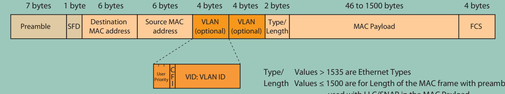
# World of 100 Gbps – The Lower Layers

## 100 Gigabit Ethernet

### MAC

802.3 MAC Frame Structure



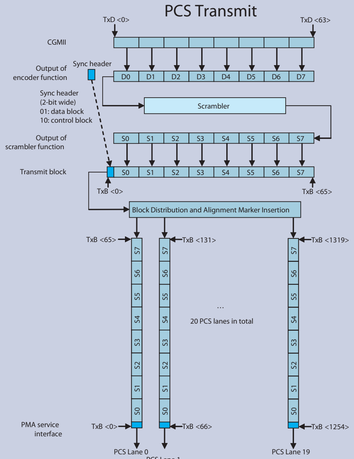

Type/ Length: Values > 1535 are Ethernet Types; Values ≤ 1500 are for Length of the MAC frame with preamble/SFP and typically used with LLC/SNAP in the MAC Payload

### PCS

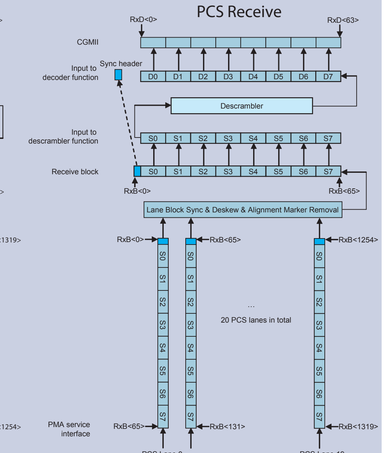
64B/66B PCS Block Format

| Input Data | | S Y N C | Block Payload | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Bit Position | | 0 | 1 | 2 | | | | | | 65 |
| Data Block Format | | | | | | | | | | |
| $D_0D_1D_2D_3/D_4D_5D_6D_7$ | 01 | | $D_0$ | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | $D_6$ | $D_7$ |
| Control Block Formats | | | Block Type Field | | | | | | | |
| $C_0C_1C_2C_3/C_4C_5C_6C_7$ | 10 | | 0x1E | $C_0$ | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ |
| $S_0D_1D_2D_3/D_4D_5D_6D_7$ | 10 | | 0x78 | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | $D_6$ | $D_7$ |
| $O_0D_1D_2D_3/Z_4Z_5Z_6Z_7$ | 10 | | 0x48 | $D_1$ | $D_2$ | $D_3$ | $O_0$ | 0x000_0000 | | |
| $T_0C_1C_2C_3/C_4C_5C_6C_7$ | 10 | | 0x87 | | | $C_1$ | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ |
| $D_0T_1C_2C_3/C_4C_5C_6C_7$ | 10 | | 0x99 | $D_0$ | | | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ |
| $D_0D_1T_2C_3/C_4C_5C_6C_7$ | 10 | | 0xAA | $D_0$ | $D_1$ | | | $C_3$ | $C_4$ | $C_5$ | $C_6$ | $C_7$ |
| $D_0D_1D_2T_3/C_4C_5C_6C_7$ | 10 | | 0xB4 | $D_0$ | $D_1$ | $D_2$ | | | $C_4$ | $C_5$ | $C_6$ | $C_7$ |
| $D_0D_1D_2D_3/T_4C_5C_6C_7$ | 10 | | 0xCC | $D_0$ | $D_1$ | $D_2$ | $D_3$ | | | $C_5$ | $C_6$ | $C_7$ |
| $D_0D_1D_2D_3/D_4T_5C_6C_7$ | 10 | | 0xD2 | $D_0$ | $D_1$ | $D_2$ | $D_3$ | $D_4$ | | | $C_6$ | $C_7$ |
| $D_0D_1D_2D_3/D_4D_5T_6C_7$ | 10 | | 0xE1 | $D_0$ | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | | | $C_7$ |
| $D_0D_1D_2D_3/D_4D_5D_6T_7$ | 10 | | 0xFF | $D_0$ | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | $D_6$ | | |

