Network Performance

Ensure the confidence of your optical signal transmission

Optical power strength loss?

This white paper is a critical guide to help you assess your optical transceivers. We offer a comprehensive analysis of optical signal strength through our TAP solutions while maintaining high data rate transmissions.

Monitoring 400Gb/s transceivers using EDGE™ TAP modules

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Introduction

Data center network operators are increasingly deploying high-speed optical transceivers to support the growing number of latency sensitive applications on their networks. Artificial Intelligence, machine learning, and other applications driven by consumer and enterprise appetite for bandwidth, require high throughput to ensure maximum optimization. A small imbalance between the expected and real throughput of these services through network elements can have negative effects on the performance of a data center network. To ensure network optimization and performance, data center operators are investing in capabilities to monitor their networks. TAP modules available with Corning Optical Communications EDGE™ and EDGE8® product lines help achieve that objective. This white paper discusses the capability of monitoring transceivers with 400Gb/s data rates with EDGE TAP modules.

The adoption of 400Gb/s transceivers is expected to accelerate as data center operators need more throughput in their network. Helping to drive the adoption is the capability of operating a 400Gb/s transceiver in break-out mode (i.e., 4 x 100Gb/s circuits) which has cost and operational advantages. The cost of a 400Gb/s transceiver is currently or will soon be less expensive than buying four 100Gb/s transceivers. Coupled with increasing the radix on network switches and reduced power requirements, it's clear that investing in 400Gb/s transceivers has a positive cost/benefit ratio.

For data center operators, there are several options to consider when choosing the correct 400Gb/s transceiver for their network application. The decision will rely on the end-to-end reach of the circuit, the type of fiber in the network, and the connector interface. Fortunately, 400Gb/s transceiver technology is maturing. Transceivers are available for medium- and long-reach applications (2-10 km), short-reach applications (100-500 m), and are available for single-mode or multimode fiber using duplex or parallel fiber connectors (i.e., LC or MTP®). A 400Gb/s DR4 transceiver will covert eight 50Gb/s transmit and receive electrical signals into four 100Gb/s optical signals carried over individual fibers within an MTP-12 connector. Transceivers with 2-fiber duplex LC connections will transmit those optical signals on four individual wavelengths on the transmit and receive fibers to achieve the aggregate 400Gb/s bandwidth. Figures 1 and 2 illustrate how the electrical circuits are mapped into optical circuits within 400G DR4 (MTP-12) and DR4 (Duplex LC) transceivers.

