

Towards 100GBASE-FR & 100GBASE-LR Baseline Proposals

Brian Welch (Cisco)

Hai-Feng Liu (Intel)

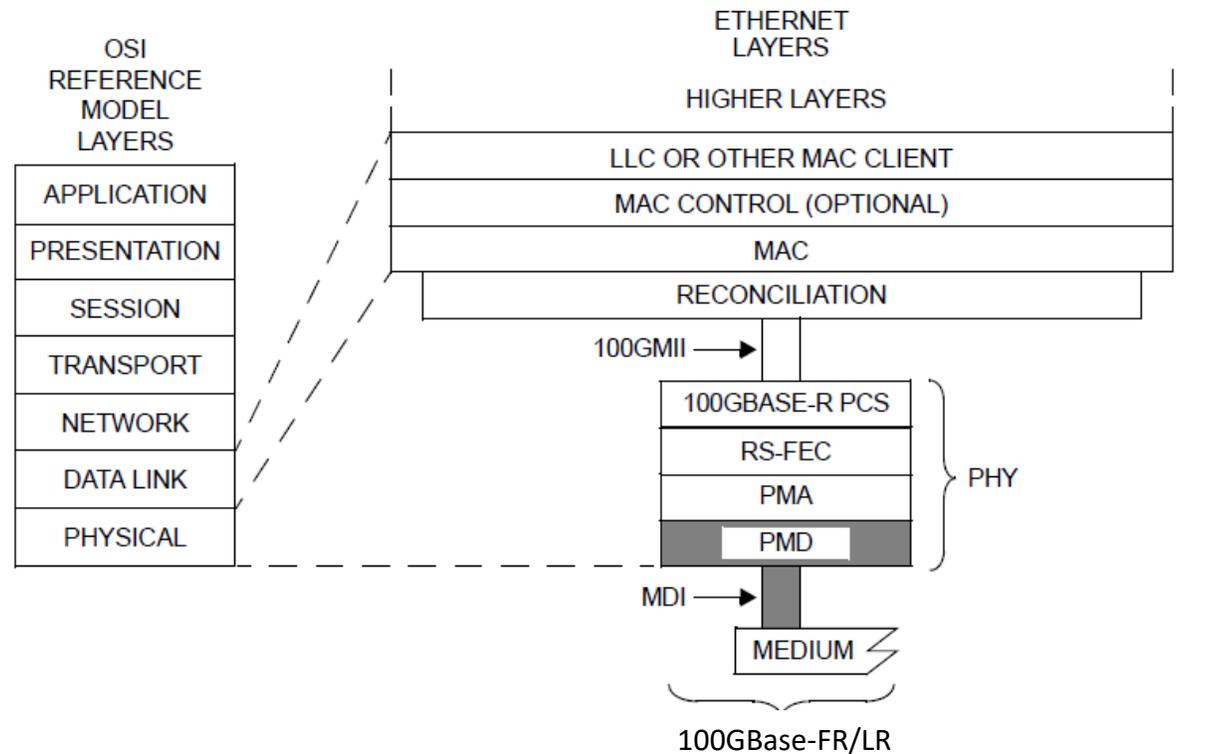
Supporters

- David Lewis (Lumentum)
- Kohichi Tamura (Lumentum)
- Gary Nicholl (Cisco)
- Justin Abbot (Lumentum)
- Jeff Maki (Juniper Networks)
- Marco Mazzini (Cisco)
- Matt Traverso (Cisco)
- Frank Chang (Source Photonics)
- Sven Otte (Sicoya)
- Jim Theodoras (HG Genuine)
- Pavel Zivny (Tektronix)
- Ed Ulrichs (Source Photonics)

Overview

- Present the work towards a baseline proposal to address the following objectives:
 - *Define a single-wavelength 100 Gb/s PHY for operation over SMF lengths up to at least 2 km*
 - *Define a single-wavelength 100 Gb/s PHY for operation over SMF lengths up to at least 10 km*
- Approach is based on 100G/λ transmission using PAM4 signaling
- Link budget is based on KP4 FEC

