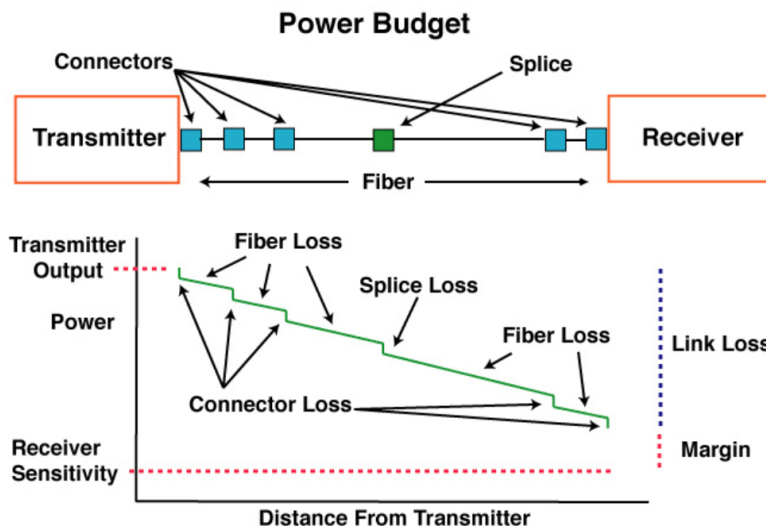




Cable Plant Passive Component Loss

Step 1. Calculate fiber loss at the operating wavelengths (length times standard estimates of loss at each wavelength)

Cable Length (km)	2.0	2.0	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 (dB)	6.0 [7.0]	2.0 [3.0]	0.8 [2/1]	0.6 [2/1]

(All specifications in brackets are maximum values per EIA/TIA 568 standard. For singlemode fiber, a higher loss is allowed for premises applications, 1 dB/km for premises, 0.5 dB/km for outside plant.)

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 (prepolished/splice connector and TIA-568 max acceptable)
Total # of Connectors	5	5
Total Connector Loss	1.5 dB	3.75 dB

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

Many designers and 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.

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!)

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

(For this loss budget calculation, all splices are allowed 0.3 max per EIA/TIA 568 standard)

Step 4. Total Cable Plant Loss

Add together the fiber, connector and splice losses to get the total link loss of the cable plant.

	Best Case [TIA 568 Max]		Best Case [TIA 568 Max]	
Wavelength (nm)	850	1300	1300	1550
Total Fiber Loss (dB)	6.0 [7.0]	2.0 [3.0]	0.8 [2/1]	0.6 [2/1]
Total Connector Loss (dB)	1.5 [3.75]	1.5 [3.75]	1.5 [3.75]	1.5 [3.75]
Total Splice Loss (dB)	0.3 [0.3]	0.3 [0.3]	0.3 [0.3]	0.3 [0.3]
Other (dB)	0	0	0	0
Total Link Loss (dB)	7.8 [11.05]	3.8 [7.05]	2.6 [6.05/5.05]	2.4 [6.05/5.05]

These values of cable plant loss 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 multimode digital link using a 1300 nm LED source.)

Operating Wavelength (nm)	1300
Fiber Type	MM
Receiver Sensitivity (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 @ 1300 nm)	3.8 (Typical)	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.

[More on link loss budgets.](#)

Project Documentation

Documentation of the cable plant is a necessary part of the design and installation process for a fiber optic network that is often overlooked. Documenting the installation properly during the planning process will save time and material in the installation. It will speed the cable installation and testing since the routing and terminations are already known. After component installation, the documentation should be completed with loss test data for acceptance by the end user. During troubleshooting, documentation eases tracing links and finding faults. Proper documentation is usually required for customer acceptance of the installation. The documentation process begins at the initiation of the project and continues through to the finish. It must begin with the actual cable plant path or location. OSP cables require documentation as to the overall route, but also details on exact locations, e.g. on which side of streets, which cable on poles, where and how deep buried cables and splice closures lay and if markers or tracing tape is buried with the cable. Premises cables require similar details inside a building in order for the cable to be located

anywhere in the path.

Most of this data can be kept in CAD drawings and a database or commercial software that stores component, connection and test data. Long outside plant links that include splices may also have OTDR traces which should be stored as printouts and possibly in computer files archived on disks for later viewing in case of problems. A computer with proper software for viewing traces must be available, so a copy of the viewing program should be on the disks with the files. If the OTDR data is stored digitally, a listing of data files should be kept with the documentation to allow finding specific OTDR traces more easily.

The Documentation Process

Documentation begins with a basic layout for the network. A sketch on building blueprints may work for a small building but a large campus, metropolitan or long distance network will probably need a complete CAD layout. The best way to set up the data is to use a facility drawing and add the locations of all cables and connection points. Identify all the cables and racks or panels in closets and then you are ready to transfer this data to a database.