400Gb/s FR4, DR4 Optical Diagram

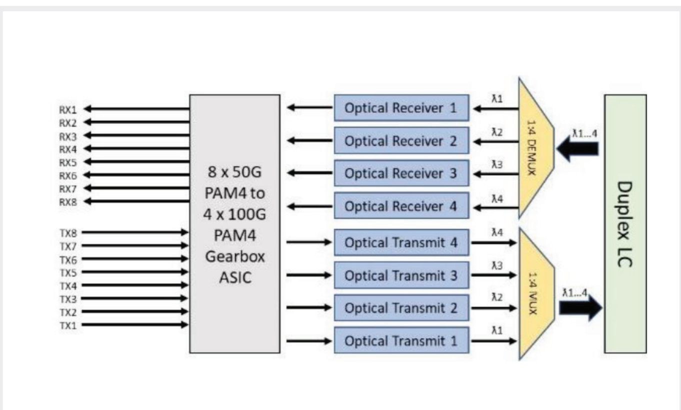

Figure 1: 400G FR4, Duplex LC

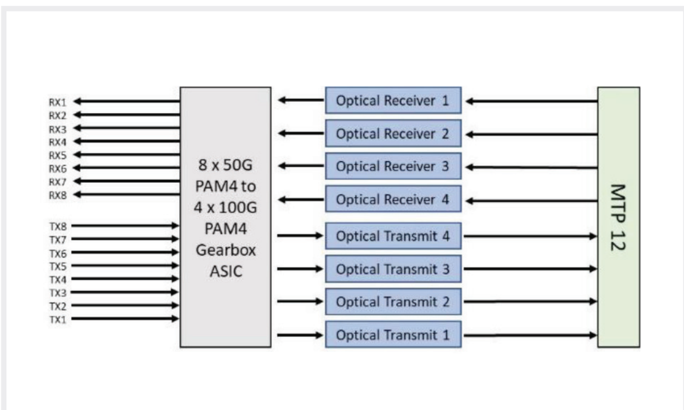

Figure 2: 400G DR4, MTP 12

TAP Module Testing

When designing an optical circuit, a network engineer will establish a link budget that takes into consideration the reach of the circuit and account for any power gains or attenuation the circuit will encounter before it reaches its destination. Understanding that adding a test access point (TAP) will add attenuation to the optical circuit, network engineers will appreciate understanding how much optical power is available on the tapped circuit. When adding a TAP into the optical link, the signal can be split into different ratios depending on the type of traffic on the circuit. For most Ethernet applications, a 50:50 split ratio is acceptable, however some traffic, such as Fiber Channel, may need more optical power. In those circuits, a TAP module with a 70:30 or 80:20 split may be appropriate.

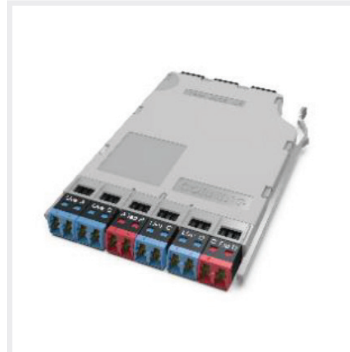

Figure 3: EDGE Tap Module

The calculation of a transceiver's power output, and receiver sensitivity values will establish the range of optical power available to support the data rate. For example, the 802.3 IEEE specification for 400G indicates that a DR4 transceiver shall have a transmit power between 4.0 dBm to -2.9 dBm, and receiver sensitivity of no less than -5.9 dBm. This would indicate a range of optical power of 9.9 dBm.

To ascertain the amount of margin an optical signal can have with an EDGE™ or EDGE8® TAP module, Corning engineers tested a variety of 400Gb/s transceivers in an optical circuit through an EDGE TAP module. The circuit(s) attenuation was measured over different fiber distances to a performance bit error rate (BER) of 2.4×10^{-4}. Transceivers tested were those with duplex LC connections, or MTP® connections. The test used an EDGE TAP module with a 50:50 split ratio. As such, the length of fiber used in each transceiver test was 50% of its reach capability. For example, an FR4 transceiver, with a 2 km reach, was tested over 1 km of fiber with a 50:50 TAP module. A variable optical attenuator (VOA) was also placed in the laser path for each transceiver to induce a failed condition.

TAP Module Test Results & Summary

Testing was performed on several 400Gb/s transceiver types, with varying reaches, to understand the performance of the transceivers which have LC duplex connectivity. Also tested were DR4 reach (500 m), XDR4 reach (2 km), and PLR4 reach (10 km) transceivers that have MTP interfaces. The test results indicate that the tapped optical circuits maintained ample optical power margin to support monitoring applications. Testing indicated that transceiver output power ranges fell within the 400Gb/s 802.3 IEEE specification for different reach optics (DR4, FR4, etc). Also noted was that 400Gb/s data rates were achieved with receiver power measurements below the IEEE specifications. As evidence, in a sample DR4 transceiver set-up, testing showed that the receiver port optical power was measured at -11.0 dBm with zero bit errors. Much less optical power than -5.9 dBm referenced in the DR4 specification. Figure 5 illustrates the dynamic optical power range of individual channels within three different DR4 transceivers. Each DR4 transceiver has four transmit and receive channels.

