MULTI-LANE PHY SPECIFICATIONS IN 802.3

CONTACT:
MAREK HAJDUCZENIA
NETWORK ARCHITECT, PRINCIPAL ENGINEER
EMAIL: MAREK.HAJDUCZENIA@MYBRIGHTHOUSE.COM

Multi-lane PHYs in 802.3

- There are a number of multi-lane PHYs specified in 802.3 today
  - Some are copper-based and of limited interest for NG-EPON SG
  - There are P2P SMF-based PHYs, e.g., 40/100GBASE-LR4/ER4. SR4 is excluded (MMF). Note that these are OOK PHYs.
- Multi-lane PHYs require specific characterization of PMDs
  - Launch power, sensitivity, center wavelength, etc. – just like any other single-lane PHY
  - Many parameters are specified on per-lane basis
  - Additional parameters need to be also defined, including e.g., maximum difference between individual lanes for output power.
- NG-EPON PHY with multiple lanes will need to reuse the same model
  - Provide standard, Clause-75 like set of parameters for Tx and Rx
  - Add per-lane excursion parameters, e.g., maximum power difference between any two lanes
  - New multi-lane tests will need to be added to the spec

4-data-lane PHY (ala' 40GBASE-LR4) [1]

- Reference model for Tx/Rx interconnect and test points

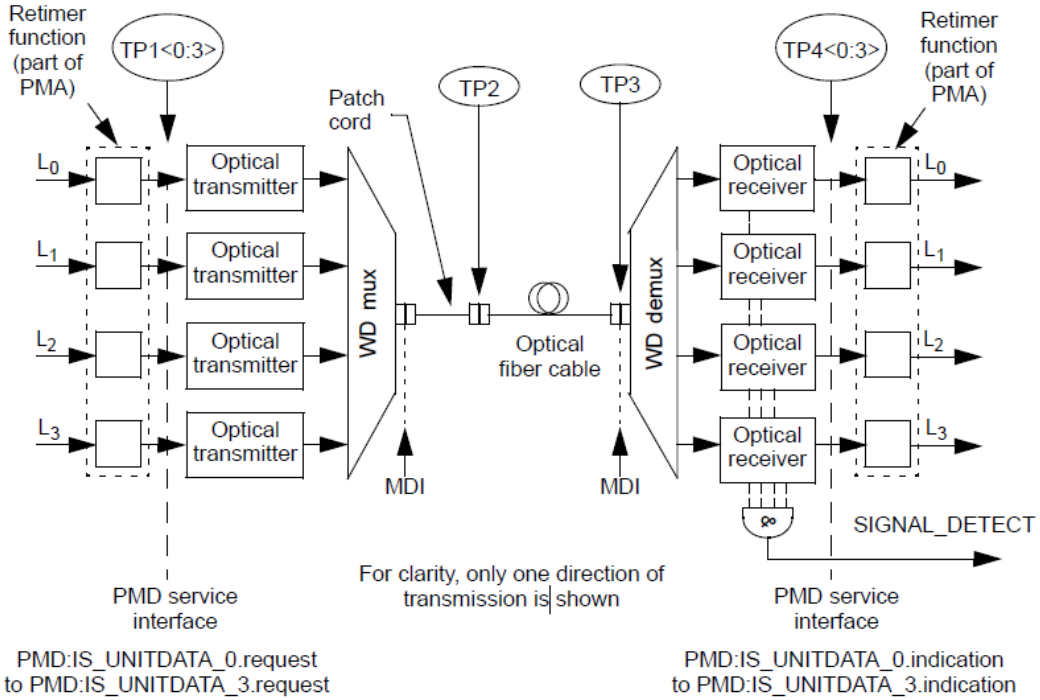

Figure 87–2
Block diagram for 40GBASE-LR4 and 40GBASE-ER4 transmit/receive paths

- SIGNAL_DETECT specified based on power levels at TP3

Receive conditions	SIGNAL_DETECT value
For any lane; Average optical power at TP3 ≤ –30 dBm	FAIL
For all lanes; [(Optical power at TP3 ≥ receiver sensitivity (max) in OMA in Table 87–8) AND (compliant 40GBASE–R signal input)]	OK
All other conditions	Unspecified

Table 87–4
SIGNAL_DETECT value definition

4-data-lane PHY (ala' 40GBASE-LR4) [2]

- Center wavelength assignment for individual channels

Lane	Center wavelength	Wavelength range
L_0	1271 nm	1264.5 to 1277.5 nm
L_1	1291 nm	1284.5 to 1297.5 nm
L_2	1311 nm	1304.5 to 1317.5 nm
L_3	1331 nm	1324.5 to 1337.5 nm

