

Optical Fiber

Identification, Testing and Results Analysis













TIA/EIA-568/598 Standards

Aonica Ltd

Fiber Optic Cable Colour Codes

TIA/EIA-598 Optical Fibre Colour Coding

The fiber optic cable colour code is based on the 10 colours that are used for plastic insulated conductor copper cables. Two more colours (Rose and Aqua) have been added to bring the optical fiber colour code to 12. *The following fiber colour code is for 12 fiber strands.*

Fiber Number	Colour Code	Colour
1	blue	
2	orange	
3	green	
4	brown	
5	slate	
6	white	
7	red	
8	black	
9	yellow	
10	violet	
11	rose	
12	aqua	

For cables that consist of more than 12 strands, the colour code repeats itself. Each group of 12 strands is identified with some other means such as:

- Multiple buffer tubes each with 12 or less strands either numbered or coloured following the same colour code, e.g., 1st tube is blue, 2nd is orange, etc.
- 24 strand groups with the colour code repeating with some variation, e.g., the 1st group of 12 strands are solid colours and the 2nd group are solid colours with a stripe or some other identifying mark.

Fiber Cable Jacket Colours

For outdoor aerial and burial type cables, the jacket colour is usually black polyethelene for both multimode and singlemode cables.

For indoor cables, the outer most fiber cable jacket may be any colour but the de facto industry standard is:

- *Orange for multimode fibers*
- *Yellow for singlemode fibers*

This is also generally true for fiber optic patch cords.

TIA-598C Recommendations on Fiber Cable Jacket Colour

Coloured outer jackets or print may be used on Premises Distribution Cable, Premises Interconnect Cable or Interconnect Cord, or Premises Breakout Cable to identify the classification and fiber sizes of the fiber.

When coloured jackets are used to identify the type of fiber in cable containing only one fiber type, the colours shall be as indicated in the following table. Other colours may be used providing that the print on the outer jacket identifies fiber classifications in accordance with subclause 4.3.3. Such colours should be as agreed upon between manufacturer and user.

Unless otherwise specified, the outer jacket of premises cable containing more than one fiber type shall use a printed legend to identify the quantities and types of fibers within the cable. The following table shows the preferred nomenclature for the various fiber types, for example "12 Fiber 8 x 50/125, 4 x 62.5/125."

When the print on the outer jacket of premises cable is used to identify the types and classifications of the fiber, the nomenclature of the following table is preferred for the various fiber types. Distinctive print characters for other fiber types may be considered for addition to this Table at some future date.

Fiber Type	Fiber Cable Jacket Colour Code		
	Non-military Applications(3)	Military Applications	Suggested Print Nomenclature
Multimode (50/125) (TIA-492AAAB)	Orange	Orange	50/125
Multimode (50/125) (850 nm Laser-optimized) (TIA-492AAAC)	Aqua	Undefined	850 LO 50 /125
Multimode (62.5/125) (TIA-492AAAA)	Orange	Slate	62.5/125
Multimode (100/140)	Orange	Green	100/140
Single-mode (TIA-492C000 / TIA-492E000)	Yellow	Yellow	SM/NZDS, SM
Polarization Maintaining Single-mode	Blue	Undefined	Undefined (2)

NOTES:

- 1) Natural jackets with coloured tracers may be used instead of solid-colour jackets.
- 2) Because of the limited number of applications for these fibers, print nomenclature are to be agreed upon between manufacturer and enduser
- 3) Other colours may be used providing that the print on the outer jacket identifies fiber classifications per subclause 4.3.3.
- 4) For some Premises Cable functional types (e.g., plenum cables), coloured jacketing material may not be available. Distinctive jacket colours for other fiber types may be considered for addition to Table 3 at some future date.

Testing Fibre Optical Cable

Guidelines On What Loss To Expect When Testing Fiber Optic Cables For Insertion Loss With A Meter and Source or OLTS

Connector Loss:

For each connector, figure 0.3 dB loss for most adhesive/polish connectors. The loss spec for prepolished/splice connectors will be higher (0.75 max per EIA/TIA 568)

When testing cable plants per OFSTP-14 (double ended), include connectors on both ends of the cable. When testing per FOTP-171 (single ended), include only one connector - the one attached to the launch cable.

Splice Loss:

For each splice, 0.3 dB (0.3 max per EIA/TIA 568)

Fiber Loss:

For multimode fiber, the loss is about 3 dB per km for 850 nm sources, 1 dB per km for 1300 nm. (3.5 and 1.5 dB/km max per EIA/TIA 568) This roughly translates into a loss of 0.1 dB per 100 feet (30 m) for 850 nm, 0.1 dB per 300 feet (100 m) for 1300 nm.

