

# Permanent Link Testing of Multimode and Singlemode Fiber Optic Cabling Systems Best Practices: PN445

*READ ALL INSTRUCTIONS COMPLETELY BEFORE PROCEEDING*

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## 1.0 Introduction

This document outlines the procedure recommended by Panduit for field permanent link loss testing of multimode and singlemode structured cabling systems.

This document describes how and where permanent link loss testing should be performed based on the specifics of the cabling system. A link loss equation is used to calculate acceptable attenuation values based on the connectivity and media types present in the structured cabling solution under test.

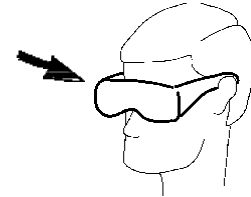
## 2.0 Essentials of Testing Permanent Links

1. The following prerequisites are required to effectively test fiber links:
  - Knowledge of the fundamental operation of fiber optic light transmissions
  - Familiarity with the basic types of fiber cables and core sizes
  - Familiarity with fiber optic terminology
  - Knowledge of fiber optic terminations
  - Experience with fiber components that includes, but not limited to connector types, adapters, sleeves, cassettes, etc.
  - Familiarity with ANSI/TIA/EIA-568-B.1 industry standards for testing fiber optic links
  - Utilizing fiber test equipment that can display and store link test results
  - Utilizing and establishing quality reference leads
  - Understanding proper fiber cleaning techniques
  - Knowledge of the correlation of light loss numbers to optical performance to determine acceptable or unacceptable results
  - Understanding of simple fault/resolution charts to resolve common problems
  
2. The following items will be discussed in this document to effectively test permanent links:
  - Setting up a tester to correctly measure a link
  - Utilizing the correct size mandrel on launch leads.
  - Two methods of settings reference values
  - Manually establishing a reference value when necessary
  - Reference lead qualifications
  - Measuring Links Under Test (LUTs)
  - Interpreting test results
  - Correct discrepancies via fault/symptom/resolution charts

### 3.0 Safety Precautions

#### 1. SAFETY GLASSES

**WARNING:** It is strongly recommended that safety glasses be worn when handling bar optical fiber. The bar fiber is very sharp and can easily damage the eye.



#### 2. LASER LIGHT PROTECTION

Use of controls or performance other than those specified herein may result in hazardous radiation exposure. The power of emission of the laser beam exceeds 1MW in class II and is less than 5MW in class IIIA/3R, so the following warnings must be followed to avoid injury:

- Never point the laser into the eyes of others/
- Do not stare directly at the laser beam.
- Do not set up tool to work at eye level or operation the tool on a reflective surface as the laser could be projected into your eyes the eyes of others.

Always turn the laser off when it is not in use or is left unattended for a period of time. Remove the batteries when storing or for an extended period of time to avoid damage to the tool should the batteries deteriorate.

Never look into the path of the visual fault locator or another laser beam.

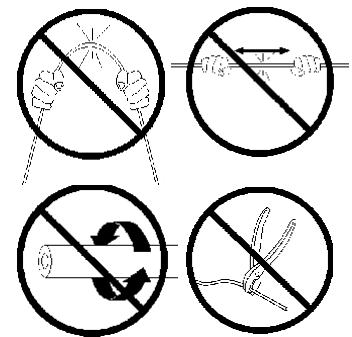
Never look into the end of a fiber which may have any visual fault locator, or any other laser coupled to it.

Never launch any visual fault locator into active equipment or microscope. Make sure that the end opposite the visual fault locator is not connected to any electronics or active equipment during termination.



#### 3. CABLE HANDLING

**WARNING:** Fiber optic cable can be damaged by excessive pulling, twisting, pushing, or bending stresses. Consult the appropriate specification sheets as provided. Any damage may decrease optical performance.



## 4.0 Equipment List

### 1. Optical Test Set (Light Source/Power Meter)

An IEC Type III field test unit should be employed when performing link loss tests. Link testing of multimode segments should be done with an 850/1300nm dual wavelength unit. Link testing of singlemode segments should be done with a 1310/1550nm dual wavelength unit.

### 2. Reference Leads (Jumpers)

Since there is not an IEC/EIA Standard in place for qualifying Reference Leads, the following is recommended by Panduit. At least two “reference-quality” leads are used to facilitate precision launch and receive for the test set. These jumpers should be 2 meters long and must be fabricated from the same type of fiber cable as the Link Under Test (LUT). One end of each reference jumper is terminated with a connector style compatible with the tester. The opposite end of each is terminated with the same connector style as the LUT. Refer to Section 8.0 (Test Lead Performance Verification) to quantify the initial and ongoing quality of these leads as “Reference Quality” Leads.

### 3. Adapters

Two adapters of the same style as the LUT connectors are required. Panduit recommends the use of singlemode quality (zirconia ceramic) adapter sleeves for all link testing. Singlemode adapters have proven to provide better core-to-core alignment than phosphor bronze split sleeves.

### 4. Mandrels

ANSI/TIA/EIA-568-B, ISO/IEC 11801:2002 and EN50173:2002 specify the use of a mandrel when testing multimode power loss in the field with an LED source (present on some testers). Mandrels allow the use of LED light sources to test both 50µm and 62.5µm fiber links for current and planned high bit rate applications including Gigabit Ethernet and 10 Gigabit Ethernet.

