FIBER TO THE ROOM DESIGN GUIDE

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About HTNG

Hotel Technology Next Generation (HTNG) is a non-profit association with a mission to foster, through collaboration and partnership, the development of next-generation systems and solutions that will enable hoteliers and their technology vendors to do business globally in the 21st century. HTNG is recognized as the leading voice of the global hotel community, articulating the technology requirements of hotel companies of all sizes to the vendor community. HTNG facilitate the development of technology models for hospitality that will foster innovation, improve the guest experience, increase the effectiveness and efficiency of hotels, and create a healthy ecosystem of technology suppliers.

Table of contents

1 Preface

This guide has been created for hotel industry professionals interested in learning more about the best practices associated with designing and deploying an advanced, fiber optic cabling infrastructure within a hotel or lodging facility. Fiber optic technology is more affordable and versatile than ever and allows a property manager or owner to essentially "future-proof" the low voltage cable plant while providing added functionality and capabilities to the guests and staff.

Historically, data network design and deployment projects within a hotel have used a myriad of non-standard technologies, such as HPNA, vDSL, Ethernet-Over-Romex and Coaxial solutions to compensate for the true IP wiring deficiencies found at the property level. This is especially true for front-of-house cabling plants and those used for guest rooms. Each of the wiring platforms mentioned above was designed for a purpose-built, specific application (which initially had nothing to do with data transmission connectivity) that has been "modified" or treated with special electronics to drive a data signal over the wire. While these types of services have been particularly attractive to the hotelier due to their ability to eliminate the need to rewire, over the years these technology platforms have proven to have a short shelf life. Bandwidth restrictions, signal degradation, varying degrees of cable plant quality, as well as the proprietary nature of some of the technologies used have led to the need to replace these services over time. As a result, the hotel finds itself with a significant TCO (total cost of ownership) in addition to operational headaches caused by the constant need to upgrade the infrastructure.

Additionally, new hospitality-focused applications and use cases are consistently being introduced, adding credence to the concept of building or retrofitting an infrastructure that is versatile and robust enough to support them. This is combined with the advancements made in provisioning, designing and connecting fiber cabling, making it far more cost-effective than it has ever been.

While the concept of provisioning fiber to the guest room has been discussed and talked about for many years, and some early-adopter hoteliers have deployed the technology in select properties, the notion has not really caught on wide scale. The hope is that this guide and the other educational fiber seminars offered by HTNG will create a momentum shift by demonstrating to the hospitality community the benefits of building long-term cabling infrastructure utilizing fiber and fiber elements within their networks.

2 Document Information

2.1 Document History

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2.0	1 May 2017	Greg Dawes, Jeremy	Major overhaul of Power Design Options

	Barndt, Mark Conner, Chris Rivas, Patrick Dunphy

2.2 Useful Resources

- GPON Calculator – available at http://www.htng.org
- Fiber 101 Webinar – currently available at http://www.htng.org/webinars
- PON 101 Webinar – currently available at http://www.htng.org/webinars

3 Property Asset Considerations and Building Types

The overview presented here discusses the different property factors and considerations to be evaluated when scoping a low voltage cable design project with fiber optic cabling for a hotel property (including new building construction and retrofits).

3.1 Types of Building Layouts

3.1.1 Hi-Rise

The Hi-Rise tower configuration is the most common construction style used in large, full-service properties in urban settings. Stacked floors that are similar in nature will typically have common vertical pathways feeding to each of the floors with a Telecommunications Room (TR) or "closet" nearby. The TR is typically used to terminate the vertical or "riser" cable being run from a centralized Equipment Room (ER) that is normally somewhere close to the main/ground-level floor of the property.

