

# Telecom Engineering Inc.

Pluggable Transceiver Standards and Naming Conventions

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SONET & SDH Transceivers (155 Mbps to 10 Gbps)											
Name	Max Reach		Max Budget	Max CD	Modulation	Wavelength	Fiber type	Number of Fibers	Connector Type	Comments	Standard
	km	miles	dB	ps/nm							
SR	10	6	7.0		NRZ	1310	SMF	2		Short Reach	SONET GR-253-Core
IR-1	20	12	12.0		NRZ	1310	SMF	2		Intermediate Reach	SONET GR-253-Core
IR-2	40	25	12.0		NRZ	1550	SMF	2		Intermediate Reach	SONET GR-253-Core
LR-1	40	25	24.0		NRZ	1310	SMF	2		Long Reach	SONET GR-253-Core
LR-2	80	50	24.0	1400	NRZ	1550, 1xxx.xx	SMF	2		Long Reach	SONET GR-253-Core
ELR	> 80 km	> 50	> 24		NRZ	1550, 1xxx.xx	SMF	2		Extended Long Reach	Industry
I-x	2	1	7.0		NRZ	1310	SMF	2		Intra-office	SDH ITU 957
S-x.1	15	9	12.0		NRZ	1310	SMF	2		Short Reach	SDH ITU 957
S-x.2	15	9	12.0		NRZ	1510	SMF	2		Short Reach	SDH ITU 957
L-x.1	40	25	24.0		NRZ	1310	SMF	2		Long Reach	SDH ITU 957
L-x.2	80	50	24 (22 for 10G)	1600	NRZ	1550, 1xxx.xx	SMF	2		Long Reach	SDH ITU 957/959.1
VSR4-4, 10G only	300m	984 ft			NRZ	850	MMF OM3/4	2			
VLR, 10G only	120	75	33.0	2400	NRZ	1550, 1xxx.xx	SMF	2		Very Long Reach	SDH ITU G.959.1
L, 40G only	80	50	22.0	1600	NRZ	1550, 1xxx.xx	SMF	2		Long Reach	SDH ITU G.959.1

10/100 Mbps Ethernet Transceivers													
Name	Reach		Budget	CD	BAUD	Modulation	Wavelength	Fiber type	Modal Bandwidth	Number of Fibers	Connector Type	Comments	Standard
	km	miles	dB	ps/nm	Mbps								
10/100BaseT	100 m	328 ft					electrical, 23 or 24 AWG				RJ45	UDP or STP	IEEE 802.3
10Base-FL	2	1.2	12.5		10	NRZ	850	cat5, cat6, cat7		2		shielded copper	IEEE 802.3
100Base-FX	2	1	11.0		100	NRZ	1300	62.5 um OM1		2			IEEE 802.3u
100Base-SX	300 m	980 ft	4.0		100	NRZ	850	50 um OM2		2			TIA/EIA-785
100Base-BX10	10	6			100	NRZ	1310/1550	62.5 um or 50 um OM1/2		1		Bidirectional single fiber	IEEE 802.3ah
100Base-LX10	10	6			100	NRZ	1310	SMF		2			IEEE 802.3ah

Gigabit Ethernet, Transceivers SFP, GBIC													
Name	Reach		Budget	CD	BAUD	Modulation	Wavelength	Fiber type	Modal Bandwidth	Number of Fibers	Connector Type	Comments	Standard
	km	miles	dB	ps/nm	Gbps								
1000Base-T	100 m	328 ft			1.25		electrical, 23 or 24 AWG				RJ45	UDP or STP	IEEE 802.3ab
1000Base-CX	25 m	82 ft			1.25		electrical	cat5e, cat6, cat7				shielded copper	IEEE 802.3z
1000Base-SX	800 m	0.5	4.5		1.25	NRZ	850	CX copper cable	2000	2	LC	Short Reach	IEEE 802.3z
1000Base-SX	550 m	1800 ft	3.6		1.25	NRZ	850	OM3, OM4	500	2	LC	Short Reach	IEEE 802.3z
1000Base-SX	220 m	722 ft	3.6		1.25	NRZ	850	OM2	160	2	LC	Short Reach	IEEE 802.3z
1000Base-SX	275 m	900 ft	3.6		1.25	NRZ	850	OM1	200	2	LC	Short Reach	IEEE 802.3z
1000Base-LX	5	3			1.25	NRZ	1310	OM1		2	LC	Long Reach	IEEE 802.3z
1000Base-LX10 or LH	10	6	8.0		1.25	NRZ	1310	SMF		2	LC	Long Reach	IEEE 802.3z
1000Base-LX <sup>4</sup>	550 m <sup>4</sup>	1800 ft			1.25	NRZ	1310	OM1 & OM2	500	2	LC	Long Reach	IEEE 802.3z
1000Base-EX	40	25			1.25	NRZ	1550, 1xxx.xx	SMF		2	LC	Extended Reach	IEEE 802.3z
1000Base-ZX	80	50	23.0		1.25	NRZ	1550, 1xxx.xx	SMF		2	LC	Industry	Industry
1000Base-EZX	120	75	32.0		1.25	NRZ	1550, 1xxx.xx	SMF		2	LC	Industry	Industry
1000Base-BX10	10	6			1.25	NRZ	1310/1490 or 1310/1550 or 1490/1550	SMF		1	LC	Bidirectional Single fiber	IEEE 802.3ah