ANSI/TIA/EIA-568-B.1 Mandrel guidelines - The mandrel diameter and number of mandrel wraps is specified in ANSI/TIA/EIA-568-B.1, clause 11.3.3. The diameter varies depending upon the fiber core size and launch cable diameter. This is shown in Table 1 below. All mandrels listed in the table require five (5) smooth wraps six inches (6”) from the source.

NOTE: Mandrels are not used for field testing singlemode links. If the source is encircled flux compliant, mandrels are not required. If the source is non-bend insensitive fiber, mandrels are necessary.

**Table 1. Mandrel Diameter Requirements Based on Fiber Core Size and Cable Diameter**

Fiber core size (µm)	Mandrel Diameter for:			
	900µm buffered fiber	1.6mm jacketed cable	2mm jacketed cable	3mm jacketed cable
50/125µm	25mm (1.0”)	23.4mm (0.921”)	23.0mm (.906”)	22mm (0.9”)
62.5/125µm	20mm (0.8”)	18.4mm (0.724”)	18.0mm (.709”)	17mm (0.7”)

### 5. Connector Cleaning Supplies

Refer to [Visual Inspection and Cleaning of Multimode and Singlemode Structured Cabling System Interconnect Components: FS061](#)

## 5.0 Permanent Link Segment Definitions

All segments in the cabling system should be the subject of link loss testing according to the guidelines presented in this document. A link segment consists of the fiber cable media and connectivity (fiber connectors, adapters, splice points, etc.) connecting different segments of the network. The link loss measurement for a network segment includes the insertion loss of connectors at the panels (termination bulkheads) on either end of the link but does not include the attenuation of any short jumpers attached to line terminating electronics or the performance of the connector at the equipment interface. Although the channel is defined as all the components in the permanent link plus additional jumpers attached to line terminating electronics – only the permanent link will be covered in this document.

The **Permanent Link Segment** is the cabling infrastructure element of a channel. The permanent link is typically seen as the fiber cabling media and connectivity that connects patch panel to patch panel and the connectivity resident in the patch panels themselves. A permanent link does not include any patch cords to the line terminating electronics. Testing of a permanent link should be completed before any patch cords are connected to the panels to complete the channel.

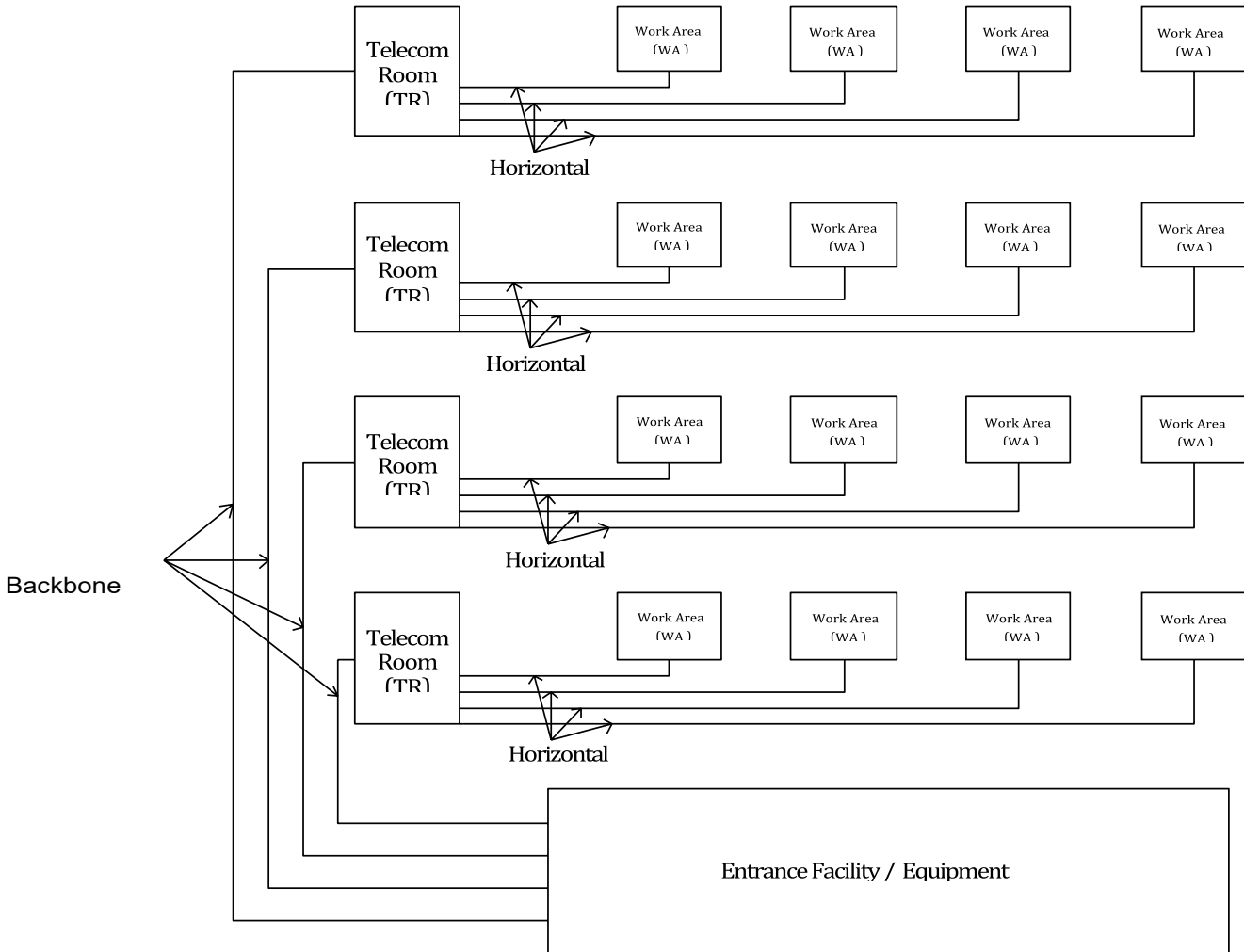
A **Fiber Channel** is made up of patch cords plus all the components of the permanent link. The Channel is constructed from components compatible with the channel length and application losses that it is required to support. Each Channel is represented by a pair of fibers that form an individual circuit, each individual circuit having a transmit side and a receive side.