PCS Transmit




PCS Receive




Alignment Markers

| $M_0$ | $M_1$ | $M_2$ | $BIP_3$ | $M_4$ | $M_5$ | $M_6$ | $BIP_7$ |
|---|---|---|---|---|---|---|---|

Alignment markers are inserted after every 16383 66-bit blocks on each PCS lane

| PCS Lane | Encoding | PCS Lane | Encoding |
|---|---|---|---|
| 0 | 0xC1, 0x68, 0x21, $BIP_3$, 0x3E, 0x97, 0xDE, $BIP_7$ | 10 | 0xFD, 0x6C, 0x99, $BIP_3$, 0x02, 0x93, 0x66, $BIP_7$ |
| 1 | 0x90, 0x71, 0x8E, $BIP_3$, 0x62, 0x8E, 0x71, $BIP_7$ | 11 | 0x89, 0x91, 0x55, $BIP_3$, 0x46, 0x6E, 0xAA, $BIP_7$ |
| 2 | 0x59, 0x4B, 0xE8, $BIP_3$, 0xA6, 0xB4, 0x17, $BIP_7$ | 12 | 0x5C, 0xB9, 0xB2, $BIP_3$, 0xA3, 0x46, 0x4D, $BIP_7$ |
| 3 | 0x4D, 0x95, 0x7B, $BIP_3$, 0xB2, 0x6A, 0x84, $BIP_7$ | 13 | 0x1A, 0xF8, 0xBD, $BIP_3$, 0xE5, 0x07, 0x42, $BIP_7$ |
| 4 | 0xF5, 0x07, 0x09, $BIP_3$, 0x0A, 0xF8, 0xF6, $BIP_7$ | 14 | 0x83, 0xC7, 0xCA, $BIP_3$, 0x7C, 0x38, 0x35, $BIP_7$ |
| 5 | 0xDD, 0x14, 0xC2, $BIP_3$, 0x22, 0xEB, 0x3D, $BIP_7$ | 15 | 0x35, 0x36, 0xCD, $BIP_3$, 0xCA, 0xC9, 0x32, $BIP_7$ |
| 6 | 0x9A, 0x4A, 0x26, $BIP_3$, 0x65, 0xB5, 0xD9, $BIP_7$ | 16 | 0xC4, 0x31, 0x4C, $BIP_3$, 0x3B, 0xCE, 0xB3, $BIP_7$ |
| 7 | 0x7B, 0x45, 0x66, $BIP_3$, 0x84, 0xBA, 0x99, $BIP_7$ | 17 | 0xAD, 0xD6, 0x87, $BIP_3$, 0x52, 0x29, 0x48, $BIP_7$ |
| 8 | 0xA0, 0x24, 0x76, $BIP_3$, 0x5F, 0xDB, 0x89, $BIP_7$ | 18 | 0x5F, 0x66, 0x2A, $BIP_3$, 0xA0, 0x99, 0xD5, $BIP_7$ |
| 9 | 0x68, 0xC9, 0xFB, $BIP_3$, 0x97, 0x36, 0x04, $BIP_7$ | 19 | 0xC0, 0xF0, 0xE5, $BIP_3$, 0x3F, 0x0F, 0x1A, $BIP_7$ |

PCS Block Distribution


Skew Tolerance

| Skew Point | Maximum Skew | Maximum Skew Variation (10.3 GBd) |
|---|---|---|
| SP1 | 29 ns (~150 UI) | 0.2 ns (~2 UI) |
| SP2 | 43 ns (~222 UI) | 0.4 ns (~2 UI) |
| SP3 | 54 ns (~278 UI) | 0.6 ns (~4 UI) |
| SP4 | 134 ns (~691 UI) | 3.4 ns (~35 UI) |
| SP5 | 145 ns (~748 UI) | 3.6 ns (~37 UI) |
| SP6 | 160 ns (~824 UI) | 3.8 ns (~39 UI) |
| At PCS Rx | 180 ns (~928 UI) | 4 ns (~41 bits) |

