800GBASE-LR1 Frequency Tuning and Tuning Range Specifications

Supporting contribution for D1.0 comment #380

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Proposed Normative Laser Frequency Accuracy and Tuning Range Requirement

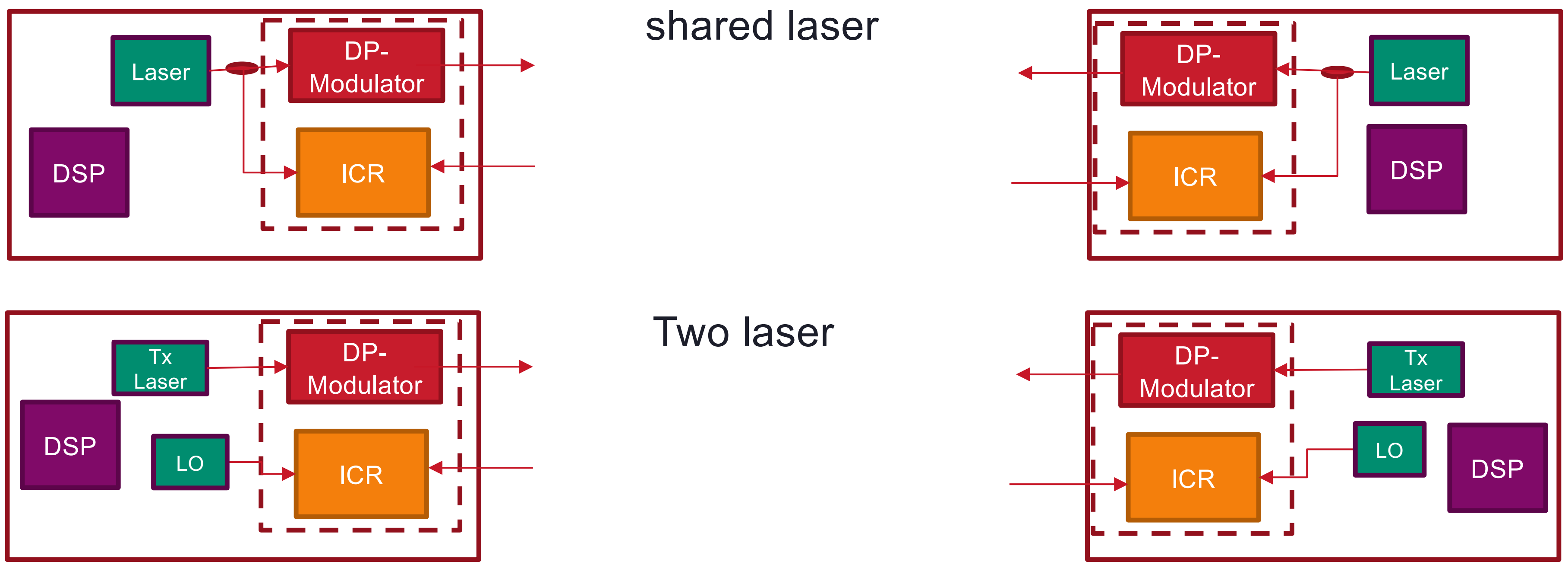
The fundamental laser frequency requirements that needs to be normative in 800GBASE-LR1 to enable a simple acquisition algorithm **are**:

- **Rx laser shall be able to tune ± MAX GHz.**
- **Tx laser shall be guaranteed to be within ± MAX GHz over all operating conditions and life.**

We are open to discussion on what is the appropriate value for **MAX** in the context of enabling *unlocked* lasers.

- Defined as the absolute guaranteed accuracy for an *unlocked* Tx laser over all operating conditions and life.
- DSP acquisition algorithm will not practically drive the selected maximum value.
- In previous work sessions there has been discussion of as much as a ± 10GHz allocation for over-life aging.
- Additional discussion on this is required to remove TBD’s

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

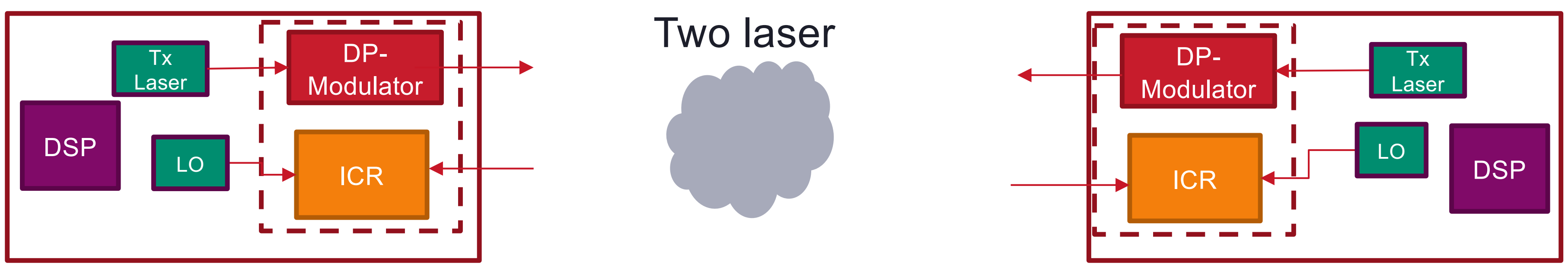
Moving to unlocked lasers, the MAX frequency error will exceed the DSP ability to digitally lock