Fiber optic cables, especially backbone cables, may contain many fibers that connect a number of different links which may not all be going to the same place. The fiber optic cable plant, therefore, must be documented for cable location, the path of each fiber, interconnections and test results. You should record the specifications on every cable and fiber: the manufacturer, the type of cable and fiber, how many fibers, cable construction type, estimated length, and installation technique (buried, aerial, plenum, riser, etc.)

It will help to know what types of panels and hardware are being used, and what end equipment is to be connected. If you are installing a big cable plant with many dark (unused) fibers, some will probably be left open or unterminated at the panels, and that must be documented also. Whenever designing a network, it's a very good idea to have spare fibers and interconnection points in panels for future expansion, rerouting for repair or moving network equipment.

Documentation is more than records. All components should be labeled with color-coded permanent labels in accessible locations. Once a scheme of labeling fibers has been determined, each cable, accessible fiber and termination point requires some labeling for identification. A simple scheme is preferred and if possible, explanations provided on patch panels or inside the cover of termination boxes.

Protecting Records

Cable plant documentation records are very important documents. Keep several backup copies of each document, whether it is stored in a computer or on paper, in different locations for safekeeping. If a copy is presented to the customer, the installer should maintain their own records for future work on the project. One complete set on paper should be kept with a "restoration kit" of appropriate components, tools directions in case of outages or cable damage. Documentation should be kept up to date to be useful so that task should be assigned to one on-site person with instructions to inform all parties keeping copies of the records of updates needed. Access to modify records should be restricted to stop unauthorized changes to the documentation.

Planning for the Installation

Once the design of a fiber optic project is complete and documented, one might think the bulk of the design work is done. But in fact, it's just beginning. The next step is to plan for the actual installation. Planning for the installation is a critical phase of any project as it involves coordinating activities of many people and companies. The best way to keep everything straight is probably to develop a checklist based on the design during the early stages of the project.

The Project Manager

Perhaps the most important issue is to have a person who is the main point of contact for the project. The project manager needs to be involved from the beginning, understands the aims of the project, the technical aspects, the physical layout, and is familiar with all the personnel and companies who will be involved. Likewise all the parties need to know this person, how to contact them (even 24/7 during the actual install) and who is the backup if one is needed.

The backup person should also be involved to such a degree that they can answer most questions, may even be more technically savvy on the project, but may not have full decision-making authority. The backup on big jobs may well be the person maintaining the documentation and schedules, keeping track of purchases and deliveries, permits, subcontractors, etc. while the project manager is more of a hands-on manager.

Design Checklist

Planning for a project is critical to the success of the project. The best way is to develop a checklist before beginning the design process. The checklist below is comprehensive but each project will have some of its own unique requirements that need to be added. Not all steps need be done serially, as some can be done in parallel to reduce time required for designing the project. The designer must interface with many other people and organizations in designing a project so contacts for outside sources should be maintained with the design documentation.

Design process

Link communications requirements

Link route chosen, inspected, special requirements noted including inspections and permits

- Specify communications equipment and component requirements
- Specify cable plant components
- Determine coordination with facilities, electrical and other personnel
- Documentation completed and ready for installation
- Write test plan
- Write restoration plans

- Contractor package for the install
- Documentation, drawings, bills of materials, instructions
- Permits available for inspection
- Guidelines to inspect workmanship at every step, test plan
- Daily review of progress, test data
- Safety rules to be posted on the job site(s) and reviewed with all supervisors and installation personnel

- Requirements for completion of cable plant installation
- Final inspection
- Review test data on cable plant
- Instructions to set up and test communications system
- Final update of documentation
- Update and complete restoration plan, store components and documentation

Developing A Project Checklist

The final project checklist will have many items, all of great importance. Each item needs a full description, where and when it will be needed and who is responsible for it. See Chapter 10 for a recommended project installation checklist. Components like cables and cable plant hardware should indicate vendors, delivery times and where, when and sometimes how it needs to be delivered. Special installation equipment needs to be scheduled also, with notes of what is needed to be purchased and what will be rented. If the jobsite is not secure and the install will take more than a day, security guards at the jobsite(s) may need to be arranged.

A work plan should be developed that indicates what specialties are going to be needed, where and when. Outside plant installations (OSP) often have one crew pulling cable, especially specialty installs like direct burial, aerial or underwater, another crew splicing and perhaps even another testing. OSP installers often do just part of the job since they need skills and training on specialized equipment like fusion splicers or OTDRs and installation practices like climbing poles or plowing-in cables. Inputs from the installation crews can help determine the approximate time needed for each stage of the installation and what might go wrong that can affect the schedule.

And things will go wrong. All personnel working on the project should be briefed on the safety rules and preferably be given a written copy. Supervisors and workers should have contact numbers for the project manager, backup and all other personnel they may need to contact. Since some projects require working outside normal work hours, for example airports or busy government buildings where cabling is often done overnight, having a project manager available – preferably onsite – while the work is being done is very important.

