100GBASE-LR Baseline Proposal

Brian Welch (Cisco)

Hai-Feng Liu

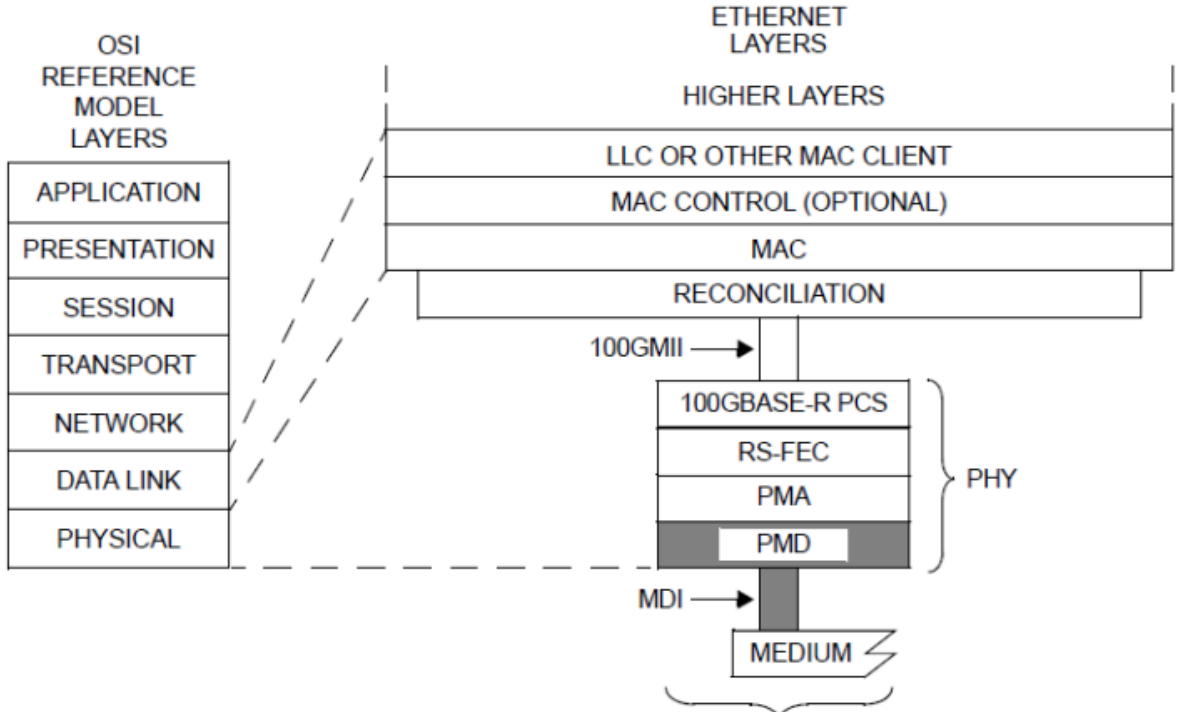
Supporters

- David Lewis (Lumentum)
- Kohichi Tamura (CIG)
- Gary Nicholl (Cisco)
- Justin Abbot (Lumenum)
- 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)
- Rang-Chen (Ryan) Yu (SiFotonics)
- Mark Kimber (Semtech)
- Scott Schube (Intel)
- Thananya Baldwin (Keysight)
- Jerry Pepper (Keysight)
- John Johnson (Broadcom)
- Kees Propstra (multiLane)
- Pirooz Tooyserkani (Cisco)
- Karen Liu (Lightwave Logic)
- Jonathan Ingham (FIT)
- Vasu Parthasarathy (Broadcom)
- Rob Stone (Broadcom)
- Ken Jackson (SEI)
- David Ofelt (Juniper)
- Paul Brooks (Viavi)
- Tom Palkert (Macom/Molex)
- Mark Kimber (Semtech)
- David Malicoat (Senko Advanced Components)
- Kent Lusted (Intel)
- Pavel Zivny (Tektronix)
- Shimon Muller (Axalume)
- Christophe Metivier (Arista)
- Nathan Tracy (TE Connectivity)
- Dirk Lutx (Eoptolink)
- Hua Zhang (Hisense)
- David Estes (Spirent)
- Curtis Knittle (Cable Labs)
- Phil Sun (Credo)
- Jeff Twombly (Credo)
- Vince Ferretti (Corning)
- Doug Coleman (Corning)
- Steve Swanson (Corning)

Overview

- Present a baseline proposal to address the following objective:
  - *Define a singe-wavelength 100 Gb/s PHY for operation overs SMF lengths up to at least 10 km*
- Approach is based on 100G/λ transmission using PAM4 signaling
- Link budget is based on clause 91 FEC

