APPLICATION NOTE

Application Note 104:

AC Performance Measurement Descriptions for 1200 Series nLIGHTEN™ Parallel Optic Modules

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Overview

The purpose of this application note is to familiarize the reader with the techniques used at W.L. Gore & Associates to measure the AC performance parameters of our nLIGHTEN 1200 series optic modules. It is assumed that the reader has a level of familiarity with the measurement equipment used for characterizing high-speed optical and electrical devices. This equipment includes but may not be limited to Digital Communications Analyzers (DCA's) with optical plug-in, electrical and optical switch boxes, optical power meters, and Data generators.

Part Numbers

This document applies to the following Gore part numbers:

Base Part Number	Part Description
nL1201	Tx – 1.25 Gbps
nL1202	Rx – 1.25 Gbps
nL1201-1.6	Tx – 1.6 Gbps
nL1202-1.6	Rx – 1.6 Gbps

Transmitter Modules

On our 12-channel transmitter modules, we measure the following characteristics:

- Optical launch power
- Risetime of the optical signal
- Falltime of the optical signal
- Extinction Ratio
- Deterministic Jitter
- Random Jitter
- Total Jitter

Note: For all optical measurements performed on the nL1201 (1.25 Gbps Tx), a 4th order Bessell-Thompson filter is used on the optical plug-in. For all optical measurements performed on the nL1201-1.6 (1.6 Gbps Tx) no filtering of the signal is used.

Optical Launch Power

Optical launch power (average output power) is a measurement of optical power launched into a fiber ribbon cable by each of the 12 channels. The measurement is made using an optical power meter. Each channel is measured while transmitting a dc-balanced code (Gore uses a 2^{7-1} pseudo random bit sequence.) A data generator connected to the inputs of the transmitter module generates this pattern. The measurement, expressed in dBm, is made at the average level (i.e. the average of the "1" bit level and the "0" bit level). The units, dBm, are a dB scale referenced to 1 mW of power.

Optical Signal Risetime (Tr)

The risetime of the optical signal is measured while each channel is transmitting a k28.7 pattern. The k28.7 pattern is a special pattern in the 8B/10B - coding table. It is a repeating sequence of five "1"s followed by five "0"s. A data generator is again used to generate this pattern. A single rising edge is displayed on the DCA with easy to predict "0" and "1" levels. The measurement is made by the DCA as the time elapsed between when the rising signal passes the 20% point and the 80% point between a "0" and "1" level. Risetime is expressed in pS.

Optical Signal Falltime (Tf)

As with risetime, the falltime of the optical signal is measured while each channel is transmitting a k28.7 pattern. A data generator is again used to generate this pattern. A single falling edge is displayed on the DCA with easy to predict "0" and "1" levels. The measurement is made by the DCA as the time elapsed between when the falling signal passes the 80% point and the 20% point between a "0" and "1" level. The value of falltime is expressed in pS.

Extinction Ratio (ER)

The extinction ratio measurement is unique to optical signals. As the name implies, Extinction Ratio is a ratio of power. It is the ratio of the power of a high or "1" bit to a low or "0" bit. This measurement may be expressed in either % or dB. At Gore, this measurement is made while each channel is transmitting a k28.7 pattern. The DCA measures the power level at the "1" bit level and the power at the "0" bit level. These measurements are made 20 times each and an average level is recorded. External software is used to calculate the ER in dB (10*log(power"1"bit/power"0"bit)).

Deterministic Jitter (DJ)

Deterministic or pattern dependant jitter is measured while each channel is transmitting a k28.5 pattern. The K28.5 pattern is a special character in the 8B/10B-coding table. A repeating K28.5 pattern (composed of K28.5+ and K28.5-) contains the symbols 00111110101100000101. K28.5 is used for frame marking and idle patterns in Fibre Channel and Gigabit Ethernet systems.
The data generator generates the pattern. The k28.5 pattern is a 20 bit long sequence with 10 transitions or edges throughout the 20 bits. The pattern is repeated through transmission. The entire 20-bit sequence is viewed on the screen of the DCA. The position in time of the first rising edge of the sequence is determined by the DCA. This measurement is made at the average power level of the signal. The location in time of the first edge is established as a reference point. Each of the 10 subsequent edges is then located in time relative to the reference point. These locations are compared to their theoretical location in time. Each edge is either occurring earlier or later in time than the theoretical prediction. Edges that occur earlier in time are recorded as negative deviations. Edges that occur later in time are recorded as positive deviations. DJ is calculated as the maximum positive deviation minus the maximum negative deviation.