The two basic types of permanent link segments include: Horizontal and Backbone these are shown in Figure 1 on the next page.

A **Horizontal Link Segment** typically spans a horizontal cross-connect to a fiber outlet, in the case of Fiber to the Desk (FTTD), or zone switch, in the case of Fiber to the Enclosure (FTTE). This outlet or switch location may be a Multi-User Telecommunications Outlet (MUTO) in an open office area or may be in a ceiling or closet enclosure and may consist of a small patch panel to the active electronics. The length of this link segment is typically 90m (295 ft) or less.

A **Backbone Link Segment** typically spans the Main Distribution Frame (MDF) to the horizontal cross-connect. Cables that span separate cross-connects or MDFs (as between two buildings) are also considered backbone link segments. The length of this link segment varies depending upon site conditions. This segment provides interconnections between telecom rooms, equipment rooms, main terminal space, and entrance facilities.

**Figure 1. Illustration of Backbone and Horizontal Links**



## 6.0 Testing Guidelines

Unless otherwise stated, all permanent link loss testing of a segment shall be performed with a handheld power meter/source. This equipment will measure link attenuation, which is the most important performance parameter when installing components. Maximum allowable attenuation of Ethernet and Fibre Channel applications can be obtained using the Panduit online link loss calculator found at [www.panduit.com/fiberlinkloss](http://www.panduit.com/fiberlinkloss).

OTDR testing isn't a requirement in fiber certification. In fact, this basic fiber certification (Tier 1) with a power meter and light source is the only type of testing required by ANSI/TIA/EIA-568B for premises cabling. This test method measures end-to-end insertion loss by using a power meter and light source. If the attenuation is within the limits of the allotted power budget, the system will work. Panduit doesn't recommend, nor provide channel warranty when testing links via the OTDR method.

ANSI/TIA/EIA-568 and ISO 11801 have established acceptable link loss measurements for each of the applications in the link loss calculator, based upon acceptable length limits for each segment and the associated number of connectors assumed for that length of segment. The acceptable loss consists of adding up the designated component losses and attenuation coefficient of the link under test. The values for calculating the acceptable losses are stated below. If the test results are outside of these designated values, troubleshooting will need to be implemented to correct the link to test within the parameters.

The acceptable link loss of the Backbone Segment can be calculated using the following equation:

$$\text{Link Attenuation} = \text{Cable Attenuation} + \text{Connector Insertion Loss} + \text{Splice Insertion Loss}$$

**Where:**

$$\text{Cable Attenuation (dB)} = \text{Attenuation Coefficient (dB/km)} \times \text{Length (km)}$$

Attenuation Coefficients are as follows:

- 3.5dB/km @ 850nm for Multimode
- 1.5dB/km @ 1300nm for Multimode
- 0.5dB/km @ 1310nm for Singlemode outside plant cable
- 0.5dB/km @ 1550nm for Singlemode outside plant cable
- 1.0dB/km @ 1310nm for Singlemode inside plant cable
- 1.0dB/km @ 1550nm for Singlemode inside plant cable

$$\text{Connector Insertion Loss (dB)} = \text{number of connector pairs} \times \text{connector loss (dB)}$$

and

$$\text{Splice Insertion Loss (dB)} = \text{number of splices} \times \text{splice loss}$$

The ANSI/TIA/EIA-568-B standards designate the allowable attenuation coefficients for the different cable types along with the loss for fixed connectors as 0.75dB per mated pair, and the allowable loss for fusion splices as 0.30dB per splice. These values are essential in calculating any link loss. A few examples of link loss calculations are shown on the following page.

**Example:**

Assume a 50-meter link with two connector pairs and a splice. We decide to measure at 1300nm. The affordable power loss budget would be calculated in the following way:

Connector Pairs	=	1.50dB (0.75dB x 2)
Cable @ 1300nm	=	0.075dB (1.5dB/km x 0.05 km)
<u>Splices</u>	=	<u>0.30dB (0.3dB x 1)</u>
<b>Power Loss Budget =</b>		<b>1.87dB</b>

### Example:

A 300m long Multimode permanent link measures 1.3dB @ 850nm and 1.2dB @ 1300nm.

Does it pass?

Cable Attenuation (@ 850nm) = 0.300km x 3.5dB/km = 1.05dB

Cable Attenuation (@ 1300nm) = 0.300km x 1.5dB/km = 0.45dB

Connector Insertion Loss = 2 connector pairs x 0.75dB = 1.5dB

So ... maximum allowable link loss

@ 850nm = 1.05dB + 1.5dB = 2.55dB (sample at 1.3dB is less than allowable so it PASSES)

@ 1300nm = 0.45dB + 1.5dB = 1.95dB (sample at 1.2dB is less than allowable so it PASSES)

## 7.0 Setting A Reference Value

There are two methods for setting a reference value presented below.

### Precaution:

Make sure that the tester is fully charged and within current calibration date before testing.