SP Points shown in Multilane Model

### Optical

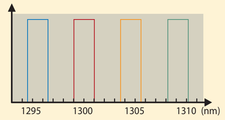
Average Optical Power

| Parameter | 100GBase-SR10 | 100GBase-LR4 | 100GBase-ER4 |
|---|---|---|---|
| Max Launch Power/lane | 2.4 dBm | 4.5 dBm | 2.9 dBm |
| Min Launch Power/lane | –8 dBm | –4.3 dBm | –2.9 dBm |
| Max Avg Rx Power/lane | 2.4 dBm | 4.5 dBm | 4.5 dBm |
| Min Avg Rx Power/lane | –9.9 dBm | –10.6 dBm | –20.9 dBm |

100GBase-LR4 and ER4 LWDM Lane Assignments

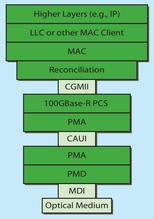
| Lane | Center λ | λ Range |
|---|---|---|
| $L_0$ | 1295.56 nm | 1294.53 to 1296.59 nm |
| $L_1$ | 1300.05 nm | 1299.02 to 1301.09 nm |
| $L_2$ | 1304.58 nm | 1303.54 to 1305.63 nm |
| $L_3$ | 1309.14 nm | 1308.09 to 1310.19 nm |

LWDM Wavelength Range

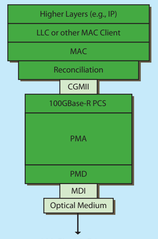



## Signal Structure

IEEE Model with CAUI (to interconnect chip devices)