Random Jitter (RJ)

Random Jitter is measured while each channel is modulated with a k28.7 pattern. Fifty waveforms are taken before the scope measures the RJ. A histogram is taken at the average power level on the rising and falling edges. The standard deviation of each histogram (both the rising edge and falling edge) is measured by the DCA. The RJ is defined as 14 * $(\sigma_{\text{rising edge}} + \sigma_{\text{falling edge}})/2$.

Total Jitter (TJ)

The total jitter is the sum of DJ + RJ.

Receiver Modules

On our 12-channel receiver modules, we measure the following characteristics:

- Amplitude of electrical output signals
- Risetime of the electrical output signal
- Falltime of the electrical output signal
- Deterministic Jitter
- Random Jitter
- Total Jitter
- Receiver sensitivity

The receiver modules are driven with a known optical source. A data generator is used to transmit the desired pattern from the optical source to the receiver module. The power of the optical signal is monitored and controlled to be within the operating parameters of the receiver module.

Output Amplitude

The amplitude of each differential output is measured while the module is transmitting a k28.7 pattern. A DCA is used to measure the voltage levels of the differential signals.

Risetime (Tr)

The risetime of the electrical signal is measured while each channel is transmitting a k28.7 pattern. A data generator is again used to generate this pattern. A single rising edge is displayed on the DCA with easy to predict "0" and "1" levels. The measurement is made by the DCA as the time elapsed between when the rising signal passes the 20% point and the 80% point between a "0" and "1" level. The value of risetime is expressed in pS.

Falltime (Tf)

As with the risetime, the falltime of the electrical signal is measured while each channel is transmitting a k28.7 pattern. A data generator is again used to generate this pattern. A single falling edge is displayed on the DCA with easy to predict

"0" and "1" levels. The measurement is made by the DCA as the time elapsed between when the falling signal passes the 80% point and the 20% point between a "0" and "1" level. The value of falltime is expressed in pS.

Deterministic Jitter (DJ)

Deterministic or pattern dependant jitter is measured while each channel is transmitting a k28.5 pattern. The data generator generates the pattern. The entire 20-bit sequence is viewed on the screen of the DCA. The position in time of the first rising edge of the sequence is determined by the DCA. This measurement is made at the 50% voltage level of the signal. The location in time of the first edge is established as a reference point. Each of the 10 subsequent edges is then located in time relative to the reference point. These locations are compared to their theoretical location in time. Each edge is either occurring earlier or later in time than the theoretical prediction. Edges that occur earlier in time are recorded as negative deviations. Edges that occur later in time are recorded as positive deviations. DJ is calculated as the maximum positive deviation minus the maximum negative deviation.

Random Jitter (RJ)

Random Jitter is measured while each channel is modulated with a k28.7 pattern. Fifty waveforms are taken before the scope measures the RJ. A histogram is taken at the 50% voltage level on the rising and falling edges. The standard deviation of each histogram (both the rising edge and falling edge) is measured by the DCA. The RJ is defined as $14 * (\sigma_{\text{rising edge}} + \sigma_{\text{falling edge}})/2$.

Total Jitter (TJ)

The total jitter is the sum of DJ + RJ.

Sensitivity

To measure the sensitivity of the Rx module, a bit error rate measurement is made. This is accomplished by using an error detector in conjunction with the data generator. The measurement begins with an optical signal of known power level (- 25 dBm) being input to the Rx module. The bit error rate is measured for this condition. A gating time of 8 seconds is used for error measurements. At 1.25 Gbps, a gating time of 8 seconds corresponds to enough bits to measure a BER of 10^{-10}. After the BER is calculated, the input power of the optical signal is increased by 0.2 dB. The BER is again measured. This process is repeated until 3 consecutive input powers yield a BER measurement of 10^{-10} or better. By plotting the Log(Log(BER)) vs. input power, a linear relationship is found. Using this linear relationship, the BER may be extrapolated to a value of 10^{-12}. The module must reach a value of 10^{-12} at a power level equal to or lower than –18 dBm to be considered passing.