10 GigE Transceivers XFP, SFP+, Xenpak													
Name	Reach		Budget	CD	BAUD	Modulation	Wavelength	Fiber type	Modal Bandwidth	Number of Fibers	Connector Type	Comments	Standard
	km	miles	dB	ps/nm	Gbps								
10GBaseT	100 m	328 ft			10		electrical, 23 or 24 AWG	cat6 STP, cat6a UTP/STP, cat7 UTP/STP			RJ45	UTP / STP, min 500Mhz cable	
10GBaseT	55 m	180 ft			10		electrical, 23 or 24 AWG	cat6 UTP copper			RJ45	UTP, min 500Mhz cable	
10GBase-CX	15 m	50 ft			10.31		electrical	OM4		2	LC	Short Reach	IEEE 802.3ae
10GBase-SR	450 m	1476 ft	3.1		10.31	NRZ	850	OM3	2000	2	LC	Short Reach	IEEE 802.3ae
10GBase-SR	300 m	984 ft	7.3		10.31	NRZ	850	OM2	500	2	LC	Short Reach	IEEE 802.3ae
10GBase-SR	82 m	25 ft	7.3		10.31	NRZ	850	OM1	160	2	LC	Short Reach	IEEE 802.3ae
10GBase-SR	26 m	85 ft	7.3		10.31	NRZ	850	OM1	200	2	LC	Short Reach	IEEE 802.3ae
10GBase-SR	33 m	108 ft	7.3		10.31	NRZ	850	SMF		2	LC	Long Reach	IEEE 802.3ae
10GBase-LR	10	6	9.0		10.31	NRZ	1310	SMF		2	LC	Long Reach	IEEE 802.3ae
10GBase-LX4	10	6	8.2		3.13	NRZ	1275, 1300, 1325, 1350, WDM	SMF		2	LC	Long Reach	IEEE 802.3ae
10GBase-LX4 <sup>4</sup>	300 m	984 ft	7.5		3.13	NRZ	1275, 1300, 1325, 1350, WDM	OM1 OM2 OM3 OM4		2	LC	Long Reach	IEEE 802.3ae
10GBase-LXM <sup>4</sup>	220 m	722 ft			10.31	NRZ	1300, Rx has EDC	OM1 OM2 OM3 OM4		2	LC	Long Reach	IEEE 802.3ae
10GBase-ER	40	25	11.0		10.31	NRZ	1550, 1xxx.xx	SMF		2	LC	Extended Reach	IEEE 802.3ae
10GBase-ZR	80	50	24.0	1600	10.31	NRZ	1550, 1xxx.xx	SMF		2	LC	Industry	Industry

40 GigE Transceivers													
Name	Reach		Budget	CD	BAUD	Modulation	Wavelength	Fiber type	EMB MHzKm	Number of Fibers	Modal/ Connector	Comments	Standard
	km	miles	dB	ps/nm	Gbps								
40GBase-CR4	7 m	23 ft			10.31		electrical, 4 twinax pairs	copper		8 coax			IEEE 802.3ba
40GBase-SR4	30m (OM2), 100m (OM3), 150m (OM4)	328ft, 490ft	1.9 (OM3), 1.5 (OM4)		10.31	NRZ	850	OM2, OM3, OM4	500, 2000, 4700	8	QSFP+ MTP/MPO	Short Reach	IEEE 802.3ba
40GBase-LR4	10	6	6.7	33.5/-59	10.31	NRZ	1271, 1291, 1311, 1331, CWDM	SMF		2	QSFP+ LC	DGD max 10ps	IEEE 802.3ba
40GBase-FR	2	1	4.0	38	41.25	NRZ	1550	SMF		2	LC	DGD max 3ps	IEEE 802.3bg
Long reach	> 10	> 6			varies	varies	1550, DWDM	SMF		2	LC	mod. DP-QPSK and other	no standard