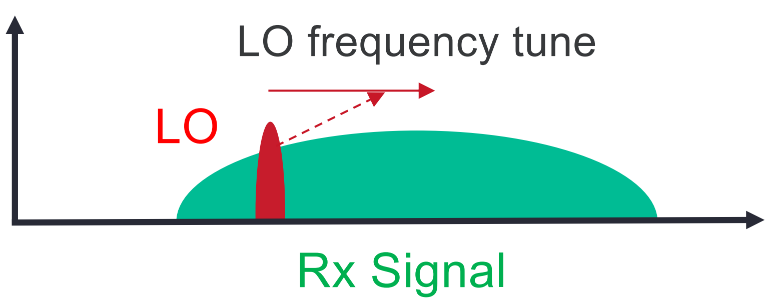
Two laser solutions

With separate Rx and LO lasers, only the LO will tune

- Tx has no means of determining offset
- LO will tune to align with Received signal

LO tuning range (MAX) must accommodate the worst-case Tx frequency inaccuracy

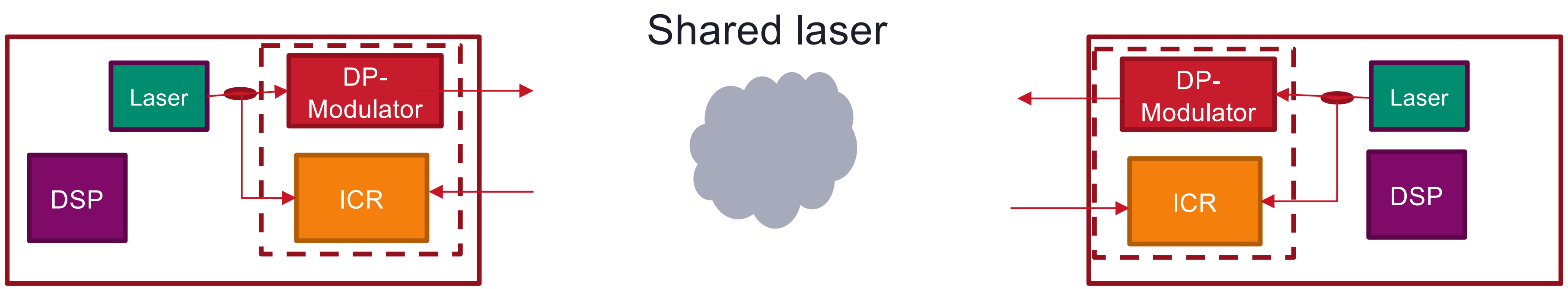




Shared Laser Solutions

With a shared laser, both lasers will tune

Tuning rates and ranges require specifications

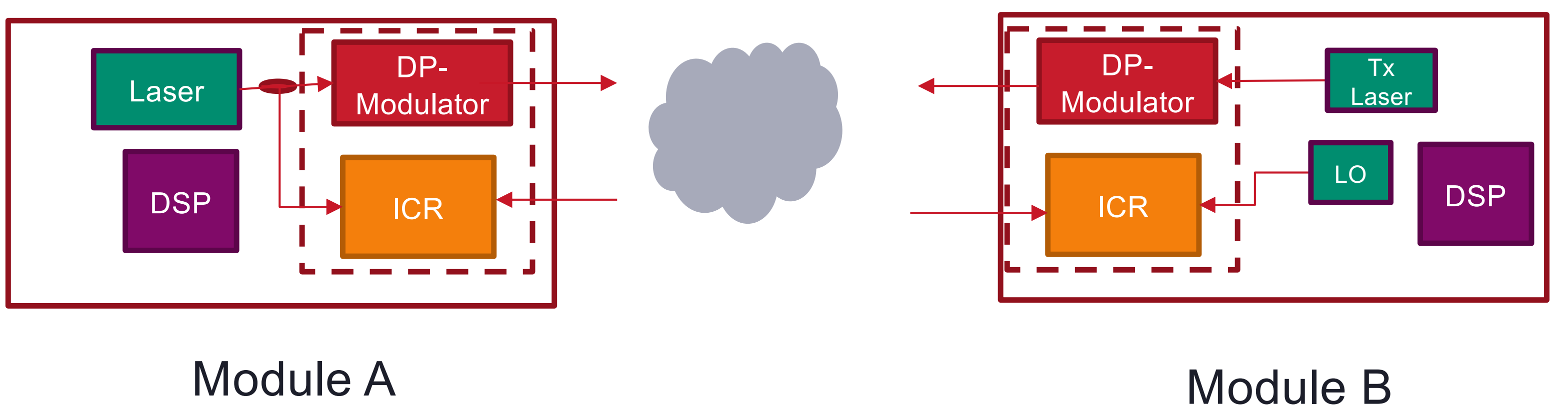


Mixed Solutions

LO tuning range (MAX) must accommodate the worst-case Tx frequency inaccuracy

Since module B Tx does not tune, Module A Laser must have sufficient range to accommodate worst case frequency offset

- Support for single-laser solutions with a limited tuning range would be incompatible with dual-unlocked lasers.