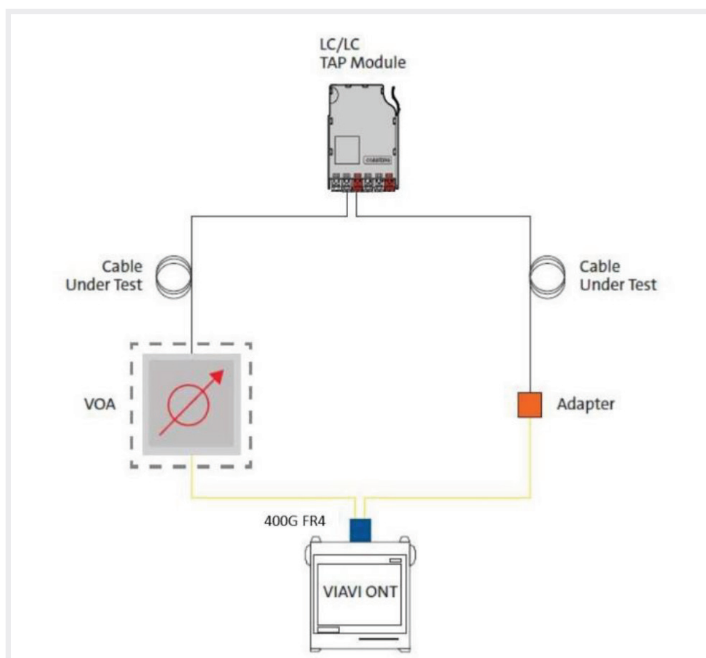

Figure 4: Test Setup

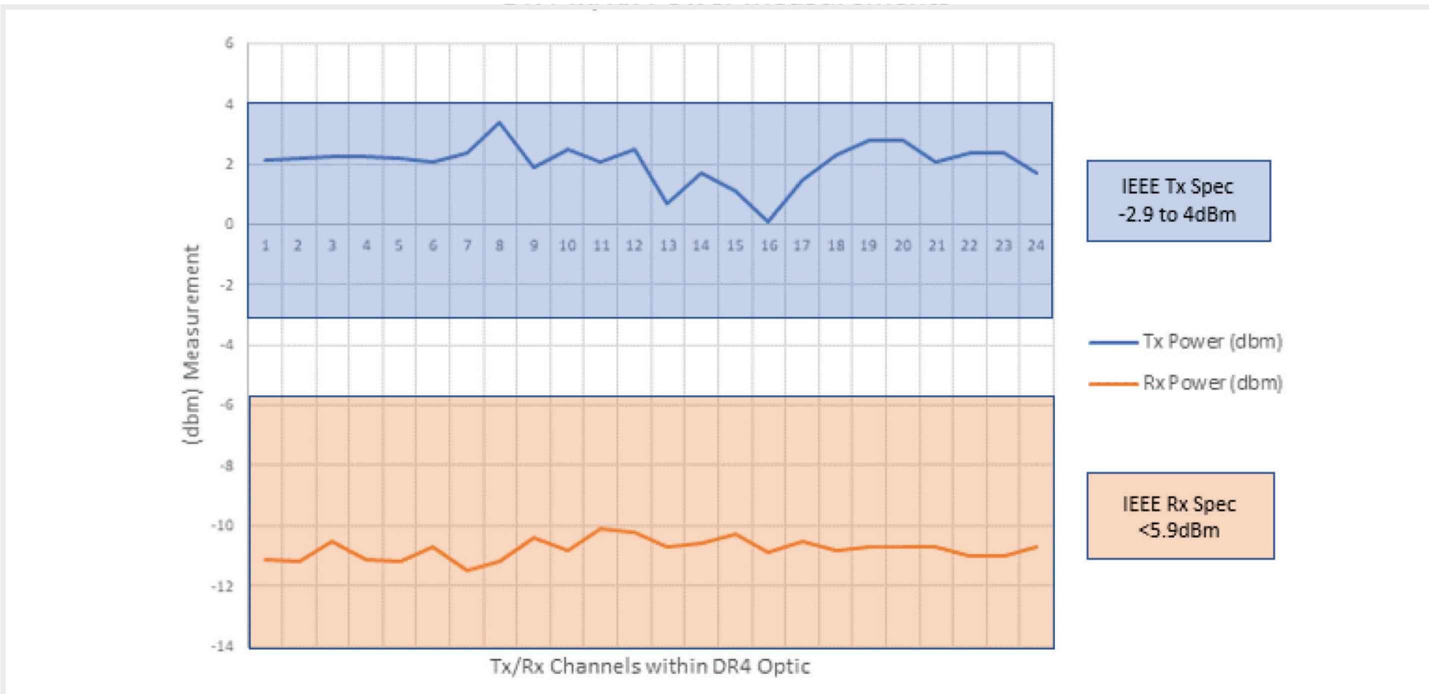

Figure 5: Per Channel Dynamic Power Range of Three DR4 Transceivers

The table below summarizes the link loss and margin for the tested transceivers. Link loss is the measure of the attention from the EDGE™ TAP module, and fiber optic cable expressed in (db). Margin is the calculation of total optical budget, less the link-loss values.