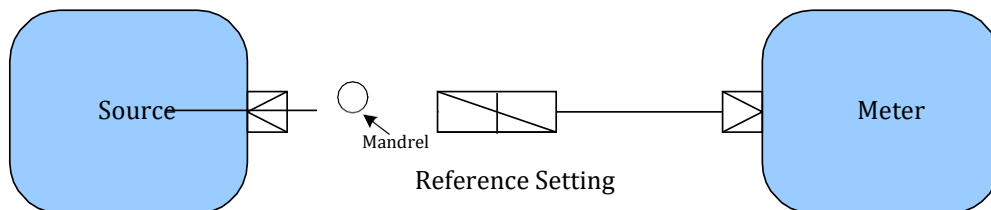
NOTE: In the event the tester has been stored in a cold environment, make no attempt to test or set reference values until the tester comes up to an ambient temperature – this will eliminate fluctuations in accuracy.

Clean all connector end-faces (reference jumpers and LUT connectors) with alcohol and lint free wipes prior to testing. Ensure that the reference leads are in good condition and meet specifications in section 12.0 Test Lead Performance Verification before testing.

### Reference Setting – Method A

Connect one reference lead to tester terminal labeled Output (A) and the other reference lead to the tester terminal labeled Input (B). Mate the other ends of the reference leads together in an adapter (Refer to ANSI/TIA/EIA-526-14C Std. Method A, Figure 2 below. This method is used in conjunction with the two jumper and three jumper test methods described later in the document.

Figure 2. Method A for Setting Reference



Follow test unit manufacturer's instructions for setting reference values for the applicable wavelengths, numbers of adapters, splices, etc.

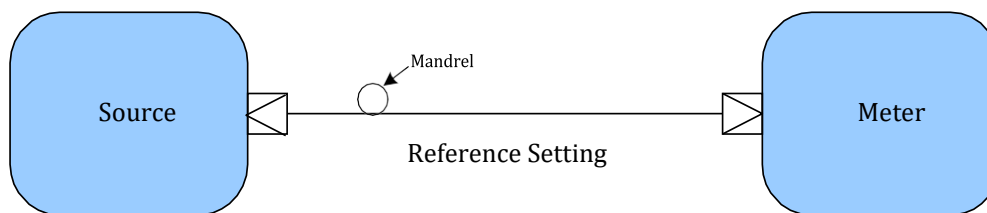


## Reference Setting – Method B

Connect one reference lead from tester terminal labeled Output (A) to the power meter terminal labeled Input (B). Refer to ANSI/TIA/EIA-526-14C Std. Method B, Figure 3 below.

NOTE: This method can only be used when the connector types of the LUT and connectors on the reference leads are of the same type. This method is used in conjunction with the one jumper test method described later in the document.

Figure 3. Method B for Setting Reference.



Even though Method “B” is proven to be slightly more accurate when setting a Ref Value, not all fiber techs have the same connector types as the LUT, therefore, most rely on Method “A” above.

Follow test unit manufacturer’s instructions for setting reference values for the applicable wavelengths, numbers of adapters, splices, etc. Once the test system is referenced, the launch and receive leads may not be removed from the test equipment. Doing so will require re-referencing.

NOTE: On less sophisticated light source/power meters, the normal method to establish a reference value is as follows:

1. Connect Launch and Receive leads with a mating adapter.
2. Record the loss shown on the power meter. This will be your reference value.
3. Connect Launch and Receive leads to their respective ends of the link under test.
4. Measure the loss. Record this value.
5. Subtract the value recorded in Step 2 from the value in step 4.
6. This is your actual link loss.

This is only necessary when the tester being used does not have the same adapter as the LUT.

Good reference values average around -19.0dB for 62.5/125 $\mu$ m, - 24.0dB for 50/125 $\mu$ m and around-8.0dB for 9/125 $\mu$ m fiber.

## 8.0 Test Lead Performance Verification

While setting reference values, the fiber optic lead exiting the light source will be referred to as the “Launch Lead”. The other fiber lead connected from the light meter will be referred to as “Receive Lead”. At all other times in this document, they will be referred to as “Reference Leads A or B” respectively. This verification is good for reference setting Method B.

Reference leads “A” and “B” shall be 2 meters long and be the same fiber cable type and core size as the link segment being tested (in compliance with ANSI/TIA/EIA-526-14C and ANSI/TIA/EIA-526-7). Reference quality connectors are only necessary on the link side of the test; the connector must match the LUTs connector type.

1. Clean the reference lead connectors and the adapters per [Visual Inspection and Cleaning of Multimode and Singlemode Structured Cabling System Interconnect Components: FS061](#).
2. Connect launch lead “A” between the Light Source and Power Meter connection labeled “Input”. Most power meters automatically display the power present (as XX.XdB<sub>m</sub>) when connected to a link. Make note of the power reading on the meter.
3. Disconnect launch lead “A” from the power meter end without disturbing the connection from the light source labeled “Output”.
4. Connect reference lead “A” to reference lead “B” using one of the Singlemode adapters specified earlier in this document. Panduit recommends using singlemode adapters only. Now connect the other end of reference lead “B” to the Power Meter connection labeled “Input”. Your setup should resemble the configuration shown in figure 3 on the previous page.
5. If the power meter is in (Normal) relative mode, the connector mated pair insertion loss will be displayed. If the meter does not have a relative mode, record the measurement (P<sub>m</sub>) and perform the following calculation:

The formula for determining Connector Insertion Loss is:

$$CIL (dB) = |P_m - P_r|$$

where:

CIL = Connector Insertion Loss in dB

P<sub>m</sub> = Power measured in the Link

P<sub>r</sub> = Power measured with reference lead

The measured mated pair insertion loss must be less than or equal to the value found in Table 4 below.