Position in IEEE 802.3 Ethernet Model

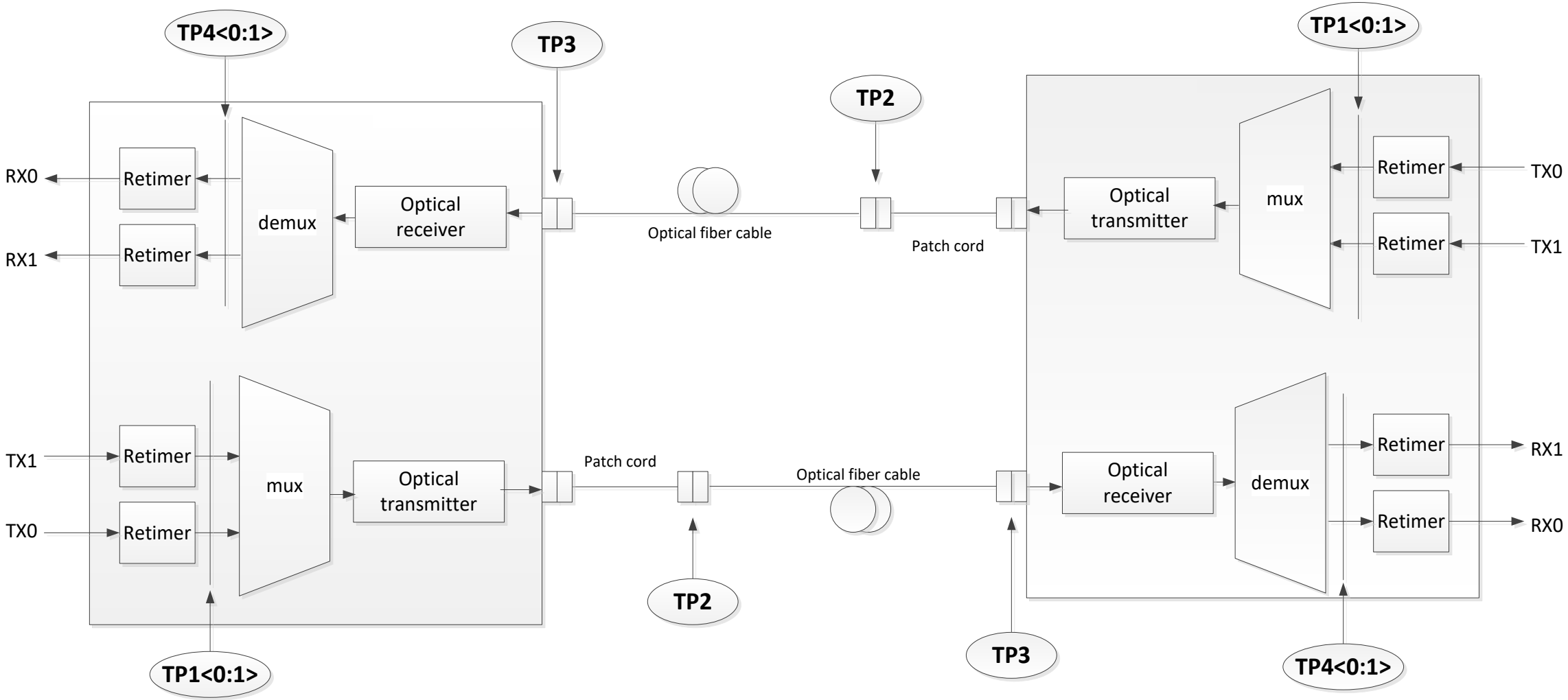


100GMII = 100 Gb/s MEDIA INDEPENDENT INTERFACE
RS-FEC = REED-SOLOMON FORWARD ERROR CORRECTION
LLC = LOGICAL LINK CONTROL
MAC = MEDIA ACCESS CONTROL
MDI = MEDIUM DEPENDENT INTERFACE
PCS = PHYSICAL CODING SUBLAYER

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



Key Revisions vs 100GBase-DR

- Power budget increased to support higher channel losses
  - 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

Proposed 100GBASE-LR Transmitter Specifications

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

[a]Average 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.

