Coherent Laser Specifications and Control for 800G 10km application

James Harley , Douglas Mcghan, Shahab Oveis Gharan, Eric Maniloff
Ciena

IEEE P802.3df

November, 2022

800G LR Coherent Laser Spec Objectives

1. Enable low-cost laser – historically coherent has used tunable DWDM lasers optimized for other applications

2. Enable both single laser and dual laser modules – applications may be optimized with different approaches

3. Enable simple interop acquisition

Laser Type Options

Laser Type	Approx. relative cost	Frequency Accuracy	Linewidth
Tuneable DWDM	x8n- x12n	+/-1.8GHz (400ZR I.A.)	<300KHz
DFB+TEC+Simple Locker	x1.2n-x1.5n	+/-3GHz (Internal Analysis)	<1MHz
DFB +TEC	n	+/-12.5GHz (Oif2021.442.02)	<1MHz

Fixed Laser sources provide a compelling cost savings versus a Tuneable DWDM laser

Note: The data in this chart is based on authors' estimates. Implementers' actual or relative costs may vary. The authors are not aware of any public sources for the information presented in this chart.

Coherent lasers / control overview

Typical coherent implementation uses a shared laser for both Tx & Rx (LO)

The optics design & specifications ensure that the frequency difference between the two lasers (IF) is small enough to be removed at the DSP Rx

Laser Architecture Options

Traditionally Tuneable DWDM lasers are shared between Tx and LO

There maybe new reasons with a less-complex laser to move to independent lasers for Tx and LO with 800G 10km.

Interop Acquisition should accommodate both Laser architectures for 800G coherent implementations.

→ This approach adds flexibility to applications support

Laser Control Issues

1. **If abs(IF) is ≤ 6GHz, Digital Acquisition will be possible without tuning the Laser for 124 Gbaud 800LR**
Note 400GBASE-ZR specifies abs(IF) ≤ 3.6GHz at 60GBaud: Allows digital acquisition. A simple frequency scaling argument applies to 124GBaud, allowing digital acquisition for abs(IF) ≤ 6GHz.

Digital Acquisition can be done independently on both ends for simple acquisition as is implemented in 400GBASE-ZR.

The frequency accuracy is selected to be agnostic to Laser architecture in Module

Enables accurate measurement of IF from the recovered signal

Laser Control Issues

2. Fine-tuning lasers with shared lasers at each module is an asynchronous coupled control loop and can be unstable as well as unpredictable unless a complex procedure is specified (not interop friendly).

- Manage different rates of Laser frequency speed with different vendors
- Manage stable interaction with Digital Acquisition
- May need in band/out of band signalling for source designation
- Coupled control loops could be unstable unless control loop parameters are specified
- There can be divergence from the coupled control loops with measurement errors

This will be difficult to standardize as well as verify with different vendors in an interop testing environment

Note ± 3GHz frequency accuracy avoids these problems in both Acquisition and In service operation.

Laser Control Issues

3. If there is an agreement that only independent lasers are supported with independent LO tuning, then the frequency spec could be relaxed

No frequency locker is required.

This requires two Lasers. Cost comparison between one DFB+TEC+Locker and two DFB+TEC should include all factors involved in the optical design rather than just component count.

This would be a useful discussion point

Proposed Laser Related Specs

Parameter	Values	Comments
Tx Laser Frequency Accuracy	± 3.0 GHz	Consistent with TEC and simple frequency locker for Tx. Does not apply to independent Rx laser if present.
Digital Acquisition IF range	± 6.0GHz	
Laser linewidth	1MHz	~0.2 dB penalty relative to 0.5MHz
Laser Phase Noise Mask	TBD	Need data from Vendors. Be consistent with laser linewidth spec.
Laser RIN	TBD	Is there cost sensitivity here ?
Laser wavelength	C or O band (TBD)	Not discussed in this contribution
Maximum Laser frequency Slew rate for Laser frequency dithers and Laser control	± 0.5GHz/s	Does not impact digital acquisition and modem ROSNR

Laser Penalty versus Lorentzian Linewidth per Laser

Linewidth	0.5 MHz	1 MHz	2MHz	3MHz
Ciena Penalty estimate	0.21 dB	0.41 dB	0.68 dB	0.93 dB
OIF2019.200.01	0.28 dB	0.4 dB	0.7 dB	0.9 dB

Recommending ≤ 1 MHz linewidth as a good trade off between cost and performance.

Note for some laser types at high output power linewidth will naturally be ≤ 1 MHz

Comparison of Key Specs

Contribution	Linewidth	Frequency Accuracy	Max Freq slew
Oif2022.485.00	1MHz	+/-3GHz	+/-0.5 GHz/s
Oif2022.341.00	1MHz	+/-5GHz	
Oif2021.442.02	3MHz	+/12.5GHz	

Relaxing specs to ± 5G or ± 12.5GHz has a similar impact:

→ This drives more complex acquisition where LO needs to be moved to enable digital acquisition

Recommendations

Recommend Laser Frequency Spec Accuracy of ± 3GHz. This enables simple fast digital acquisition (like 400GBASE-ZR) at a small cost premium.

- This still results in a significant cost savings relative to Tuneable DWDM lasers

Recommend Linewidth ≤ 1 MHz. This may be cost savings relative to 0.5MHz, the performance penalty is small (0.2dB) and the laser will typically be driven at high power, hence this linewidth range may be natural

Recommend Maximum frequency slew rate of ± 0.5GHz/s for any laser frequency dither and laser control to prevent any disturbance of digital acquisition and any performance impact in service.

Thanks!