6. Flip the ends of reference lead “A” so that the end connected to the power meter “Output” is now connected to the adapter. Reference lead “B” on the other side of the adapter should still be connected as before: connected to the Power Meter “Input”.
7. Record the new Power Measurement (P<sub>m</sub>). Perform the proper calculations if not using Relative Power Measurement Mode and verify that the connection attenuation is less than or equal to the value found in the table on the next page.

Table 2. Mated Connector Maximum Insertion Loss

Fiber Type	ST/SC/FJ	LC
Multimode	0.25dB	0.15dB
Singlemode	0.35dB	0.25dB

If both measurements are found to be less than or equal to the values found in the table above, reference lead “A” is acceptable for testing purposes.

NOTE: Unacceptable attenuation measurements may be attributable to reference lead “A” or “B”. Examine each reference lead with a handheld microscope, and clean or replace, if necessary. Repeat this procedure from the beginning by reversing reference leads “A” and “B” in order to verify the performance of reference Lead “B”.

## 9.0 Testing a Permanent Link

There are four standard methods of completing a link loss test.

- i. One Jumper Method (Method B)
- ii. Two Jumper Method (Method A)
- iii. Three Jumper Method (Modified Method B or Fluke Method)
- iv. “Golden” Jumper Method

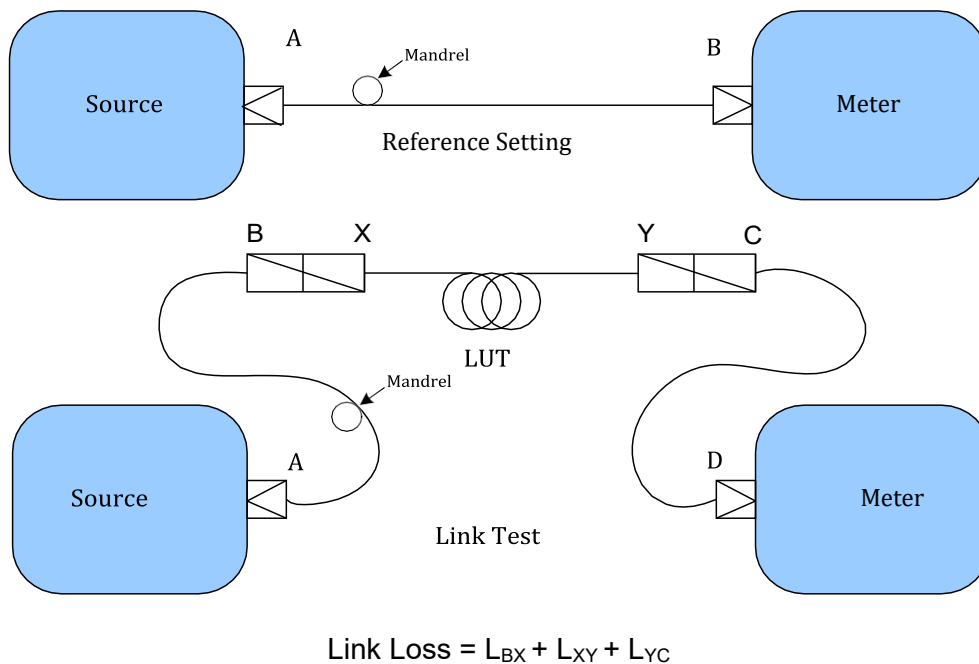
NOTE: All the methods that will be discussed “reference quality” patch cords and adapters need to be used to ensure accurate, repeatable, and reproducible measurements.

## One Jumper Method (Method B)

The one jumper method calculates the link loss as the loss of the two adapters and the link under test. This is the preferred method as outlined in ANSI/TIA/EIA-568-B.1 and the secondary method outlined in ISO/IEC 11801. Here the power meter test lead must have the same connector type as the LUT. This has been proven to be the most accurate and reproducible method. In utilizing this method, you must set a reference value using Method B as stated on Page 9.

Store/record permanent link loss measurement for future reference.

Figure 4. One Jumper Method



Where  $L_{BX}$  is the loss value of the adapter on the transmit side,  $L_{YC}$  is the loss value of the adapter on the receive side and  $L_{XY}$  is the total link under test.

As shown in Figure 4 above, start by setting a reference as described previously in this document. Once the reference is set, we are ready to move on to test the LUT.

