

SONET & SDH Transceivers (155 Mbps to 10 Gbps)

Name	Max Reach km miles	Max Budget dB	Max CD ps/nm	Source	Modulation	Wavelength nm	Fiber type	Number of Fibers	Connector Type	Comments	Standard
SR	10	6	7	Laser	NRZ	1310	SMF	2		Short Reach	SONET GR-253-Core
IR-1	20	12	12	DFB	NRZ	1310	SMF	2		Intermediate Reach	SONET GR-253-Core
IR-2	40	25	12	DFB	NRZ	1550	SMF	2		Intermediate Reach	SONET GR-253-Core
LR-1	40	25	24	DFB	NRZ	1310	SMF	2		Long Reach	SONET GR-253-Core
LR-2	80	50	24	EML	NRZ	1550, 1xxx.xx	SMF	2		Long Reach	SONET GR-253-Core
ELR	> 80 km	> 50	> 24	EML	NRZ	1550, 1xxx.xx	SMF	2		Extended Long Reach	Industry
I-x	2	1	7	Laser	NRZ	1310	SMF	2		Intra-office	SDH ITU 957
S-x.1	15	9	12	Laser	NRZ	1310	SMF	2		Short Reach	SDH ITU 957
S-x.2	15	9	12	Laser	NRZ	1510	SMF	2		Short Reach	SDH ITU 957
L-x.1	40	25	24	DFB	NRZ	1310	SMF	2		Long Reach	SDH ITU 957
L-x.2	80	50	24 (22 for 10G)	EML	NRZ	1550, 1xxx.xx	SMF	2		Long Reach	SDH ITU 957/959.1
VSR4-4, 10G only	300m	984 ft		VCSEL	NRZ	850	MMF OM3/4	2			
VLR, 10G only	120	75	33	Laser	NRZ	1550, 1xxx.xx	SMF	2		Very Long Reach	SDH ITU G.959.1
L, 40G only	80	50	22	EML	NRZ	1550, 1xxx.xx	SMF	2		Long Reach	SDH ITU G.959.1

10/100 Mbps Ethernet Transceivers

Name	Reach km miles	Budget dB	CD ps/nm	Source	BAUD Mbps	Modulation	Wavelength nm	Fiber type	Modal Bandwidth	Number of Fibers	Connector Type	Comments	Standard
10Base-FL	2	1.2	12.5	LED	10	NRZ	850	62.5 um OM1		2			IEEE 802.3
100Base-FX	2	1	11	LED	100	NRZ	1300	50 um OM2		2			IEEE 802.3
100Base-SX	300 m	980 ft	4	LED	100	NRZ	850	62.5 um or 50 um OM1/2		2			TIA/EIA-785

Gigabit Ethernet, Transceivers SFP, GBIC

Name	Reach km miles	Budget dB	CD ps/nm	Source typical	BAUD Gbps	Modulation	Wavelength nm	Fiber type	Modal Bandwidth	Number of Fibers	Connector Type	Comments	Standard
1000Base-T	100 m	328 ft			1.25	NRZ	electrical	cat5e, cat6, cat7				UTP	IEEE 802.3ab
1000Base-CX	25 m	82 ft			1.25	NRZ	electrical	CX copper cable				shielded copper	IEEE 802.3z
1000Base-SX	1	0.6	3.6	VCSEL	1.25	NRZ	850	OM3, OM4	2000	2	LC	Short Reach	IEEE 802.3z
1000Base-SX	550 m	1800 ft	3.6	VCSEL	1.25	NRZ	850	OM2	500	2	LC	Short Reach	IEEE 802.3z
1000Base-SX	220 m	722 ft	3.6	VCSEL	1.25	NRZ	850	OM1	160	2	LC	Short Reach	IEEE 802.3z
1000Base-SX	275 m	900 ft	3.6	VCSEL	1.25	NRZ	850	OM1	200	2	LC	Short Reach	IEEE 802.3z
1000Base-LX	10	6	8	FP	1.25	NRZ	1310	SMF		2	LC	Long Reach	IEEE 802.3z
1000Base-LX [®]	550 m [®]	1800 ft		FP	1.25	NRZ	1310	OM1 & OM2	500	2	LC	Long Reach	IEEE 802.3z
1000Base-EX	40	25		DFB	1.25	NRZ	1550, 1xxx.xx	SMF		2	LC	Extended Reach	Industry
1000Base-ZX	80	50	23	EML	1.25	NRZ	1550, 1xxx.xx	SMF		2	LC		Industry