100 GigE Transceivers													
Name	Reach		Budget	CD	BAUD	Modulation	Wavelength	Fiber type	EMB MHzKm	Number of Fibers	Modal/ Connector	Comments	Standard
	km	miles	dB	ps/nm	Gbps								
100GBase-CR10	7 m	23 ft			10x11.2	NRZ	electrical, 10 twinax pairs	copper		20 coax			IEEE 802.3ba
100GBase-CR4	5 m	16 ft			4x25	NRZ	electrical, 4 twinax pairs	copper		8 coax	QSFP2	not ratified	Future IEEE, 2013
100GBase-KR4	1 m	3 ft			4x24	NRZ	Backplane	copper				not ratified	Future IEEE, 2013
100GBase-SR4	100 m	33 ft			4x25	NRZ	?	OM3			QSFP2/MPO	not ratified	Future IEEE, 2013
100GBase-SR10	100m (OM3), 150m (OM4)	328ft, 490ft	1.9 (OM3), 1.5 (OM4)		10x11.2	NRZ	850	OM3, OM4	2000, 4700	20	CXP/MTP	Short Reach	IEEE 802.3ba
100GBase-FR10	2	1.2			10x10	NRZ	?	SMF			CFP/LC	not ratified	Future IEEE, 2011
100GBase-FR4	2	1.2			4x25	NRZ	?	SMF			CFP2/LC	not ratified	Future IEEE, 2013
100GBase-LR4	10	6	6.3	9.5/-28	4x28.78125	NRZ	1295, 1300, 1305, 1310, 800GHz WDM	SMF		2	CFP/LC	DGD max 8ps	IEEE 802.3ba
100GBase-ER4	40	25	18.0	36/-114	4x28.78125	NRZ	1295, 1300, 1305, 1310, 800GHz WDM	SMF		2	CFP/LC	DGD max 10.3ps	IEEE 802.3ba
Long reach	> 40	> 25			varies	varies	1550, DWDM	SMF		2	LC	mod. DP-QPSK and other	no standard

400 GigE and 1000 GigE Transceivers													
Name	Reach		Budget	CD	BAUD	Modulation	Wavelength	Fiber type	EMB MHzKm	Number of Fibers	Modal/ Connector	Comments	Standard
	km	miles	dB	ps/nm	Gbps								
Future						unkno							Future

IEEE Naming Nomenclature (100GBase-LR4)			
Speed	Medium		Line C <sub>t</sub> Lanes
	Copper	Fiber	
10G=10Gbps	C=Twinax	F=Short 100m	R=scrarr n=number of lanes or wavelengths
40G=40Gbps	K=Backplane	F=2km	64/66B if n=1, it is not shown
100G=100Gbps	T=Twisted pair	L=Long 10km	X=8B/10B Coding
		E=Extended 40km	
		Z=Extended 80km	

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### ISO/IEC11801/24702 Fiber Cable Types

Cable Type	Fiber Core size	Maximum Att	Min Modal
		dB/km	Bandwidth
OM1 (legacy)	62.5	3.5 @ 850 nm	200 @ 850 nm
		1.5 @ 1300 nm	500 @ 1300 nm
OM2	50	3.5 @ 850 nm	1500 @ 850 nm
		1.5 @ 1300 nm	500 @ 1300 nm
OM3	50	3.5 @ 850 nm	2000 @ 850 nm
		1.5 @ 1300 nm	500 @ 1300 nm
OM4	50	3.5 @ 850 nm	3500 @ 850 nm
		1.5 @ 1300 nm	4700 @ 850 nm
OS1	10	1 @ 1310 nm	
		1 @ 1550 nm	
OS2	10	0.4 @ 1310 nm	
		0.4 @ 1383 nm	
		0.4 @ 1550 nm	

Note, LED transceiver can be used for all MM fiber types

Single Mode Fiber Type	ITU Spec	IEC Spec	IEC Type	Typical Application
Standard Single Mode Fiber SSMF	G.652 A/B	OS1	B1.1	All
Low Water Peak SSMF	G.652 C/D	OS2	B1.3	All and CWDM
Dispersion Shifted Fiber DSF	G.653 A/B		B2	none
Cutoff Shifted Fiber CSF	G.654		B1.2	long haul
NonZero Dispersion Shifted Fiber NZDSF	G.655 C/D		B4	long haul
Wide Band NZDSF (1460-1625nm)	G.656		B5	Long Haul DWDM in LBand
Bend Insensitive Fiber G.652d complianc	G.657.A1		Min Bend Rad 10mm	FTTH long reach
Bend Insensitive Fiber G.652d complianc	G.657.A2		Min Bend Rad 7.5mm	FTTH long reach
Bend Insensitive Fiber	G.657.B2		Min Bend Rad 7.5mm	FTTH short < 1Km
Bend Insensitive Fiber	G.657.B3		Min Bend Rad 5mm	FTTH short < 1Km