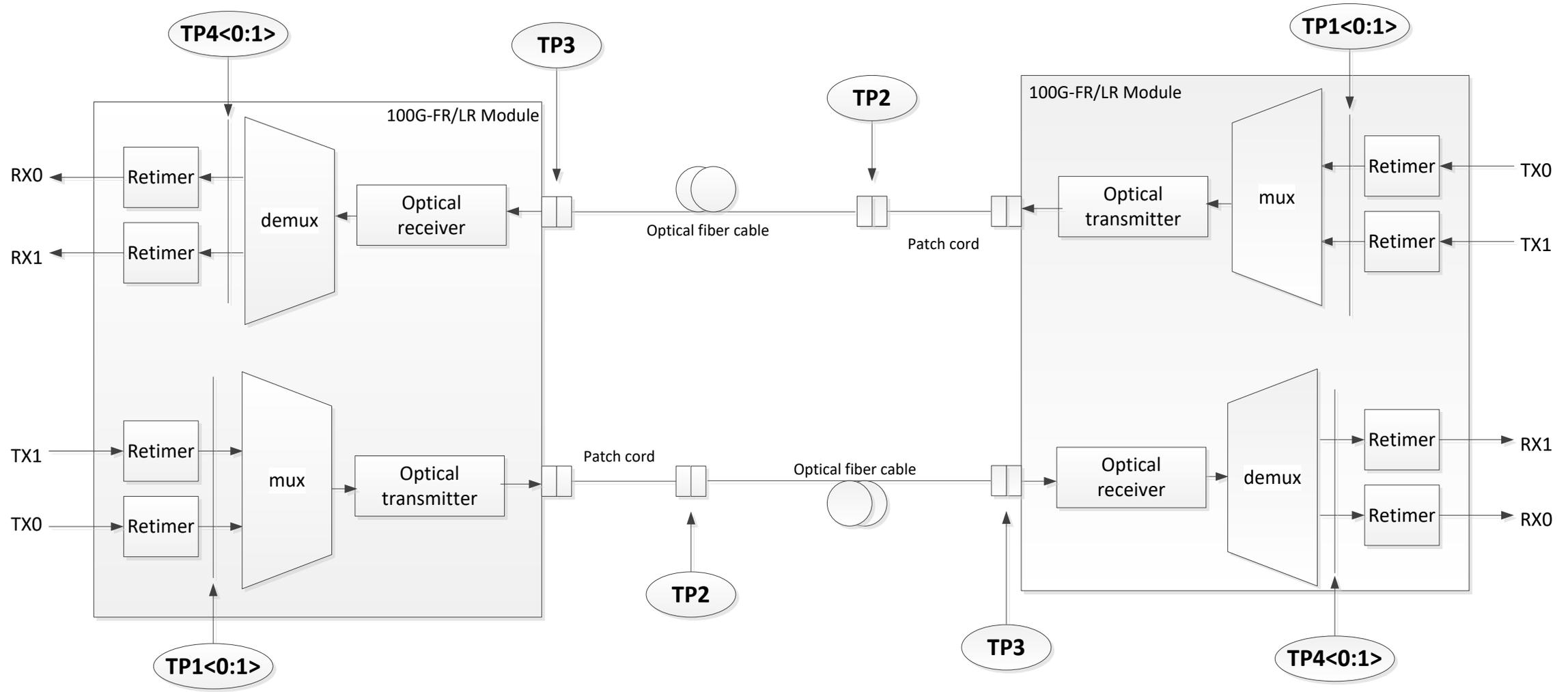
Position in IEEE 802.3 Ethernet Model



100GMII = 100 Gb/s MEDIA INDEPENDENT INTERFACE
 RS-FEC = REED-SOLOMON FORWARD ERROR CORRECTION
 LLC = LOGICAL LINK CONTROL
 MAC = MEDIA ACCESS CONTROL
 MDI = MEDIUM DEPENDENT INTERFACE
 PCS = PHYSICAL CODING SUBLAYER

PHY = PHYSICAL LAYER DEVICE
 PMA = PHYSICAL MEDIUM ATTACHMENT
 PMD = PHYSICAL MEDIUM DEPENDENT
 FR = PMD FOR SINGLE-MODE FIBER – 2km
 LR = PMD FOR SINGLE-MODE FIBER – 10km

PMD Block Diagram – for Duplex 2km and 10km



Key Revisions vs 100GBase-DR

- Power budget increased to support higher channel losses
 - 100GBase-FR approximately 1.2 dB higher power budget than 100GBase-DR
 - 100GBase-LR approximately 3.7 dB higher power budget than 100GBase-DR
- Power budgets increased by moving TX specification up and RX specifications down
 - Approximately even split on each side