For singlemode fiber, the loss is about 0.5 dB per km for 1300 nm sources, 0.4 dB per km for 1550 nm. (1.0 dB/km for premises/0.5 dB/km at either wavelength for outside plant max per EIA/TIA 568) This roughly translates into a loss of 0.1 dB per 600 (200m) feet for 1300 nm, 0.1 dB per 750 feet (250m) for 1300 nm.

So for the estimated loss of a cable plant:

Calculate the approximate loss as:

$(0.5 \text{ dB} \times \# \text{ connectors}) + (0.2 \text{ dB} \times \# \text{ splices}) + (\text{fiber attenuation} \times \text{the total length of cable})$

What about OTDR testing?

OTDRs are used for verifying splice loss on long links with inline splices or for troubleshooting. All standards require an insertion loss test for qualification of the link loss. In MM fibers, the OTDR will underestimate the loss considerably - as much as 3 dB in a 10 dB link - but the amount is unpredictable. In long distance SM links, the difference may be less, but there are other measurement uncertainties, like connector or splice loss, where the OTDR can show a gain.

Will the network run on that link?

Below is a table showing the loss margin for most fiber optic LANs and links. If the loss of the cable plant is less than the maximum loss allowed for the link, it should run (but margin is required!)

(1062 Mbaud)	Supportable distance m (ft)	-	-	-	-	-	-	10000 (32810)	-
Fibre Channel 200-MX-SN-I (2125 Mbaud)	Channel attenuation (dB)	2.1	-	2.6	-	3.3	-	-	-
	Supportable distance m (ft)	150 (492)	-	300 (984)	-	500 (1640)	-	-	-
Fibre Channel 200-SM-LC-L (2125 Mbaud)	Channel attenuation (dB)	-	-	-	-	-	-	7.8	-
	Supportable distance m (ft)	-	-	-	-	-	-	10000 (32810)	-
Fibre Channel 400-MX-SN-I (4250 Mbaud)	Channel attenuation (dB)	1.8	-	2.1	-	2.5	-	-	-
	Supportable distance m (ft)	70 (230)	-	150 (492)	-	270 (886)	-	-	-
Fibre Channel 400-SM-LC-L (4250 Mbaud)	Channel attenuation (dB)	-	-	-	-	-	-	7.8	-
	Supportable distance m (ft)	-	-	-	-	-	-	10000 (32810)	-
Fibre Channel 1200-MX-SN-I (10512 Mbaud)	Channel attenuation (dB)	2.4	-	2.2	-	2.6	-	-	-
	Supportable distance m (ft)	33 (108)	-	82 (269)	-	300 (984)	-	-	-
Fibre Channel 1200-SM-LL-L (10512 Mbaud)	Channel attenuation (dB)	-	-	-	-	-	-	6.0	-
	Supportable distance m (ft)	-	-	-	-	-	-	10000 (32810)	-
FDDI PMD ANSI X3.166	Channel attenuation (dB)	-	11.0	-	6.0	-	6.0	-	-
	Supportable distance m (ft)	-	2000 (6560)	-	2000 (6560)	-	2000 (6560)	-	-
FDDI SMF-PMD ANSI X3.184	Channel attenuation (dB)	-	-	-	-	-	-	10.0	-
	Supportable distance m (ft)	-	-	-	-	-	-	10000 (32810)	-

- means Not Applicable

Specifications For Legacy Fiber Optic Networks

Here is a listing of many fiber optic LANs and links available in the last 20 years, with basic operational specs.

Application	Wavelength	Max distance (m) for fiber type			Link Margin (dB) for fiber type		
		62.5/125	50/125	SM	62.5	50	SM
10Base-F	850	2000	2000	NS	12.5	7.8	NS
FOIRL	850	2000	NS	NS	8	NS	NS
T oken Ring 4/16	850	2000	2000	NS	13	8.3	NS
Demand Priority (100VG-AnyLAN)	850	500	500	NS	7.5	2.8	NS
Demand Priority (100VG-AnyLAN)	1300	2000	2000	NS	7.0	2.3	NS
100Base-FX (Fast Ethernet)	1300	2000	2000	NS	11	6.3	NS
10/100Base-SX	850	300	300	NS	4.0	4.0	NS
FDDI	1300	2000	2000	40,000	11.0	6.3	10-32
FDDI (low cost)	1300	500	500	NA	7.0	2.3	NA
ATM 52	1300	3000	3000	15,000	10	5.3	7-12
ATM 155	1300	2000	2000	15,000	10	5.3	7-12
ATM 155	850(laser)	1000	1000	NA	7.2	7.2	NA
ATM 622	1300	500	500	15,000	6.0	1.3	7-12
ATM 622	850(laser)	300	300	NA	4.0	4.0	NA
Fibre Channel 266	1300	1500	1500	10,000	6.0	5.5	6-14
Fibre Channel 266	850(laser)	700	2000	NA	12.0	12.0	NA
Fibre Channel 1062	850(laser)	300	500	NA	4.0	4.0	NA
Fibre Channel 1062	1300	NA	NA	10,000	NA	NA	6-14
1000Base-SX	850(laser)	220	550	NA	3.2	3.9	NA
1000Base-LX	1300	550	550	5000	4.0	3.5	4.7
ESCON	1300	3000	NS	20,000	11	NS	16

NA = Not Applicable

NS = Not Specified. Most LANs and links not specified to run on SM fiber have media converters available to allow them to run on SM fiber.