DR4 Optics	Test Result/250 m	Link Loss (db)	Margin (db)
Vendor 1	Pass	5.26	7.74
Vendor 2	Pass	4.47	7.15
Vendor 3	Pass	5.59	7.81
DR4 Optics	**Test Result/250 m**	**Link Loss (db)**	**Margin (db)**
Vendor 1	Pass	4.11	7.2
Vendor 2	Pass	4.22	7.95
Vendor 3	Pass	4.02	7.34
Vendor 4	Pass	4.05	7.62
DR4 Optics	**Test Result/250 m**	**Link Loss (db)**	**Margin (db)**
Vendor 1	Pass	6.69	6.11
DR4 Optics	**Test Result/250 m**	**Link Loss (db)**	**Margin (db)**
Vendor 1	Pass	5.69	4.3
Vendor 2	Pass	5.79	6.28
Vendor 3	Pass	5.66	7.97
Vendor 4	Pass	5.78	9.11
DR4 Optics	**Test Result/250 m**	**Link Loss (db)**	**Margin (db)**
Vendor 1	Pass	6.95	5.09

In a real-world environment, there is a high likelihood that a 400Gb/s optical circuit traversing through an EDGE TAP module will also transverse through multiple components of the structured cabling system or need to travel into and out of buildings on a data center campus. For example, an optical signal traveling through a mated pair of LC connections could add .25 db of attenuation on single-mode fiber. An MTP®/LC connection could add .60 db on single-mode fiber. These added components will add attenuation into the optical circuit and should be accounted for in an optical circuit design. Additionally, variability in the output power and receiver sensitivity of transceivers from different OEMs will have a direct impact on the amount of margin available on those circuits. Still, the tests conducted, and margins calculated by our Corning engineers are instrumental in helping customers design their optical circuit(s) for maximum optimization and performance.

100G BiDi Performance with Corning EDGE8® TAP Module with a 50:50 Split Ratio

Introduction

Corning Optical Communications offers optical tether access point (TAP) modules for multimode and single-mode Ethernet and Fibre Channel data rates. Inclusive to the offering is the Foxconn Interconnect Technology (FIT) 40G BiDi Ethernet transceiver that operates with OM3/OM4/OM5 multimode fiber. Industry demand for higher data rates led to the development and commercial release of the 100G BiDi transceiver. This white paper describes Corning's internal 100G BiDi evaluation using the EDGE8® TAP Module with a 50:50 split ratio that demonstrated compliant performance.

100G BiDi Technology

The 100G BiDi is a pluggable duplex multimode fiber optic QSFP28 transceiver, which integrates four 25Gb/s electrical data lanes into two 50Gb/s PAM4 optical lanes at two different wavelengths (850 nm and 910 nm), giving an aggregated bandwidth of 100 Gb/s. The two wavelengths transmit optical data in opposite directions (bi-directionally) in each multimode fiber.