Potential 100GBASE-FR and 100GBASE-LR Transmitter Specifications

| Description | 100GBase-FR | 100GBase-LR | Unit |
|--|------------------|------------------|-------|
| PAM4 Signaling rate, (range) | 53.125 ± 100 ppm | 53.125 ± 100 ppm | GBd |
| Wavelength (range) | 1304.5- 1317.5 | 1304.5- 1317.5 | nm |
| Side-mode suppression ratio (SMSR), (min) | 30 | 30 | dB |
| Average launch power, (max) | 4 | 4.5 | dBm |
| Average launch power, ^a (min) | -2.4 | -1.4 | dBm |
| Outer Optical Modulation Amplitude (OMA _{outer}), (max) | 4.2 | 4.7 | dBm |
| Outer Optical Modulation Amplitude (OMA _{outer}), ^b (min) | -0.2 | 0.7 | dBm |
| Launch power in OMA _{outer} minus TDECQ, (min): for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB | -1.6 -1.5 | -0.7 -0.6 | dBm |
| Transmitter and dispersion penalty eye closure for PAM4 (TDECQ), (max) | 3.4 | 3.4 | dB |
| TDECQ – 10*log ₁₀ (C _{eq}) (max) ^d | 3.4 | 3.4 | dB |
| Average launch power of OFF transmitter, (max) | -15 | -15 | dBm |
| Extinction ratio (min) | 3.5 | 3.5 | dB |
| Optical return loss tolerance (max) | 17.1 | 15.6 | dB |
| Transmitter reflectance ^c (max) | -26 | -26 | dB |
| Transmitter transition time (max) | 17 | 17 | ps |
| RIN _{17.1} OMA (max) for FR, RIN _{15.6} OMA (max) for LR | -136 | -136 | dB/Hz |

^aAverage launch power, (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.

^b Even if the TDECQ < 1.4 dB for an extinction ratio of ≥ 4.5 dB or TDECQ < 1.3 dB for an extinction ratio of < 4.5 dB, the OMA_{outer} (min) must exceed this value.

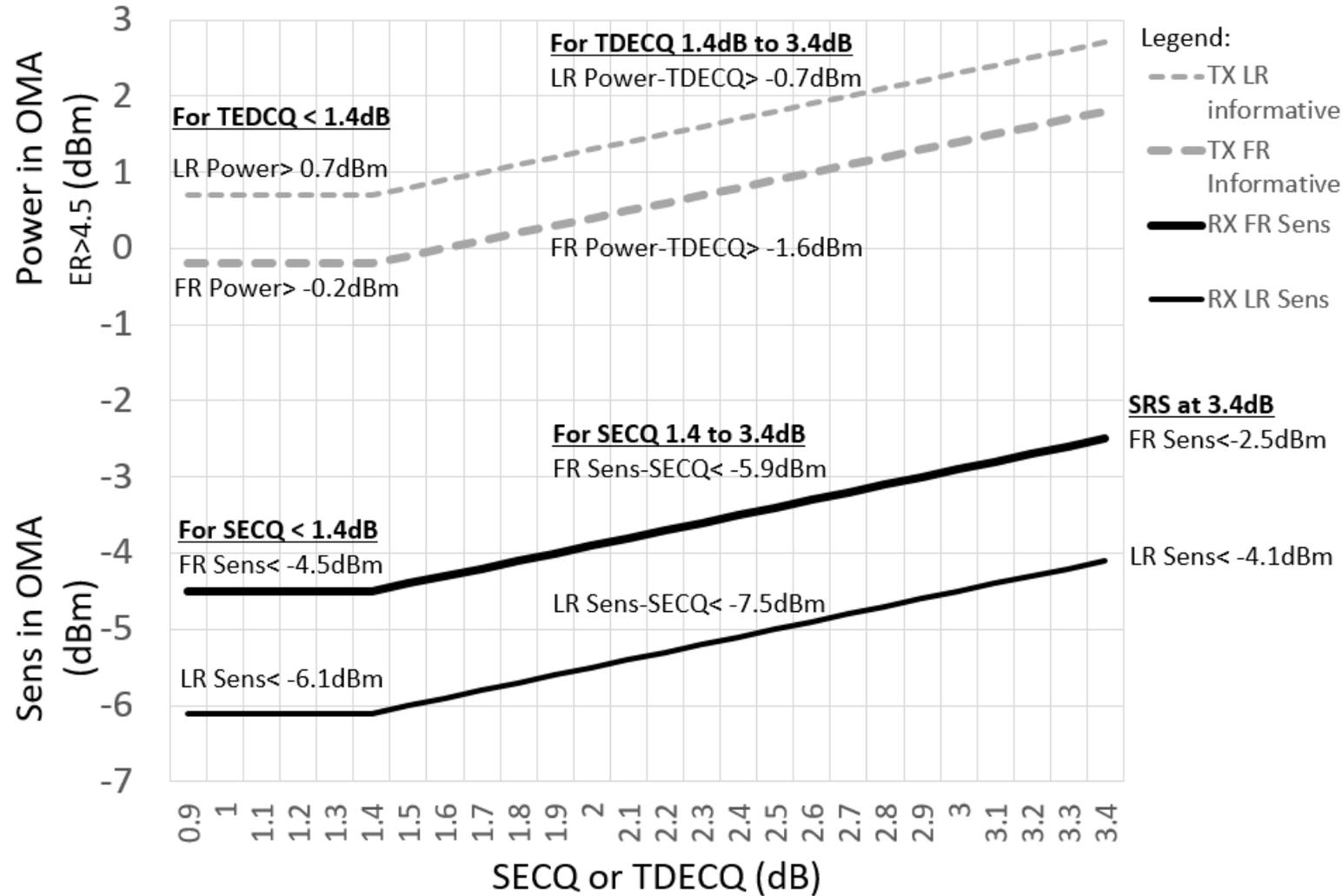
^cTransmitter reflectance is defined looking into the transmitter.

