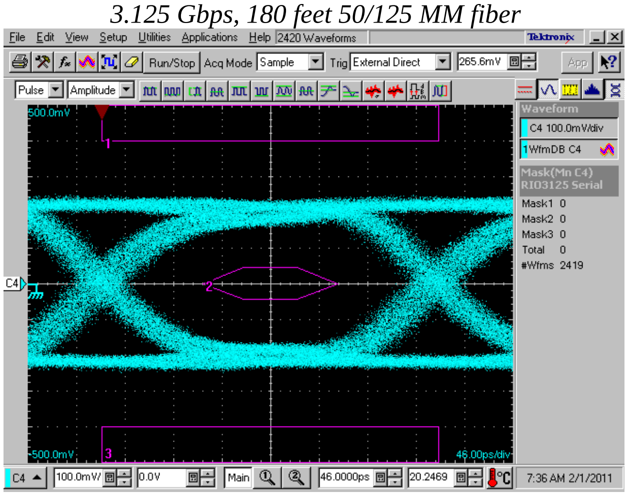
Please consult the factory for more information.




*2.125 Gbps, 180 feet 50/125 MM fiber*




*3.125 Gbps, 180 feet 50/125 MM fiber*




Careful examination of the EPD's show some deterministic jitter introduced by the test interface, but an eye height well in excess of the required FC protocol mask

## Discussion

What this means for the industry is that with careful design of packaging we can now provide a robust copper separable interface for many of the high speed electrical protocols on the market today. By using different TOSA's and ROSA's we can drive the signals at rates of up to 10 Gbps. and adding a Phy chip can bring media converter capability for Ethernet applications. With the limitations previously handcuffing copper only designs removed and the issues with a fiber optic interface dealt with, our design integrates the best of both design strengths and brings many benefits including:

- Robust separable interface
- Increased speed
- Increased length
- Reduced weight
- Elimination of EMI/RFI issues

## Conclusion and available options

By bringing our engineering design strengths in both high speed copper and fiber optics, we have made available to the industry an exciting and powerful new interconnect tool for their high speed systems. This technology allows the system designer to design all their high speed I/O using copper components, which are more robust and less expensive, and using Sabritec designed technology can incorporate the appropriate interconnect for the application saving money while optimizing system performance. For example when signals are relatively close (<30 feet) we can provide an all copper interconnect path and deliver the appropriate high speed signals with excellent fidelity to their appropriate destination.
However as the various system constraints of:

- Physical separation
- Weight
- EMI/RFI
- Distance
- Harsh environment

Please consult the factory for more information.

Are factored in we can incorporate our E/O transceiver technology to maximize your cost/performance needs.

The following is a partial list of some of the available options.
- Fast Ethernet
- Gigabit Ethernet
- 1x, 2x, 4x Fibre Channel
- sFPDP Communication links
- Infiniband
- ARINC 818 Video links

Link distances of up to 10 km are supported.

Please consult the factory for more information.