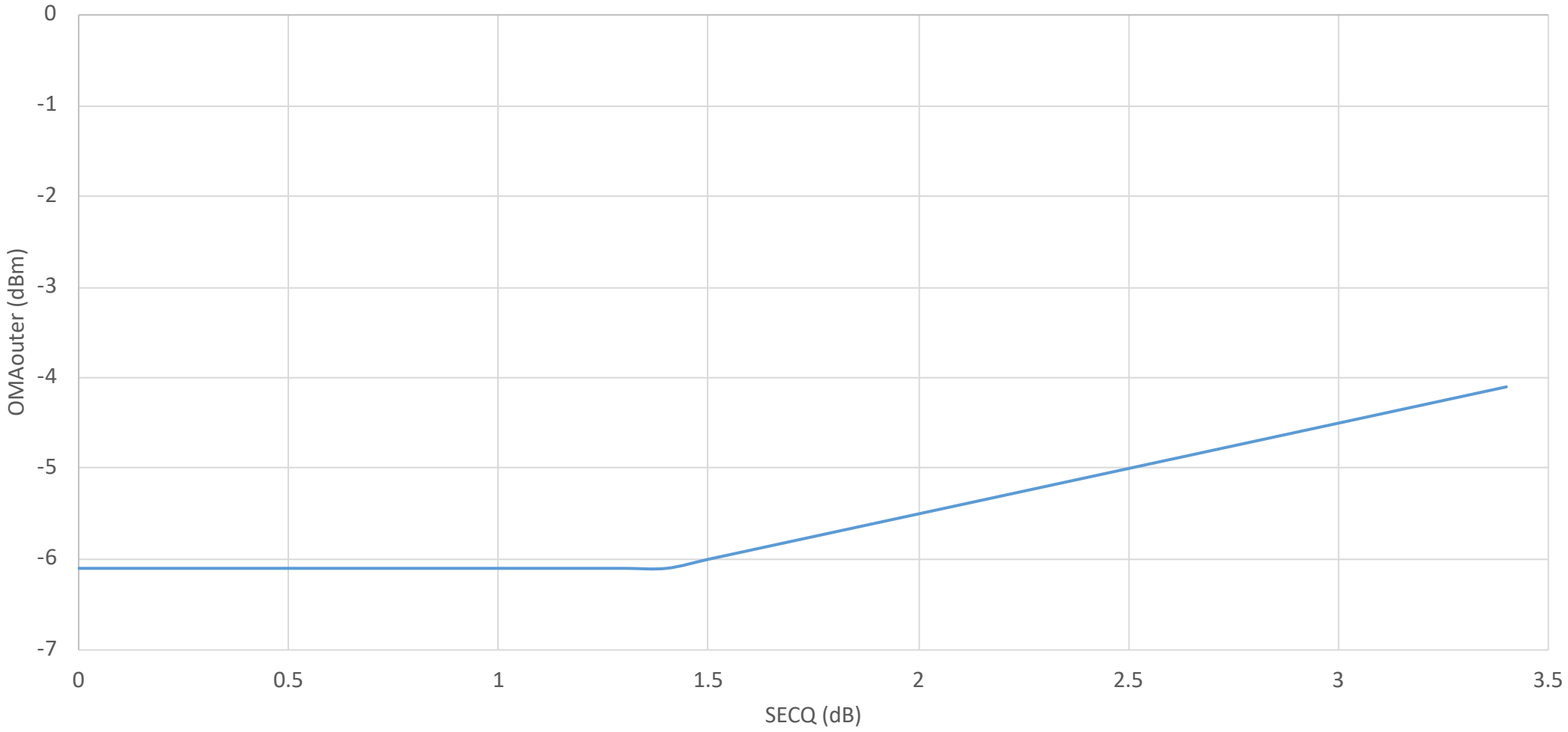
[c]Transmitter reflectance is defined looking into the transmitter.

[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.

Proposed 100GBASE-LR Receiver Specifications

Description	100GBASE-LR	Unit
PAM4 Signaling rate, (range)	53.125 ± 100 ppm	GBd
Wavelength (range)	1304.5 to 1317.5	nm
Damage threshold, (min)[a]	5.5	dBm
Average receive power, (max)	4.5	dBm
Average receive power,[b] (min)	-7.7	dBm
Receive power, (OMA_{outer}) (max)	4.7	dBm
Receiver reflectance (max)	-26	dB
Receiver sensitivity (OMA_{outer}),[c] (max)	= max(-6.1, SECQ-7.5)	dBm
Stressed receiver sensitivity (OMA_{outer}),[d] (max)	-4.1	dBm
Conditions of stressed receiver sensitivity test[e]:		
Stressed eye closure for PAM4 (SECQ)	3.4	dB
SECQ – $10*\log_{10}(C_{eq})$ (max) [e]	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.		

Proposed 100GBASE-LR Receiver Specification



Illustrative Optical Link Budget

Description	100G-LR Value	Unit
Power budget (for max TDECQ) for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	 10.2 10.3	dB
Operating distance	10.0	km
Channel insertion loss[a]	6.3	dB
Maximum discrete reflectance	See table below	dB
Allocation for penalties[b] (for max TDECQ) for extinction ratio ≥ 4.5 dB for extinction ratio < 4.5 dB	 3.9 4.0	dB
Additional insertion loss allowed	0	dB
[a]The channel insertion loss is calculated using the maximum distance specified in Table 2-1 and cabled optical fiber attenuation of 0.43 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 LR	Unit
1	-22	dB
2	-29	dB
4	-33	dB
6	-35	dB
8	-37	dB
10	-39	dB

Thank You