^d C_{eq} is a coefficient defined in IEEE Std 802.3-2018 clause 121.8.5.3 which accounts for reference equalizer noise enhancement.

Potential 100GBASE-FR and 100GBASE-LR Receiver Specifications

| Description | 100GBASE-FR | 100GBASE-LR | Unit |
|---|------------------|------------------|------|
| PAM4 Signaling rate, (range) | 53.125 ± 100 ppm | 53.125 ± 100 ppm | GBd |
| Wavelength (range) | 1304.5 to 1317.5 | 1304.5 to 1317.5 | nm |
| Damage threshold, (min) ^a | 5.5 | 5.5 | dBm |
| Average receive power, (max) | 4.5 | 4.5 | dBm |
| Average receive power, ^b (min) | -6.4 | -7.7 | dBm |
| Receive power, (OMA _{outer}) (max) | 4.7 | 4.7 | dBm |
| Receiver reflectance (max) | -26 | -26 | dB |
| Receiver sensitivity (OMA _{outer}), ^c (max) | See Next Page | See Next Page | dBm |
| Stressed receiver sensitivity (OMA _{outer}), ^d (max) | -2.5 | -4.1 | dBm |
| Conditions of stressed receiver sensitivity test ^e : | | | |
| Stressed eye closure for PAM4 (SECQ) | 3.4 | 3.4 | dB |
| SECQ – 10*log ₁₀ (C _{eq}) (max) ^e | 3.4 | 3.4 | dB |
| ^a The receiver shall be able to tolerate, without damage, continuous exposure to an optical signal having this average power level. The receiver does not have to operate correctly at this input power. | | | |
| ^b Average receive power, (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance. | | | |
| ^c Receiver sensitivity (OMA _{outer}), (max) is informative and is defined for a transmitter with a value of SECQ up to 3.4 dB for 100G-FR and 3.4 dB for 100G-LR. | | | |
| ^d Measured with conformance test signal at TP3 (see 3.11) for the BER specified in IEEE Std 802.3cd clause 140.1.1. | | | |
| ^e These test conditions are for measuring stressed receiver sensitivity. They are not characteristics of the receiver. | | | |
| ^e C _{eq} is a coefficient defined in IEEE Std 802.3-2018 clause 121.8.5.3 which accounts for reference equalizer noise enhancement. | | | |

Potential 100GBASE-FR and 100GBASE-LR Receiver Specifications



Illustrative Optical Link Budget

| Description | 100G-FR Value | 100G-LR Value | Unit |
|--|---------------|---------------|------|
| Power budget (for max TDECQ) for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB | 7.7 7.8 | 10.2 10.3 | dB |
| Operating distance | 2.0 | 10.0 | km |
| Channel insertion loss ^a | 4.0 | 6.3 | dB |
| Maximum discrete reflectance | See Table 2-5 | See Table 2-5 | dB |
| Allocation for penalties ^b (for max TDECQ) for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB | 3.7 3.8 | 3.9 4.0 | dB |
| Additional insertion loss allowed | 0 | 0 | dB |
| ^a The channel insertion loss is calculated using the maximum distance specified in Table 2-1 and cabled optical fiber attenuation of 0.5 dB/km at 1304.5 nm plus an allocation for connection and splice loss given in 5.2.1. | | | |
| ^b Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested. | | | |

| Number of discrete reflectances above -55dB | Maximum value for each discrete reflectance for FR | Maximum value for each discrete reflectance for LR | Unit |
|---|--|--|------|
| 1 | -25 | -22 | dB |
| 2 | -31 | -29 | dB |
| 4 | -35 | -33 | dB |
| 6 | -38 | -35 | dB |
| 8 | -40 | -37 | dB |
| 10 | -41 | -39 | dB |

Thank You