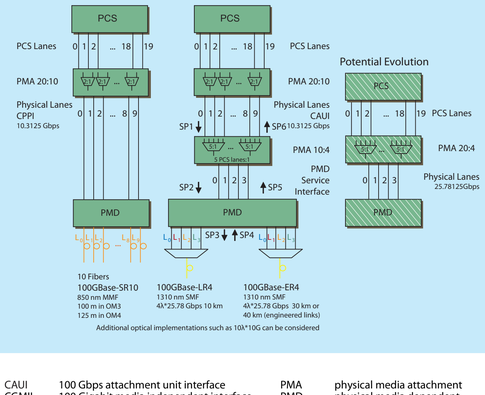



IEEE Layer Model




100 Gigabit Ethernet 103.125 Gbps ± 100 ppm

Multilane Model

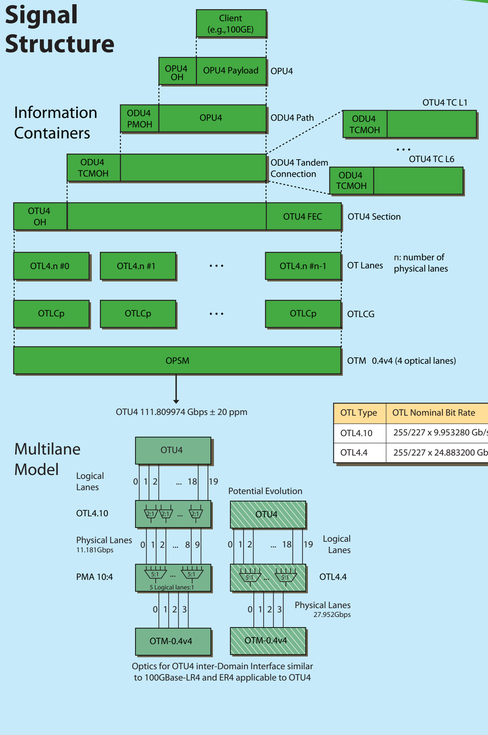



Additional optical implementations such as 10λ*10G can be considered

| | | | |
|---|---|---|---|
| CAUI | 100 Gbps attachment unit interface | PMA | physical media attachment |
| CGMII | 100 Gigabit media independent interface | PMD | physical media dependent |
| CFI | canonical format indicator | RS | reconciliation sublayer |
| CPPI | 100 Gbps parallel physical interface | SFD | start frame delimiter |
| FCS | frame check sequence | SP | skew point |
| LLC | logical link control | VLAN | virtual local area network |
| LWDM | LAN wave division multiplexing | | |
| MAC | media access control | | |
| MDI | media dependent interface | | |
| PCS | physical coding sublayer | | |

## OTU4

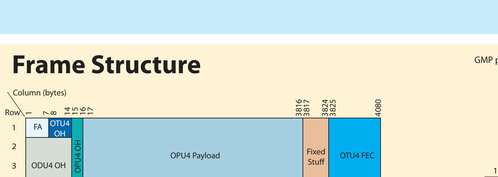
### Signal Structure




OTU4 111.809974 Gbps ± 20 ppm

| OTL Type | OTL Nominal Bit Rate |
|---|---|
| OTL4.10 | 255/227 x 9.953280 Gb/s = 11.180997 Gbps |
| OTL4.4 | 255/227 x 24.883200 Gb/s = 27.952493 Gbps |

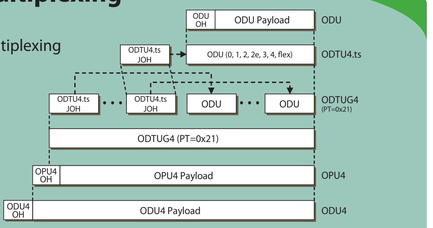
Multilane Model



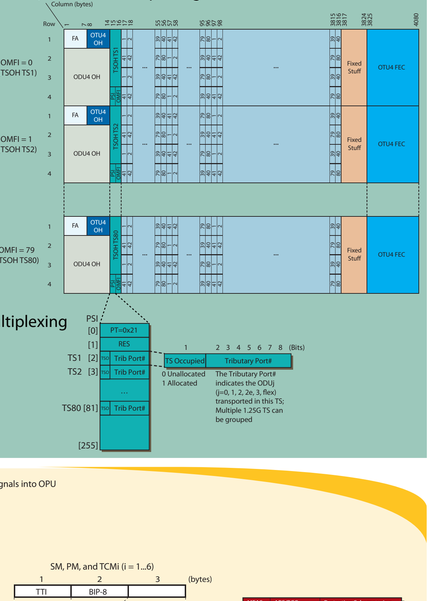

Optics for OTU4 inter-Domain Interface similar to 100GBase-LR4 and ER4 applicable to OTU4

### ODU Multiplexing

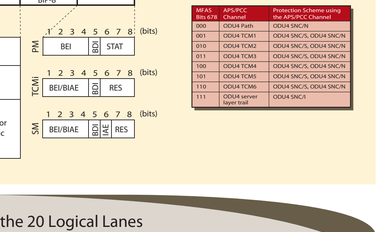
ODU4 Multiplexing




Tributary Slots (1.25G) for Multiplexing

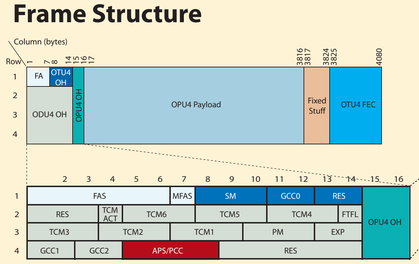



PSI for Multiplexing



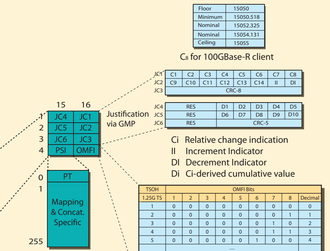

### Frame Structure

GMP provides a generic mapping method for the justification of CBR client signals into OPU