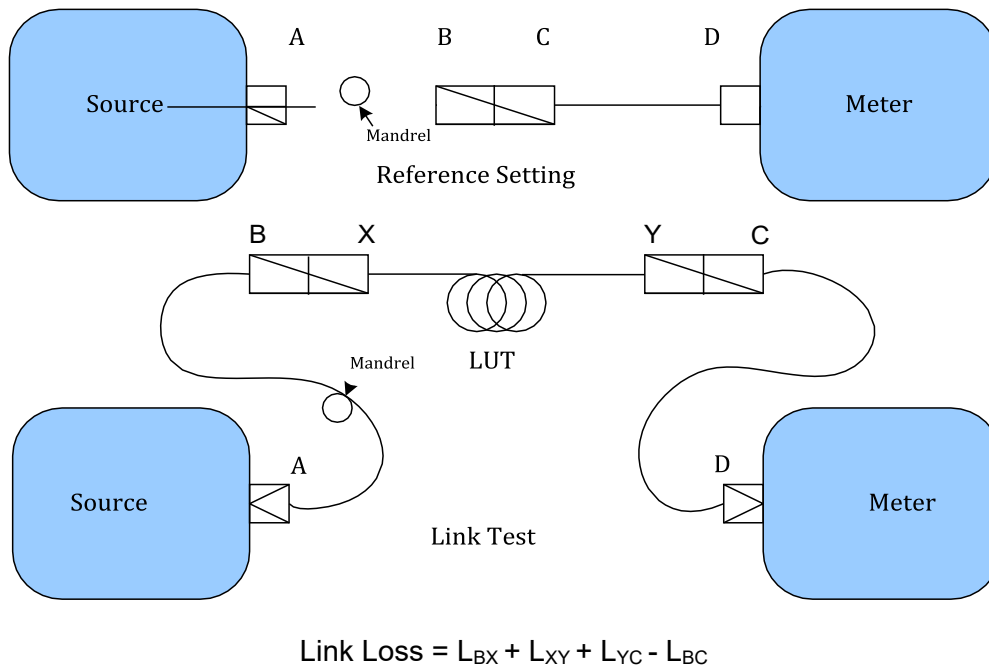
It is best to test the LUT from the fiber adapter panel to fiber adapter panel. This ensures that all splices, connections, and fiber cables in the link are included in the test. These two points are labeled as X and Y in the above illustration.

The source side remains at one end of the link while the meter side is moved to the far end receive side of the link. Link loss will be calculated by the test equipment. If not, it can be calculated by subtracting link loss minus the reference value measured.

## Two Jumper Method (Method A)

The two jumper method calculates the link loss as the loss of the adapter in the original reference setup subtracted from the sum of the two adapters and the link under test. This method is preferred by contractors even though it is not referenced in ISO/IEC 11801 because the power meter test lead does not have to have the same connector type as the LUT. This method also assumes that most of the loss is in the fiber cable itself and not the connectors.

Figure 5. Two Jumper Method



Where  $L_{BX}$  is the loss of the adapter on the transmit side,  $L_{XY}$  is the loss of the link under test,  $L_{YC}$  is the loss of the adapter on the receive side and  $L_{BC}$  is the loss of the adapter in the reference setup.

As shown in the Figure 5 above, start by setting a reference as described previously in this document. Once the reference is set, we are ready to move on to test the LUT.

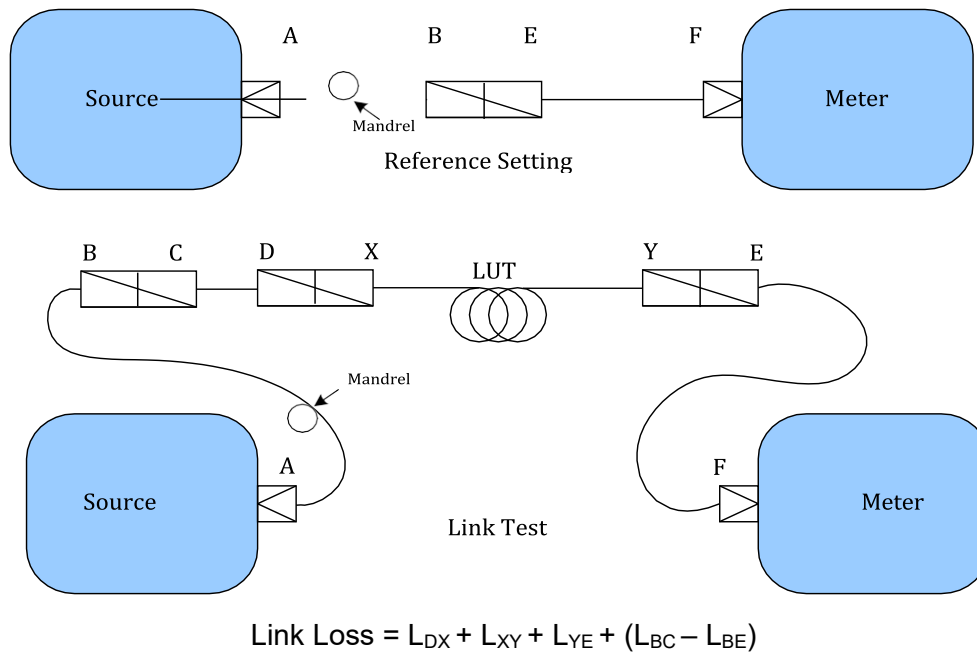
It is best to test the LUT from the fiber adapter panel to fiber adapter panel. This ensures that all connections, patch cables, and fiber cables in the link are included in the test. These two points are labeled as X and Y in the above illustration.

The source side remains at one end of the link while the meter side is moved to the far end receive side of the link. Link loss will be calculated by the test equipment, if not it can be calculated by subtracting the loss of the link measures during the link test minus the reference value measured.

### Three Jumper Method (Modified Method B or Fluke Method)

The three jumper method calculates the link loss as the sum of the loss of the adapter in the original reference setup and the loss of the adapter on the transmit side of the test minus the sum of the loss of the second adapter on the transmit side (attached to the LUT), the loss of the link under test, and the loss of the connector on the receive side. This method was introduced by Fluke to allow for the use of older test equipment with SC/ST fixed connector types. This test method is not referenced in neither the ANSI/TIA/EIA-568-B.1 or ISO/IEC 11801. It includes a short test jumper  $L_{CD}$  with a like connector of the LUT so that the test results will be the same as the results gained from using Method B, see Figure 3 on page 9.