Table 87–5
Wavelength-division-multiplexed lane assignments

- Illustrative link power budget

Parameter	40GBASE-LR4	40GBASE-ER4		Unit
Power budget (for max TDP)	9.3	21.1		dB
Operating distance	10	30	40[a]	km
Channel insertion loss	6.7[b]	16.5[b]	18.5[a]	dB
Maximum discrete reflectance	–26	–26		dB
Allocation for penalties[c] (for max TDP)	2.6	2.6		dB
Additional insertion loss allowed	0	2	0	dB

Table 87–9
40GBASE-LR4 and 40GBASE-ER4 illustrative link power budgets

- Test patterns for 40GBASE

Pattern	Pattern description	Defined in
Square wave	Square wave (8 ones, 8 zeros)	83.5.10
3	PRBS31	83.5.10
4	PRBS9	83.5.10
5	Scrambled idle	82.2.11

Table 87–10
Test patterns

4-data-lane PHY (ala' 40GBASE-LR4) [3]

- Tx specifications

Table 87–7
40GBASE-LR4 and 40GBASE-ER4 transmit characteristics

Description	40GBASE-LR4	40GBASE-ER4	Unit
Signaling rate, each lane (range)	10.3125 ± 100 ppm		GBd
Lane wavelengths (range)	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5		nm
Side-mode suppression ratio (SMSR), (min)	30		dB
Total average launch power (max)	8.3	10.5	dBm
Average launch power, each lane (max)	2.3	4.5	dBm
Average launch power, each lane[a] (min)	–7	–2.7	dBm
Optical Modulation Amplitude (OMA), each lane (max)	3.5	5	dBm
Optical Modulation Amplitude (OMA), each lane (min)[b]	–4	0.3	dBm
Difference in launch power between any two lanes (OMA) (max)	6.5	4.7	dB
Launch power in OMA minus TDP, each lane (min)	–4.8	–0.5	dBm
Transmitter and dispersion penalty (TDP), each lane (max)	2.6		dB
Average launch power of OFF transmitter, each lane (max)	–30		dBm
Extinction ratio (min)	3.5	5.5	dB
$RIN_{20}OMA$ (max)	–128		dB/Hz
Optical return loss tolerance (max)	20		dB
Transmitter reflectance[c] (max)	–12		dB
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3}	{0.25, 0.4, 0.45, 0.25, 0.28, 0.4}		

Wavelength range, per lane

Launch power: total, min/max per lane

OMA: min/max per lane

OMA different between lanes

Transmitter Dispersion Penalty

Power level in off state + ER (min)

Return loss and reflectance

Transmitter mask

4-data-lane PHY (ala' 40GBASE-LR4) [4]

- Rx specifications

Table 87–8
40GBASE-LR4 and 40GBASE-ER4 receive characteristics

Description	40GBASE-LR4	40GBASE-ER4	Unit
Signaling rate, each lane (range)	10.3125 ± 100 ppm		GBd
Lane wavelengths (range)	1264.5 to 1277.5 1284.5 to 1297.5 1304.5 to 1317.5 1324.5 to 1337.5		nm
Damage threshold[a] (min)	3.3	3.8	dBm
Average receive power, each lane (max)	2.3	–4.5	dBm
Average receive power, each lane[b] (min)	–13.7	–21.2	dBm
Receive power, each lane (OMA) (max)	3.5	–4	dBm
Difference in receive power between any two lanes (OMA) (max)	7.5	7	dB
Receiver reflectance (max)	–26		dB
Receiver sensitivity (OMA), each lane[c] (max)	–11.5	–19	dBm
Receiver 3 dB electrical upper cutoff frequency, each lane (max)	12.3		GHz
Stressed receiver sensitivity (OMA), each lane[d] (max)	–9.6	–16.8	dBm
Conditions of stressed receiver sensitivity test:			
Vertical eye closure penalty,[e] each lane	1.9	2.2	dB
Stressed eye J2 Jitter,[e] each lane	0.3		UI
Stressed eye J9 Jitter,[e] each lane	0.47		UI

Signaling rate, per lane

Wavelength range, per lane

Damage threshold, for all lanes

Receive power, per lane (min/max)

Receive power, per lane (OMA)

Difference between lane power (OMA)

Receiver sensitivity, per lane (OMA)

Stressed receiver sensitivity, per lane (OMA)

What we need for NG-EPON…

- Specify PHY with up to 4 channels (100Gb/s PHY) with the following parameters defined:
  - Wavelength channel allocation
    - Center, width, isolation, excursion, etc., per lane
  - Tx and Rx parameters
    - Copy all parameters from 10G-EPON (10Gb/s only) Tx and Rx specifications – these need to be specified per lane (min/max values)
    - Specify maximum excursion for individual parameters, e.g., Tx power level for any two data lanes
- For 25Gb/s and 50Gb/s operation, we only need to identify one/two of four data lanes available in 100 Gb/s PHY
  - There is no benefit in creating a subset PHY
  - We only need to identify the lane(s) which should be used by 25/50Gb/s PHYs from all 4 data lanes available in 100Gb/s PHY

THANK YOU!