During the installation itself, a knowledgeable person should be onsite to monitor the progress of installation, inspect workmanship, review test data, create daily progress reports and immediately notify the proper management if something looks awry. If the project manager is not technically qualified, having someone available who is technical is important. That person should have the authority to stop work or require fixes if major problems are found.

Facilities and Power/Ground issues

This chapter primarily focuses on the unique aspects of fiber optic cable plant design and installation, but this process cannot be done in a vacuum. Cable plants may require municipal permits, cooperation from other organizations to allow access through their property and construction disruptions. Any communications system requires not only the cable plant but facilities for termination at each end, placing communications equipment, providing power (usually uninterruptible data quality power) and a separate data ground. Inside the facility, connections must be made to the end users of the link.

The large number of options involved in almost every project make it impossible to summarize the issues in a few sentences, so let's just say you must consider the final, complete design to gain cooperation and coordinate the final installation. One of the most valuable assets you can have when designing and installing a fiber optic project is an experienced contractor.

Developing A Test Plan

Every installation requires confirmation that components are installed properly. The installer or contractor wants to ensure the work is done properly so the customer is satisfied and callbacks for repair will not be necessary. Customers generally require test results as well as a final visual inspection as part of the documentation of a proper installation before approving payment. In our experience, however, there is often confusion about exactly what should be tested and how documentation of test results is to be done on fiber optic projects. These issues should be agreed upon during the design phase of the project. Project paperwork should include specifications for testing, references to industry standards and acceptable test results based on a loss budget analysis done during the design phase of the project.

The process of testing any fiber optic cable plant may require testing three times. testing cable on the reel before installation.

testing each segment as it is installed, including verifying every splice as it is made using an OTDR and finally testing complete end to end loss of every fiber in the cable plant. Practical testing usually means testing only a few fibers on each cable reel for continuity before installation to ensure there has been no damage to the cable during shipment. Then each segment is tested as it is spliced and/or terminated by the installers. Finally the entire cable run is plugged together and tested for end-to-end loss for final documentation.

One should require visual inspection of cable reels upon acceptance and, if visible damage is detected, testing the cable on the reel for continuity before installing it, to ensure no damage was done in shipment from the manufacturer to the job site. Since the cost of installation usually is high, often much higher than the cost of materials, it only makes sense to ensure that one does not install bad cable, which would then have to be removed and replaced. It is generally sufficient to just test continuity with a fiber tracer or visual fault locator. However, long spools of cable may be tested with an OTDR if damage is suspected and one wants to document the damage or determine if some of the cable needs to be cut off and discarded (or retained to get credit for the damaged materials.)

After cable installation, splicing and termination, each segment of the cable plant should be tested individually as it is installed, to ensure each splice, connector and cable is good. One should never complete splicing cables without verifying the splices are properly done with an OTDR before sealing the splice closure. Finally each end to end run (from equipment to equipment connected on the cable plant) should be tested for loss as required by all standards. Remember that each fiber in each cable will need to be tested, so the total number of tests to be performed is calculated from the number of cable segments times the number of fibers in each cable. This can be a time-consuming process.

Required vs. Optional Testing

Testing the complete cable plant requires insertion loss testing with a source and power meter or optical loss test set (OLTS) per TIA standard test procedure OFSTP-14 for multimode or OFSTP-7 for singlemode. The test plan should specify the "0 dB" reference method option (one, two or three reference cables) as this will affect the value of the loss. TIA 568 calls for a one cable reference, but this may not be possible with all combinations of test sets and cable plant connectors. The required test methods need to be agreed upon by the contractor and user beforehand.

OTDR testing is generally done on outside plant cables, but OTDR testing alone is not acceptable for cable plant certification. Long lengths of outside plant cabling which include splices should be tested with an OTDR to verify splice performance and look for problems caused by stress on the cable during installation.

While there are advocates of using OTDRs to test any cable plant installation, including short premises cables, it is not required by industry standards nor is it recommended for premises cabling. The shorter lengths of premises cabling runs and frequent connections with high reflectance often create confusing OTDR traces that cause problems for the OTDR autotest function and are sometimes difficult for even experienced OTDR users to interpret properly.

Coordinating Testing and Documentation

The Test Plan should be coordinated with the cable plant documentation. The documentation must show what links need testing and what test results are expected based on loss budget calculations. The Test Plan should also specify how the test data are incorporated into the documentation for acceptance of the installation and for reference in case of future cabling problems that require emergency restoration.

Planning for Restoration



About once a day in the USA, a fiber optic cable is broken by a contractor digging around the cable, as this photo shows.

Premises cables are not as vulnerable, except for damage caused by clumsy personnel or during the removal of abandoned