$C_R$ for 100GBase-R client

| Floor | 15050 |
|---|---|
| Minimum | 15050.518 |
| Nominal | 15052.325 |
| Nominal | 15054.131 |
| Ceiling | 15055 |







| MFAS Bits 678 | APS/PCC Channel | Protection Scheme using the APS/PCC Channel |
|---|---|---|
| 000 | ODU4 Path | ODU4 SNC/N |
| 001 | ODU4 TCM1 | ODU4 SNC/S, ODU4 SNC/N |
| 010 | ODU4 TCM2 | ODU4 SNC/S, ODU4 SNC/N |
| 011 | ODU4 TCM3 | ODU4 SNC/S, ODU4 SNC/N |
| 100 | ODU4 TCM4 | ODU4 SNC/S, ODU4 SNC/N |
| 101 | ODU4 TCM5 | ODU4 SNC/S, ODU4 SNC/N |
| 110 | ODU4 TCM6 | ODU4 SNC/S, ODU4 SNC/N |
| 111 | ODU4 server layer trail | ODU4 SNC/I |

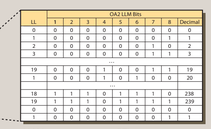
### Logical Lanes

Logical Lane Markers

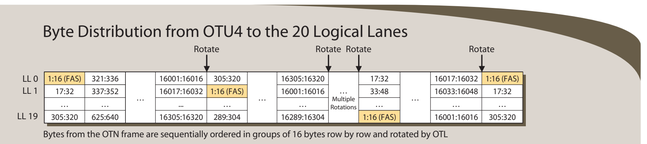
Used for logical lane identification and skew

**FAS Byte Values**

| OA1 | OA1 | OA1 | OA2 | OA2 | OA2 | ... |
|---|---|---|---|---|---|---|
| F6 | F6 | F6 | 28 | 28 | LLM | |




Byte Distribution from OTU4 to the 20 Logical Lanes




| | | | | | |
|---|---|---|---|---|---|
| APS | automatic protection switching | GCC | General Communication Channel | OH | overhead |
| BDI | backward defect indication | GMP | generic mapping procedure | OMFI | OPU multi-frame identifier |
| BEI | backward error indication | IAE | incoming alignment error | OPSM | optical physical section multilane |
| BIAE | backward incoming alignment error | JC | justification control | OPU | optical channel payload unit |
| BIP-8 | bit interleaved parity-8 | JOH | justification overhead | OTL | optical channel transport lane |
| DAPI | destination access point identifier | LLM | logical lane marker | OTLCG | optical transport lane carrier group |
| EXP | experimental | MFAS | multi-frame alignment signal | OTN | optical transport network |
| FAS | frame alignment signal | ODTU | optical channel data tributary unit | OTU | optical channel transport unit |
| FEC | forward error correction | ODTUG | optical channel data tributary unit group | PCC | protection communication channel |
| FTFL | fault type and fault location | ODU | optical channel data unit | PM | path monitoring |
| PMA | physical media attachment | SNC/S | SNC protection with sublayer monitoring |
| PMOH | performance monitoring overhead | STAT | status |
| PSI | payload structure identifier | TC | tandem connection |
| PT | payload type | TCM | tandem connection monitoring |
| RES | reserved | TCM ACT | TCM activation |
| SAPI | source access point identifier | TCMOH | tandem connection monitoring overhead |
| SM | section monitoring | TS | tributary slot |
| SNC | subnetwork connection | TTI | trail trace identifier |
| SNC/I | SNC protection with inherent monitoring | | |
| SNC/N | SNC protection with non-intrusive monitoring | | |

## To learn more, www.jdsu.com/test

References:

| | |
|---|---|
| 100GE | IEEE 802.3ba, and 802.1Q |
| OTU4 | ITU-T G.709, G.872, G.695, and G.959.1 |
| Line I/F | OIF IA# OIF-SFI-S and IA# OIF2008.388.00 |