Figure 6. Three Jumper Method



Where  $L_{DX}$  is the loss of the second connector on the transmit side attached to the LUT,  $L_{XY}$  is the loss of the link under test,  $L_{YE}$  is the loss of the connector on the receive side,  $L_{BC}$  is the loss of the first adapter on the transmit side attached to the reference cable and  $L_{BE}$  is the loss of the connection in the original reference setup.

As shown in Figure 6 above, start by setting a reference as described previously in this document. Once the reference is set, we are ready to move on to test the LUT.

It is best to test the LUT from the fiber adapter panel to fiber adapter panel. This ensures that all splices, connections, and fiber cables in the link are included in the test. These two points are labeled as X and Y in the above illustration.

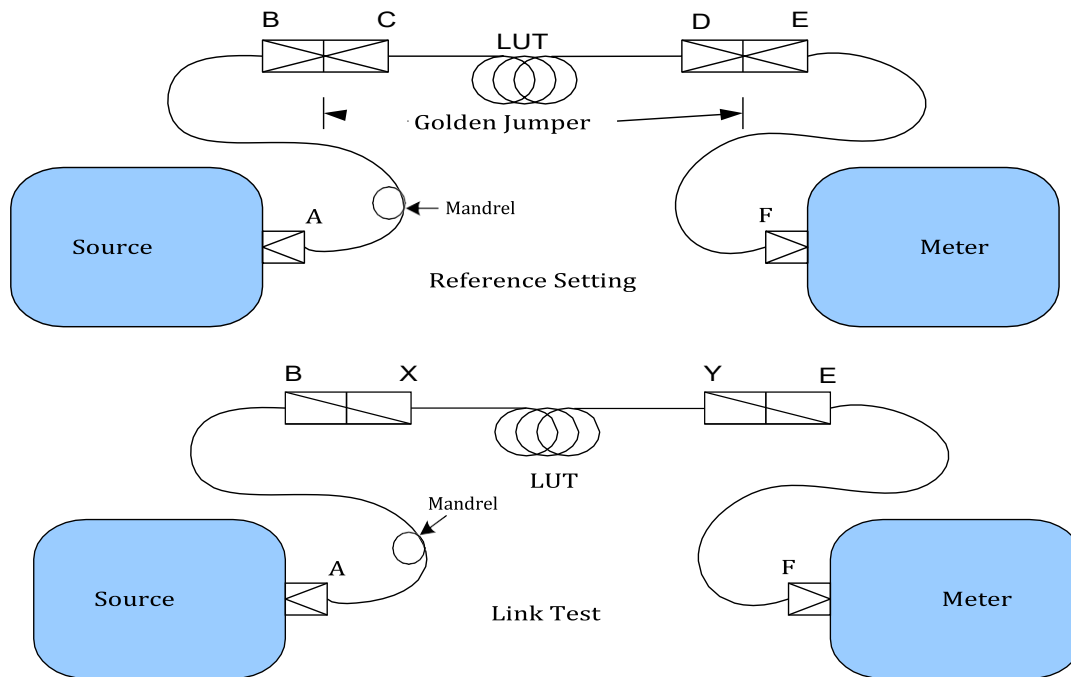
The source side remains at one end of the link while the meter side is moved to the far end receive side of the link. Link loss will be calculated by the test equipment. If not, it can be calculated by subtracting link loss minus the reference value measured.

The drawback to this method is having to add an additional reference patch cord to match the connectors with the LUT, which leads to greater uncertainty.

## Golden Jumper Method

This is the preferred method outlined in ISO/IEC 11801, but not referenced in ANSI/TIA/EIA-568-B.1. The “Golden” jumper method, see Figure 7 below, calculates the link loss as the sum of the loss of the adapter on the transmit side, the loss of the link under test and the loss of the connector on the receive side minus the sum of the connectors on the receive and transmit side of the link under test in the original reference setup. This method has the highest variability of all the methods discussed.

Figure 7. “Golden” Jumper Method



$$\text{Link Loss} = L_{BX} + L_{XY} + L_{YE} - (L_{BC} + L_{DE})$$

Where  $L_{BX}$  is the loss of the connector on the transmit side of the link under test,  $L_{XY}$  is the link under test,  $L_{YE}$  is the connector on the receive side,  $L_{BC}$  is the loss of the connection on the transmit side of the reference setup, and  $L_{DE}$  is the loss of the connection on the receive side of the reference setup.

Initiate Link Test per manufacturer’s instructions.

\*\* Depending on the tester manufacturer, it may be necessary to set the reference for each wavelength individually if not done automatically by the tester.

Store/record permanent link loss measurement for future reference as per requirements discussed in Section 12 (Documenting Permanent Link Test Results).

## 10.0 Interpreting Test Results

Most fiber loss test sets provide a PASS/FAIL indication. Each tester has a means of manually defining the link under test (LUT) so the test results will be given based upon the amount of light loss and knowing those optical characteristics which have a direct effect on the total optical loss of the LUT. The link characteristics you need to define to the tester include:

- Core Size: 50/125 $\mu\text{m}$ , 62.5/125 $\mu\text{m}$ , or 9/125 $\mu\text{m}$
- Number of adapters in the link (normally two)
- Number of splices (mechanical or fusion)

NOTE: The link length does not need to be defined; the tester will determine the link length. If the Fluke DTX-1800 is used, it measures the length by gathering the values from the fiber characteristics (such as Index of Refraction) combined with the time it takes the light source to reach the remote unit and this allows the unit to calculate the length of the fiber run. Given that the index of refraction is the speed the light travels through the fiber, all we need is the time it takes at that speed to determine the distance the light has traveled.