Justification using Laser Implementation Examples

1. **Separate Tx + LO lasers, both unlocked: ± MAX GHz**
   a. Don’t move the Tx (because you don’t know how)
   b. LO moves to lock on Rx input (vendor optimized procedure, no standard implications)
2. **Shared Tx+LO laser, unlocked ± MAX GHz**
   a. Move laser to minimize offset at Rx at the agreed slew rate to an agreed target offset. Dead zone for offset, before moving algorithm kicks in again.
3. **Separate Tx + LO lasers, Tx locked to ± 3GHz, Rx locked or unlocked but Rx needs ± MAX GHz of tuning range.**
   a. Don’t move Tx (because it is close enough)
   b. LO moves to lock on Rx input ± MAX GHz regardless of whether Rx has a locker or not (vendor optimized procedure, no standard implications.)
4. **Shared Tx+LO laser locked to ≤ ±3GHz**
   a. Natural desire is to say Tx and Rx do not move because they are close enough, but this causes interop issues with #1.
   b. Needs to use the same algorithm as #2. Does not stop a vendor building this implementation, but it must be possible *to move* the laser by ± MAX GHz regardless of being locked.
   c. Although Ethernet is bidirectional, there is a general expectation that a unidirectional connection will establish lock and allow BER measurement of the link. Note the Rx on #4a is dependent on the Tx of #2 to fall into the lock range and therefore fails this test.

Interop Operation

- 1 to 1: No issue
- 2 to 2: Standards algorithm
- 3 to 3: No issue
- 1 to 2: Standards algorithm, 2 does not know it is the only one moving.
- 2 to 3: Standards algorithm, 2 does not know it is the only one moving.
- 3 to 1: No issue
- 4a to 4a: No issue
- 4a to 3: No issue
- 4a to 2: Standards algorithm, 2 does not know it is the only one moving. Note that #4a is dependent on #2 operation to acquire, not ideal.
- **4a to 1: Broken because 4a Rx will not lock because neither Tx moves**

Unlocked #1 favored over locked #4

FW Driven Hunt for Acquisition Procedure

- **We agree with the the hunt for acquisition procedure proposed by Kishore Kota in kota_3dj_01a_2403.pdf when references to ± 10GHz are changed to ± MAX GHz.**
- We can agree with the high level offset targets: Stop laser frequency adjustments at ± 250MHz; dead-zone before re-adjusting starts again up to ± 400MHz, thus providing margin to a ± 900MHz worst case relative offset specification.
- **Laser frequency maximum change during hunt for acquisition procedure needs to be specified.**
  - Work required to remove TBD's

- **We agree on this procedure.**
- **Agree laser aging is deterministic**

Module Startup Procedure for shared TX/RX Type 2 laser

± MAX

- Module starts up and transmits signal with a laser frequency accurate to ~~±10GHz~~ based on factory calibration settings
- Receiver DSP has ability to provide an estimate of the relative LO offset to module firmware
- Module firmware makes small adjustments to transmit laser frequency in the direction which reduces the relative LO offset. Laser frequency changes cannot be faster than the specified rate.
- The frequency adjustment stops when the relative LO offset is within a pre-determined threshold chosen by the module designer (for e.g. ±0.25GHz)
- Use a "dead-zone" to avoid un-necessary laser frequency adjustments
- Periodic re-adjustments if the relative LO offset exceeds the dead-zone chosen by the module designer (for e.g. ±0.4GHz) with some margin to the worst case relative offset specification of ±0.9GHz
- Any laser adjustments need to stay within the limits required to ensure absolute accuracy ~~(±10GHz)~~

± MAX

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Tx additions for 800GBASE-LR1

- **Currently the 800GBASE-LR1 Tx specifies a ±TBD frequency range for the Tx**
- **The following should be added:**
  - Maximum Tx laser frequency slew rate: Preacquisition [Units GHz/s]
  - Maximum Tx laser frequency slew rate: Post acquisition [Units GHz/ms]
  - Laser Relative Frequency tracking accuracy [Units GHz]
- **Details of the values to be added after discussion**

Table 185–4—800GBASE-LR1 transmit characteristics

Description	Value	Unit
Signaling rate (range)	123.6364 ± 50 ppm	GBd
Modulation format	DP-16QAM	—
Average channel output power (max)	TBD	dBm
Average channel output power (min)	TBD	dBm
Carrier frequency (range)	228.675 ± TBD GHz	THz
Power difference between X and Y polarizations (max)	1.5	dB
Skew between X and Y polarizations (max)	TBD	ps
Transmitter quality metric	TBD	TBD
Instantaneous I-Q offset per polarization (max)	−20	dB

Summary

- **We have agreement on the high-level algorithm to be implemented to allow unlocked lasers to be used in 800GBASE-LR1**

- **A number of new parameters will be needed to fully define this approach**

- **Moving forward details will be included in subsequent drafts of 802.3dj**

Thanks!