Cable Plant Link Loss Budget Analysis

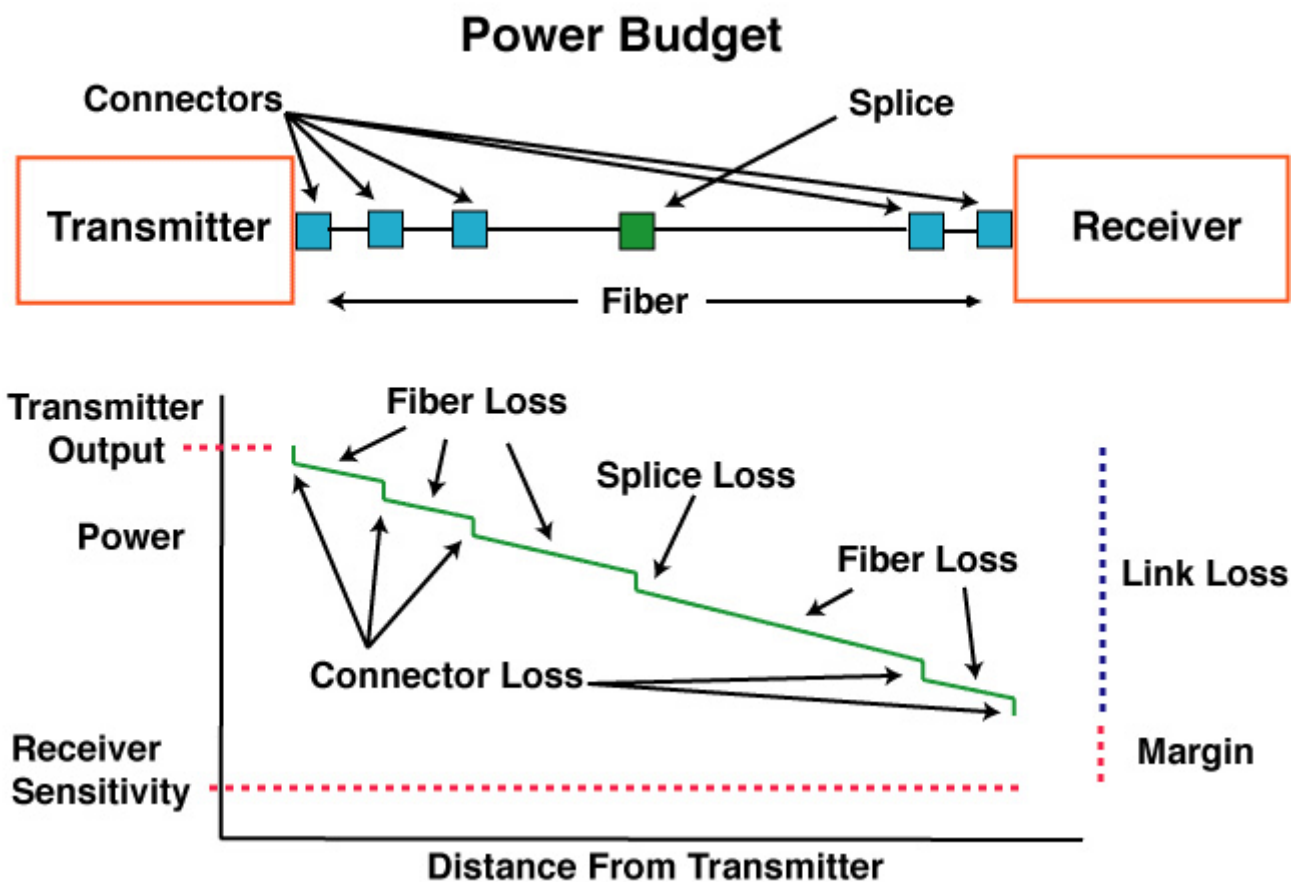
Loss budget analysis is the calculation and verification of a fiber optic system's operating characteristics. This encompasses items such as routing, electronics, wavelengths, fiber type, and circuit length. Attenuation and bandwidth are the key parameters for budget loss analysis.