Based upon the Ref Value you have set plus the link characteristics defined to the tester, it will provide you with a PASS or FAIL based upon the Industry Standards stored within the tester's firmware. The most current tester firmware should be available from the vendor's website and should always be up to date on the tester.

**PASS / FAIL:** Some testers automatically determine whether a link passes or fails depending on a number of given specifications internal to the tester that are selected before testing. If the tester does not automatically determine PASS/FAIL then use the calculation presented in Section 6.0 to determine the maximum allowable link loss (Reference ANSI/TIA/EIA 568-B.1 Std., Section 11.3.3.4).

PASS or FAIL is a matter of measuring permanent link optical power loss against accepted industry standards per IEC/TIA 568-B.1.

If a link fails immediately, it is possibly a polarity issue where the transmit and receive patch cords are flipped. Consider using a visual light source to manually observe whether light can travel from one end of the link to the other. This is a safe and practical means of troubleshooting. This will save time as testing post-installation will likely reveal some polarity problems, which are much easier to correct than other light loss or light obstruction problems.



## Tester Link Loss Formula:

### **Optical Link Headroom = Permanent Link Loss Budget – Permanent Link Loss Measured**

If the test results show that your Optical Link Headroom is equal or greater than the Permanent Link Loss Budget, the tester will show a **PASS**. If the Optical Link Headroom displayed is in the negative direction, your Permanent Link Loss Budget is experiencing too much optical loss and will not meet IEC/TIA 568-B.1 requirements and show a **FAIL**.

With the tester set up to correctly reflect the optical characteristics of the permanent link, test the link to see if the losses encountered are within the allowable limits set by the IEC/TIA that have already been loaded into the tester.

Sometimes the test results may show that more light was “gained” in the link. This result is erroneous and called a “gainer”.

A gainer is normally described as an increase in optical power from the referenced value to the total loss of the LUT.

Knowing in advance what an expected, good reference value is, is very important.

The higher the reference value – the more error in accurate link measurements!

As an example, if you’re measuring multimode fiber and your reference value is –25dB. In testing a LUT your meter now reads only –19.5dB. Your link has gained power! This is not possible and should alert you to a problem within the link.

There are two possible causes for “gainers”:

Your reference leads connectors end-faces were initially dirty and when you disconnected the reference leads to attach to the LUT, the dirt/debris is displaced and now you have significantly more light being received at the far end.

The second way to gain light is when the core-to-core alignment of the reference leads is not well centered with one another. This can be improved insuring that proper reference cords are being used and not just “bucket” cords and by using zirconia ceramic split sleeves found in the blue singlemode adapters rather than the phosphor bronze split sleeves found in the electric ivory multimode adapters. Zirconia ceramic split sleeves maintain better core-to-core alignment than phosphor bronze split sleeves.

Assuming the initial core-to-core alignment was off-center, taking the reference value now will indicate a higher amount of loss than normally found. Continuing with the test and connecting both ends of the reference leads to the LUT can improve the loss amount since the core-to-core alignment can be made better without the offsets of the reference leads. Tests completed in this scenario will surely show erroneous light gains, commonly known as “gainers”.

## 11.0 Troubleshooting Unacceptable Segment Attenuation

Condition	Recommended Action
Dirty connectors and/or adapter sleeves	Visually inspect connector end-faces using Panduit FSCOPE 200x microscope. If necessary, clean end-faces per Panduit Best Practices document <a href="#">Visual Inspection and Cleaning of Multimode and Singlemode Structured Cabling: FS061</a>
Connector end-face issues (polished glass surface)	Inspect connector end-faces and clean properly per Panduit Best Practices document Visual Inspection and Cleaning of Multimode and Singlemode Structured Cabling System:
Excessive epoxy on the tip of a connector	Inspect connector end-face with a Panduit FSCOPE 200x microscope and re-polish. Follow Panduit Installation Instructions for your specific connector and re-polish. After the connector has been re-polished, follow the Panduit Best Practices document Visual Inspection and Cleaning of Multimode and Singlemode Structured Cabling System Interconnect Components: FS061
Excessive bending of fiber cable in enclosures and routing facilities (bends smaller than recommended minimum bend radius of fiber cable)	Inspect all fiber cable routing to ensure proper bend radius is maintained. The standard minimum bend radius for fiber optic cables is: > 10 times the cables outside diameter.
Poor mechanical or fusion splice performance	Identify suspect splices with an OTDR and re-splice to correct.

NOTE: Using a Visual Fault Locator (VFL) can be a quick way to spot potential trouble areas.

## 12.0 Documenting Permanent Link Test Results

In compliance with ANSI/TIA/EIA-526-14C “Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant” and ANSI/TIA/EIA-526-7 “Measurement of Optical Power Loss of Installed Singlemode Fiber Cable Plant”, the following data should be documented as a result of link loss testing:

- Date of link testing
- Names of personnel conducting the test
- Test equipment details (manufacturer, model, serial number, firmware level, calibration date)
- Center wavelength(s) and spectral width(s) of the test unit
- Fiber details (type)
- Test direction and end point locations
- Reference power measurement (if applicable)
- Segment link loss results
- Link Loss Budget

For more information contact Panduit Technical Support at [TechSupport@panduit.com](mailto:TechSupport@panduit.com) or [800-777-3300](tel:800-777-3300).