10 GigE Transceivers XFP, SFP+, Xenpak

Name	Reach km miles	Budget dB	CD ps/nm	Source typical	BAUD Gbps	Modulation	Wavelength nm	Fiber type	EMB MHzKnm	Number of Fibers	Connector Type	Comments	Standard
10GBase-CX	15 m	50 ft			10.31	NRZ	electrical	copper					IEEE 802.3ae
10GBase-SR/SX	550 m	1800 ft		VCSEL	10.31	NRZ	850	OM4		2	LC	Short Reach	IEEE 802.3ae
10GBase-SR/SX	300 m	984 ft	2.6	VCSEL	10.31	NRZ	850	OM3	2000	2	LC	Short Reach	IEEE 802.3ae
10GBase-SR/SX	82 m	25 ft	2.6	VCSEL	10.31	NRZ	850	OM2	500	2	LC	Short Reach	IEEE 802.3ae
10GBase-SR/SX	26 m	85 ft	2.6	VCSEL	10.31	NRZ	850	OM1	160	2	LC	Short Reach	IEEE 802.3ae
10GBase-SR/SX	33 m	108 ft	2.6	VCSEL	10.31	NRZ	850	OM1	200	2	LC	Short Reach	IEEE 802.3ae
10GBase-LR/LX	10	6	9	FP	10.31	NRZ	1310	SMF		2	LC	Long Reach	IEEE 802.3ae
10GBase-LX4 [®]	300 m	984 ft		FP/DFB	10.31	NRZ	1275, 1300, 1325, 1350, WDM	OM1 OM2 OM3 OM4		2	LC	Long Reach	IEEE 802.3ae
10GBase-LXM [®]	220 m	722 ft		FP/DFB	10.31	NRZ	1300, Rx has EDC	OM1 OM2 OM3 OM4		2	LC	Long Reach	IEEE 802.3ae
10GBase-ER/EX	30	19	11	DFB	10.31	NRZ	1550, 1xxx.xx	SMF		2	LC	Extended Reach	IEEE 802.3ae
10GBase-ZR/ZX	80	50	24	EML	10.31	NRZ	1550, 1xxx.xx	SMF		2	LC		Industry

40 GigE Transceivers

Name	Reach km miles	Budget dB	CD ps/nm	Source typical	BAUD Gbps	Modulation	Wavelength nm	Fiber type	EMB MHzKnm	Number of Fibers	Modal/ Connector	Comments	Standard
40GBase-CR4	7 m	23 ft			10.31	NRZ	electrical, 4 twinax pairs	copper					IEEE 802.3ba
40GBase-SR4	100m (OM3), 150m (OM4)	328ft, 490ft	1.9 (OM3), 1.5 (OM4)	VCSEL	10.31	NRZ	850	OM3, OM4	2000 4700	8	QSFP/CX4 12 fiber MTP/MPO	Short Reach	IEEE 802.3ba
40GBase-LR4	10	6	6.7	Laser	10.31	NRZ	1271, 1291, 1311, 1331, CWDM	SMF		2		DGD max 10ps	IEEE 802.3ba
40GBase-FR4	2	1	4	Laser	41.25	NRZ	1550	SMF		2		DGD max 3ps	IEEE 802.3bg
Long reach	> 10	> 6		Laser	varies	varies	1550, DWDM	SMF		2	LC	mod. DP-QPSK and other	no standard

100 GigE Transceivers

Name	Reach km miles	Budget dB	CD ps/nm	Source typical	BAUD Gbps	Modulation	Wavelength nm	Fiber type	EMB MHzKnm	Number of Fibers	Modal/ Connector	Comments	Standard
100GBase-CR10	7 m	23 ft			10x11.2	NRZ	electrical, 10 twinax pairs	copper		20 coax	CXP		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
100Base-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)	VCSEL	10x11.2	NRZ	850	OM3, OM4	2000 4700	20	24 fiber MTP/MPO	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		2	CFP/LC	not ratified	Future IEEE, 2013
100GBase-LR4	10	6	6.3	Laser	4x28.78125	NRZ	1295, 1300, 1305, 1310, 800GHz WDM	SMF		2	CFP/LC	DGD max 8ps	ITU G.694.1
100GBase-ER4	40	25	18	Laser	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 Gig and 1000 Gig Transceivers

Name	Reach km miles	Budget dB	CD ps/nm	Source typical	BAUD Gbps	Modulation	Wavelength nm	Fiber type	EMB MHzKnm	Number of Fibers	Modal/ Connector	Comments	Standard
Future						unkno							future

IEEE Naming Nomenclature

Speed	Medium	Coding	Lanes
10G=10Gbps 40G=40Gbps 100G=100Gbps	K=Backplane C=Copper	R=scrambled 64/66B	n=number of lanes or wavelengths if n=1, it is not shown

ISO/IEC11801/11803/EIATIA492AAA/ABCD Multimode Fiber Types

MM Fiber Type	Fiber Core size	Maximum Att	Min Modal
	um	dB/km	Bandwidth
OM1 (legacy)	62.5	3.5 @ 850 nm	200 @ 850 nm 160 @ 850 nm
		1.5 @ 1300 nm	500 @ 1300 nm
OM2	50	3.5 @ 850 nm	500 @ 850 nm
		1.5 @ 1300 nm	500 @ 1300 nm
OM3	50	3.5 @ 850 nm	1500 @ 850 nm
		1.5 @ 1300 nm	2000 @ 850 nm 500 @ 1300 nm
OM4	50	3.5 @ 850 nm	3500 @ 850 nm
		1.5 @ 1300 nm	4700 @ 850 nm 500 @ 1300 nm

Note, LED can be used for all MM fiber types

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 fiber
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 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)

Telecom Engineering contact toll free 1.888.250.1562 or 1.807.683.1770 or email info@TelecomEngineering.com

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These values are for general information only, please refer to actual standards or manufacturer specifications for true values.

Pluggable Transceivers

NOT to SCALE

10G Module Evolution

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



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

100G Module Evolution

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



Finisar XFP Module
rate 10G
fiber connector dual LC



Finisar GBIC Module
rate 1 GigE
fiber connector dual SC



Finisar CFP
rate 40G or 100G
fiber connector dual LC



Xenpak Module
rate 10GigE
fiber connector dual SC



QSFP with fiber cable
rate 40G or 100G
fiber connector MPO



Optone X2 Module
rate 10GigE
fiber connector dual SC



CXP module
rate 40G or 100G
fiber connector MPO