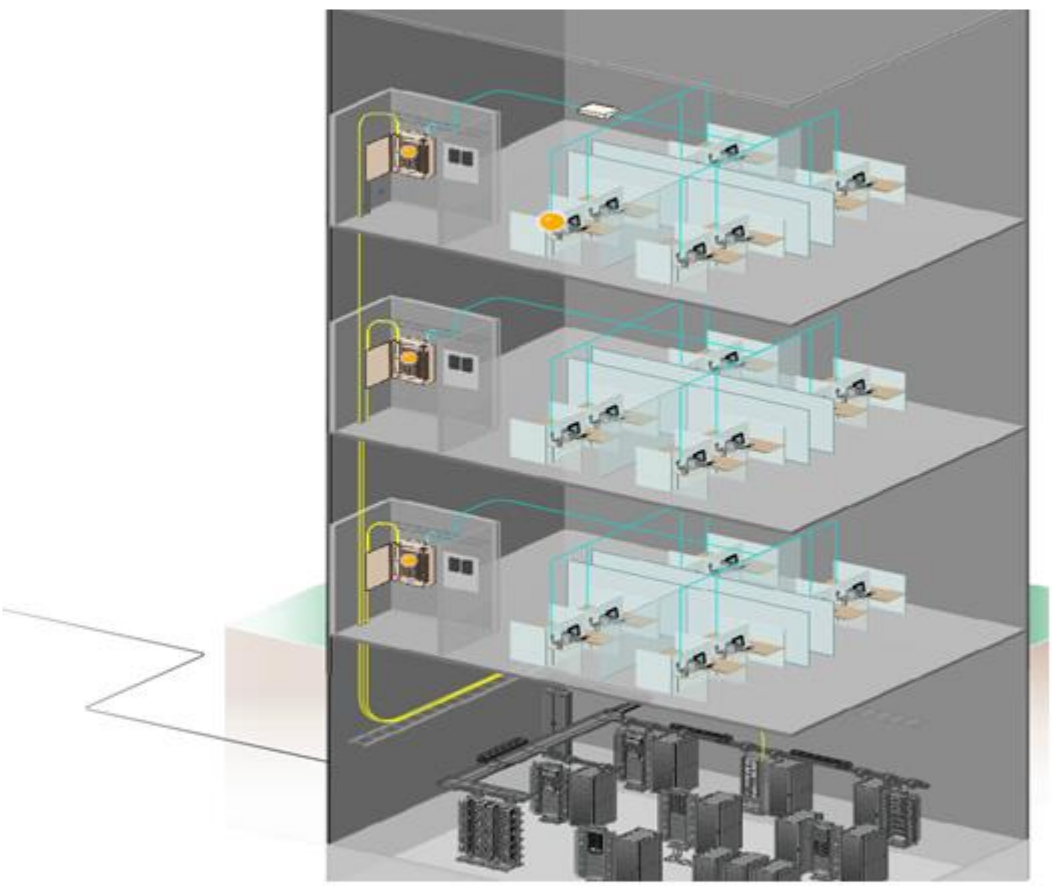


Figure 3-1

Figure 3-1 This depiction is a cross section drawing of a Hi-Rise tower configuration that illustrates an example cable plant environment.

As shown in Figure 3-1, the vertical riser cable is designed as a Fiber optic trunk, as the tower is usually designed with open vertical pathways to accommodate cabling, conduit, plumbing runs and the like. These vertical runs are generally devoid of severe bends or right angle turns that historically have created signal loss in fiber runs. Once the fiber cabling is terminated at the TR, signal delivery to the rooms has commonly been designed using copper cabling (e.g. CAT 5, 5e, 6, or 6a)

3.1.2 Resort

Resort construction typically integrates traditional hotel form and function with additional or multiple entertainment, recreational and dining venues in one self-contained unit. Connectivity requirements are varied and diverse, requiring the low voltage plant to adapt to the requirements needed. As a general rule, the multiple venues supporting the diverse activities on property can create requirements that extend past a traditional brick and mortar guest room tower. Connectivity and cabling requirements could extend to:

- Casino/Gaming Areas
- Pool Deck
- Restaurant/Bar
- Entertainment/Stage Area
- Fitness Center
- Kids' Clubs
- Retail Venues
- Beach/Waterfront Areas

3.1.3 Convention Center Property

In a convention center property, which is built adjacent to or as part of a municipal convention center, one would find the tower configuration described in section 3.1.1 for the sleeping rooms, and would also encounter a large amount of convention or meeting space. The meeting space is usually confined to a certain area of the building, and is more distributed than conventional guest room space. Generally speaking, the meeting room space in this type of property has extensive delivery mechanisms from the back of the house to service the guest and/or meeting participant, including ease of access to cabling pathways and access to the ER or TR. Copper cable length limitations that may be experienced on guest room floors are usually not found in the meeting areas except for the largest of properties.

3.1.4 Campus Style

Requirements for a campus style property draw from elements for both outside cable plant (OSP) as well internal building cable delivery methodologies. A typical campus style arrangement, seen in many instances in the time-share and resort-focused sub-verticals, is developed on multiple acres with distributed residences and/or sleeping units. The distance between buildings lends itself well to fiber cabling deployments.

Figure 3-2

Note the generic layout of a campus style property shown in Figure 3-2.

The OSP approach differs from intra-building cabling deployments in that you need to incorporate cabling contingencies for new buildings. There may also be unique environmental issues, as well as issues with shifting conduit runs that have been previously buried. Pre-planning the conduit runs and providing for future growth at the outset will save considerable expense for any expansion or changes.