### Notes

**Reach** using standard single mode fiber. G.652, with attenuation less than 0.275 dB/km @ 1550 nm, 0.4 dB/km @ 1310 nm and no other losses  
**#** Mode conditioning patch cord (MCP) required to launch optical power into OM1 and OM2 fiber for 1300nm lasers. OM3 and OM4 fiber type do not require MCP.  
**DDM** digital diagnostics monitoring  
**DOM** digital optical monitoring  
**MMF** multimode fiber  
**SMF** standard single mode fiber, G.652  
**1xxx.xx** DWDM or CWDM wavelength  
**n.a.** not available  
**budget** optical budget, penalties if applicable not included  
**CD** CD limit shown for 1550nm for Cband and 1310nm for Oband  
**DGD** Differential group delay limit  
**FP** Fabry-Perot laser  
**VCSEL** Vertical cavity surface emitting laser  
**BAUD** The actual optical fiber signal transmission rate  
**MPO** Multi-fiber Push On connector  
**MTP** Corning brand type MPO connector  
**EML** Externally modulated laser  
**DFB** Distributed feedback laser  
**LED** Light emitting diode  
**EDC** Electronic dispersion compensation  
**OM1,2,3,4** multimode fiber, fiber type Optical Mode designation

### Fiber Connector and Adapter Colors

Aqua - 850 nm laser optimized 50/125 um fiber, OM3 or OM4  
 Black - 50/125 um fiber  
 Beige - 62.5/125 um fiber  
 Blue - single-mode fiber  
 Green - single-mode angled (APC)

### ITU-T G.709 OTN Refresher

OTU	ODU	Rate	Signal Rate OTU	Payload Rate OPU	Client Payload
	0	1.25G	NA	1.23Gbps	1GigE LAN
OTU1	1	2.5G	2.666Gbps	2.488Gbps	OC-48/STM-16
OTU1e	1e	10G	11.049Gbps	10.312Gbps	10GigE LAN
OTU1f	1f	10G	11.270Gbps	10.518Gbps	10G Fibre Channel
OTU2	2	10G	10.709Gbps	9.953Gbps	OC-192/STM-64
OTU2e	2e	10G	11.095Gbps	10.312Gbps	10GigE LAN
OTU2f	2f	10G	11.317Gbps	10.518Gbps	10G Fibre Channel
OTU3	3	40G	43.018Gbps	39.813Gbps	OC-768/STM-256
OTU3e1	3e1	40G	44.570Gbps	4x10.312Gbps	4xODU2e
OTU3e2	3e2	40G	44.583Gbps	16x2.488Gbps	4xODU2e
OTU4	4	100G	111.809Gbps	104.794Gbps	100GigE

### OTL(OTU)n

where n is the number of lanes that are used to multiplex up to the OTU level

### Example OTL4.4

100GE system with 4 lanes or wavelengths (assuming 2 fibers) at 24.883Gbps

### Example OTL4.10

100GE system with 10 lanes or wavelengths (assuming 2 fibers) at 9.953Gbps

### Pluggable Transceivers Pictures

#### 10G Module Evaluation

1st Generation 2002 300 pin MSA  
 2nd Generation 2003/4 Xenpak, X2  
 3rd Generation 2006 XFP  
 3rd Generation 2009 SFP+

#### 100G Module Evaluation

1st Generation 2010 CFP, CXP  
 2nd Generation 2011 QSFP  
 2nd Generation 2013 CFP2  
 2nd Generation 2013 CFP4

Standard Name	Standard	PerLane Rate
SFP	MSA	1G
SFP+	SFF-8083	10G
XFP	MSA	10G
QSFP	MSA	4G
QSFP+	SFF-8436	10G
CXP	FF-8642/EIA-96	10G
HD	SFF-8644	6G
CFP		
CFP2		



Finisar SFP and SFP+ Module  
 Rates 100M to 2.7G for SFP, and 10G for SFP+ fiber connector dual LC



Finisar XFP Module  
 rate 10G fiber connector dual LC



Optone X2 Module  
 rate 10GigE fiber connector dual SC



Finisar GBIC Module  
 rate 1 GigE fiber connector dual SC



QSFP  
 rate 40G



Finisar CFP (future smaller version CFP2 and SFP4)  
 rate 40G or 100G fiber connector dual LC



Xenpak Module  
 rate 10GigE fiber connector dual SC



CXP module  
 rate 40G or 100G 12Tx and 12 Rx fibers

These informatin is provided as is with no warranty on accuracy, please refer to actual standards or manufacturer specifications for true values.