# VCSEL Friendly 1550nm Specifications

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# Interoperability with 1310nm/10km specification

- The receivers will work with either wavelength
  - InGaAs/InP detectors respond to either wavelength
  - Quantum efficiency is actually better at 1550nm
- Allows more flexible designs
  - Allows aggregation of 10GB signals on a single fiber using readily available passive components
  - Allows for bi-directional link operation on a single fiber using wavelength multiplexing - An approach under consideration in EFM and other fiber to the X approaches
- The cost delta for single mode VCSELs at 1310 or 1550nm is marginal at best
- Relatively straight forward addition to the standard
  - Add transmit table
  - Add triple trade off curves?
  - Modify receive table to include 1530-1560nm

# The long wavelength VCSEL RELIABILTY question

- To date, no reliability studies have been published on any long wavelength VCSELs
- 1550nm single mode VCSELs will have larger apertures, and thus have lower thermal impedance
- AlGaInAs/InP is a well known material system for making 1550nm lasers, and has a large database of reliability information
- InGaAsN/GaAs is unknown, and some literature reports question the reliability because of N clustering and removal
- Lower photon energy at 1550nm may be beneficial
- No one knows which material system will prove most reliable
- The Technology associated with developing long wavelength VCSELs is difficult
  - Either wavelength will fit the need for 10km links, so why not let the material problems be worked on simultaneously

# The long wavelength VCSEL PERFORMANCE question

- High temperature lasing
  - 1550nm VCSELs have larger apertures, which mean lower thermal impedance and less thermal lensing
  - Band offsets may be better for 1550nm VCSELs, meaning better carrier confinement in quantum wells
  - Similar results have been demonstrated for 1310 and 1550nm VCSELs
- Single mode operation
  - 1550nm VCSELs can use larger aperture devices
- Modulation bandwidth
  - Demonstrated in both wavelengths
  - Chirp will be the biggest issue for 1550nm VCSELs

**No long wavelength VCSEL has been demonstrated that will meet all of the GBE performance requirements. Why limit it to one wavelength?**

# The Receiver table changes

Receive Characteristics

| Description | 10GBASE LR/LW | | Unit |
|---|---|---|---|
| Signaling Speed (Nominal) | | | |
| 10GBASE-LR | 10.3125 | | GBd |
| 10GBASE-LW | 9.95328 | | |
| Clock Tolerance | +/-100 | | ppm |
| Wavlength Range | 1265 to 1355 | 1530 to 1565 | nm |
| Average Receive Power (max) | 1 | | dBm |
| Receive Sensitivity in OMA | 0.0477 (-13.23) | 0.0477 (-13.23) | mW (dBm) |
| Return Loss | 12 | | dB |
| Stressed Receive Sensitivity in OMA | 0.0857 (-11.68) | 0.09 (-10.15) | mW (dBm) |
| Vertical eye closure penalty | 1.78 | 2.22 | dB |
| Receive electrical 3dB upper cutoff frequency (max) | 12 | | GHz |

# The transmitter table changes

Transmit Characteristics

| Description | 10GBASE LR/LW | | Unit |
|---|---|---|---|
| Signaling Speed (Nominal) | | | GBd |
| 10GBASE-LR | 10.3125 | | |
| 10GBASE-LW | 9.95328 | | |
| Clock Tolerance | +/-100 | | ppm |
| Wavlength Range | 1265 to 1355 | 1530 to 1565 | nm |
| Tr/Tf (max, 20%-80% response) | 40 | 33 | ps |
| RMS Spectral width | footnote | 0.13 | nm |
| Side mode suppression | 30 | | dB |
| Average launch power | 1 | -3 | dBm |
| Launch power min in OMA | footnote | -3 | dBm |
| Average lanuch power of an OFF transmitter | -30 | | dBm |
| Extinction Ratio (min) | 4 | | dB |
| RIN | -125 | | dB/Hz |
| Return Loss | 12 | | dB |

# The link budget table changes

Worst case link power budget and penalties

| Parmeter | 10GBASE-LR/LW | | Unit |
|---|---|---|---|
| | 1265 to 1355 | 1530 to 1565 | |
| Link power budget | 10 | | dB |
| Operating distance | 10 | | km |
| Channel insertion loss | 7.04 | 5.44 | dB |
| Link power penalties | 2.46 | 4.22 | dB |
| Unallocated margin in link power budget | 0.5 | 0.34 | dB |

# Recommendation

- Adopt 1550nm VCSEL friendly specifications
  - Minimal changes to the standard
  - Interoperable with 1310nm solution
  - Lessens risk due to VCSEL development
  - Added flexibility for systems implementation