Analyse Link Loss In The Design Stage

Prior to designing or installing a fiber optic system, a loss budget analysis is recommended to make certain the system will work over the proposed link. Both the passive and active components of the circuit have to be included in the budget loss calculation. Passive loss is made up of fiber loss, connector loss, and splice loss. Don't forget any couplers or splitters in the link. Active components are system gain, wavelength, transmitter power, receiver sensitivity, and dynamic range. Prior to system turn up, test the circuit with a source and FO power meter to ensure that it is within the loss budget.

The idea of a loss budget is to insure the network equipment will work over the installed fiber optic link. It is normal to be conservative over the specifications! Don't use the best possible specs for fiber attenuation or connector loss - give yourself some margin!

The best way to illustrate calculating a loss budget is to show how it's done for a 2 km multimode link with 5 connections (2 connectors at each end and 3 connections at patch panels in the link) and one splice in the middle. See the drawings below of the link layout and the instantaneous power in the link at any point along its length, scaled exactly to the link drawing above it.



Cable Plant Passive Component Loss

Step 1. Fiber loss at the operating wavelength

Cable Length	2.0	2.0		
Fiber Type	Multimode		Singlemode	
Wavelength (nm)	850	1300	1300	1550
Fiber Atten. dB/km	3 [3.5]	1 [1.5]	0.4 [1/0.5]	0.3 [1/0.5]
Total Fiber Loss	6.0 [7.0]	2.0 [3.0]		

(All specs in brackets are maximum values per EIA/TIA 568 standard. For singlemode fiber, a higher loss is allowed for premises applications)

Step 2. Connector Loss

Multimode connectors will have losses of 0.2-0.5 dB typically. Singlemode connectors, which are factory made and fusion spliced on will have losses of 0.1-0.2 dB. Field terminated singlemode connectors may have losses as high as 0.5-1.0 dB. Let's calculate it at both typical and worst case values.

Connector Loss	0.3 dB (typical adhesive/polish connector)	0.75 dB (TIA-568 max acceptable)
Total # of Connectors	5	5
Total Connector Loss	1.5 dB	3.75 dB

(Remember: All connectors are allowed 0.75 max per EIA/TIA 568 standard)

Step 3. Splice Loss

Multimode splices are usually made with mechanical splices, although some fusion splicing is used. The larger core and multiple layers make fusion splicing about the same loss as mechanical splicing, but fusion is more reliable in adverse environments. Figure 0.1-0.5 dB for multimode splices, 0.3 being a good average for an experienced installer. Fusion splicing of singlemode fiber will typically have less than 0.05 dB (that's right, less than a tenth of a dB!)

Typical Splice Loss	0.3 dB
Total # splices	1
Total Splice Loss	0.3 dB

(Remember: All splices are allowed 0.3 max per EIA/TIA 568 standard)

Step 4. Total Passive System Attenuation

Add the fiber loss, connector and splice losses to get the link loss.

	Best Case		TIA 568 Max	
	850 nm	1300 nm	850 nm	1300 nm
Total Fiber Loss (dB)	7.0	2.0	7.0	3.0
Total Connector Loss (dB)	1.5	1.5	3.75	3.75
Total Splice Loss (dB)	0.3	0.3	0.3	0.3
Other (dB)	0	0	0	0
Total Link Loss (dB)	8.8	3.8	11.05	7.05

Remember: these should be the criteria for testing. Allow +/- 0.2 -0.5 dB for measurement uncertainty and that becomes your pass/fail criterion.

Equipment Link Loss Budget Calculation:

Link loss budget for network hardware depends on the dynamic range, the difference between the sensitivity of the receiver and the output of the source into the fiber. You need some margin for system degradation over time or environment, so subtract that margin (as much as 3dB) to get the loss budget for the link.

Step 5. Data From Manufacturer's Specification for Active Components (Typical 100 Mb/s link)

Operating Wavelength (nm)	1300
Fiber Type	MM
Receiver Sens. (dBm@ required BER)	-31
Average Transmitter Output (dBm)	-16
Dynamic Range (dB)	15
Recommended Excess Margin (dB)	3

Step 6. Loss Margin Calculation

Dynamic Range (dB) (above)	15	15
Cable Plant Link Loss (dB)	3.8 (Typ)	7.05 (TIA)
Link Loss Margin (dB)	11.2	7.95

As a general rule, the Link Loss Margin should be greater than approximately 3 dB to allow for link degradation over time. LEDs in the transmitter may age and lose power, connectors or splices may degrade or connectors may get dirty if opened for rerouting or testing. If cables are accidentally cut, excess margin will be needed to accommodate splices for restoration.

NOTE: Many technicians forget when doing a loss budget, that the connectors on the end of the cable plant must be included in the loss budget. When the cable plant is tested, the reference cables will mate with those connectors and their loss will be included in the measurements.