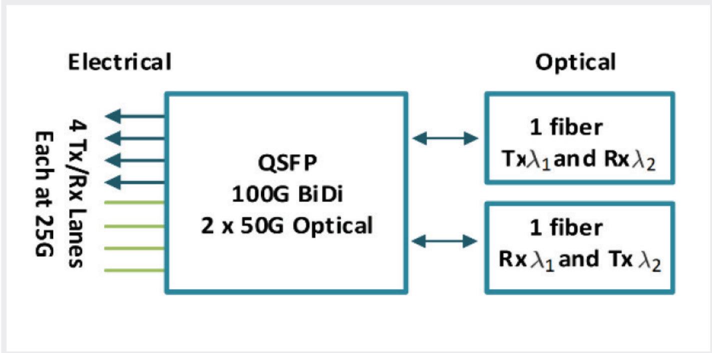

Figure 6: 100G BiDi: 4 x 25G Electrical to 2 x 50G Optical lanes

Test Setup and Measurements

A Viavi optical network tester (ONT-600) was used in the testing. The ONT platform is a multifunctional, multiport solution for fast, flexible testing of optical transport networks up to 100G. It controls the transceivers to generate framed data, which is then used in performance testing parameters, including measuring and validating basic errors, like conventional bit error rate tester (BERT), except that the data is framed and more efficient.

Three random FIT 100G BiDi transceivers were evaluated on a 50 m OM4 fiber channel length that included an EDGE8 TAP Module with a 50:50 split ratio. The wavelengths of each fiber were tested to a maximum IQA-12 BER compliance performance metric. A variable optical attenuator (VOA) was also included in the link to ascertain the additional channel insertion loss required to induce a failed condition. An additional 4.7 dB worst case insertion loss was exhibited, which means the system holds at least 4.7 dB power margin while using the TAP module. Figures 8 and 9 illustrate the optical TAP module and test setup.

Figure 7: Viavi ONT-600

Figure 8: EDGE8 TAP Module BiDi 50:50 Split Ratio

Summary

Corning Optical Communications tested three random FIT/Broadcom 100G BiDi transceivers on a 50 m OM4 channel length that included an EDGE8® TAP Module with a 50:50 split ratio that easily passed a maximum 10^{-12} BER compliance specification.

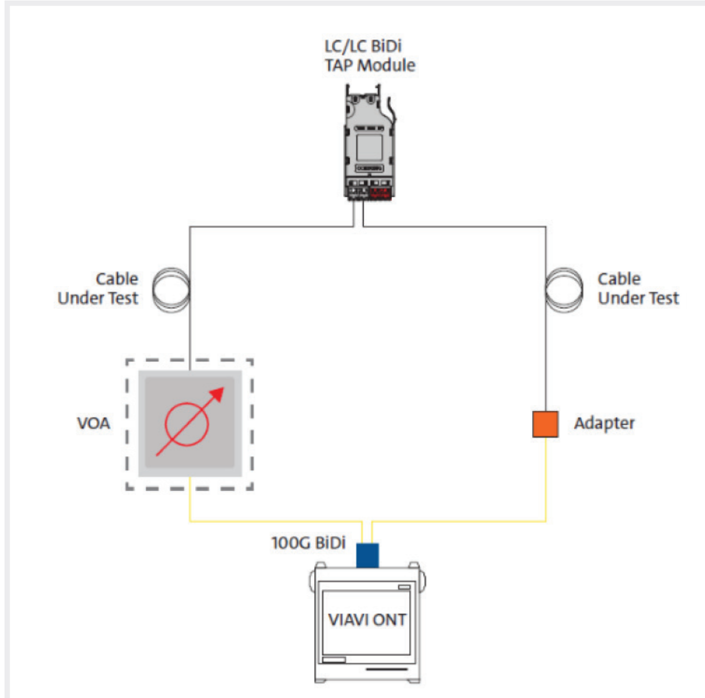

Figure 9: 100G BiDi Optical Tap Evaluation Test Set Up

100G BiDi EDGE8 Tap Module 50:50 Split Ratio Compliant Test Results

Transceiver	Fiber	Port	Test Result	Channel Link Loss (dB)	Maximum VOA Atenuation (dB)
1	1	850 mm	Pass	4	5.7
	1	910 mm	Pass	4	5.9
	2	850 mm	Pass	4	5.7
	2	910 mm	Pass	4	6.3
2	1	850 mm	Pass	4	5.1
	1	910 mm	Pass	4	5.1
	2	850 mm	Pass	4	5.1
	2	910 mm	Pass	4	4.7
3	1	850 mm	Pass	4	5.5
	1	910 mm	Pass	4	5.3
	2	850 mm	Pass	4	5.3
	2	910 mm	Pass	4	5.5

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