3.1.5 Historic or Older Buildings

Historic buildings, which have stood the test of time by operating as a lodging property over years, decades or centuries, can pose unique challenges to the owner or operator. Absence of modern construction methods, ad-hoc construction or building activity (i.e. expansion) that lacks planning and utilized outdated building materials can create uncertainty and surprises as it relates to the design and deployment of a cable plant within these properties. Extra care and diligence needs to be taken during the design and survey activities to reduce the likelihood of construction anomalies that could potentially increase scope costs.

Fortunately, with the properties of modern fiber (bend insensitive, compact design), retrofits for this type of building are now typically easier and less costly to complete.

3.2 Construction Styles

3.2.1 Stick-Built

In its purest sense, a “stick-built” structure is one that is entirely built on the construction site, not pre-fabricated. However, this term typically also extends to properties that have been built with walls/floors using lumber construction materials. Low voltage cable deployment in these buildings does not have the expense of cutting or drilling through concrete to thread cabling, conduit or sleeves, which assists in keeping labor costs contained.

3.2.2 Concrete

Buildings using extensive concrete as a primary construction material can create cabling deployment challenges in a couple of ways:

- Coring or drilling can be time consuming and expensive.
- If the hallway ceilings within the property are hard-capped, it may be necessary to construct a chase, or concealed pathway, to string the cabling to the guest rooms.

Both items mentioned here will add to the scope and cost of a cable deployment if a retrofit (upgrade) is being done. Designed intelligently and planned properly, new construction properties can build a conduit distribution that works with the building materials instead of against it.

3.2.3 Hurricane and/or Seismic Rated

Buildings that have this designation or have been constructed to meet building codes in areas that are susceptible to these environmental conditions typically are built using reinforced masonry techniques, meaning there is steel combined with concrete within the structure of the building. This will further increase the labor cost and labor elements, if drilling or boring is necessary.

3.3 Asset Considerations

3.3.1 Owner's Objectives

A very important aspect to consider when planning for a cabling upgrade is to evaluate the useful life of the infrastructure that is being installed. TCO (Total Cost of Ownership) can and should be evaluated across the entire life-cycle of the low voltage system. In addition, operating costs for many of the network types described are also comparatively lower, which adds to financial attractiveness for operating the asset. Lastly, owners should consider what additional capital value is brought to the asset by installing an advanced information transport platform.

3.3.2 Brand-Imposed Standards

There are emerging discussions indicating that many of the large hospitality brands will start to issue low voltage cabling standards, similar to the standards issued for other technology-related platforms such as premium television or Wi-Fi. As these standards become required, the operators will be upgrading the cabling as part of property improvement projects dictated or recommended by the brand.

3.3.3 Asset Revenue and Net Operating Income (NOI)

Upgraded wiring will allow a more robust network infrastructure to be delivered, thus the ability to offer higher tiers of bandwidth for guest use could subsequently create a revenue stream. Additionally, the property will be able to provide enough throughput for bandwidth-intensive events if the cable plant is sufficiently designed, which will assist in driving additional top-line revenue for group business. Further, because the new fiber plant can act as a neutral host platform for multiple applications (no restrictions on bandwidth), the cost of deploying additional networks to address additional applications is reduced or eliminated, again aiding in cost reduction. NOI may be impacted negatively if the capital spent to deploy the cabling is amortized against property revenues.

3.4 Additional Building Considerations

3.4.1 Furniture, Fixtures, and Equipment (FF&E) Life Cycle

Depending on the scope of the cabling project, smart planning for a low voltage cabling upgrade includes working in coordination with other front-of-house renovations, such as guest or meeting room renovations for furniture, fixtures and equipment (FF&E). In many instances, construction crews are taking entire floors out of service to complete a renovation, so if cabling work needs to be completed in the hallways or guest rooms on those same floors, guest disruption is minimized and cable technicians can work uninterrupted. The other benefit is that if the rooms are vacant and without furniture, access to wall plates, cutting access panels and installing equipment in-room can be accomplished more easily. New in-room, guest-facing products that can leverage a fiber delivery to the guest room are now being introduced.

3.4.2 Space/Pathways/Distances

A critical element of any cable plant design, whether for a new-build property or a retrofit to an existing property, is to focus on the space, pathways and distances for the cabling runs. TR/ER placement, rack construction and access to power are also major considerations. It is remarkable that even in today's technology-centric society, hospitality properties are still being built without the proper thought given to these elements. In many retrofit environments, the existing phone room closets and Telco Entrance Facilities (EF) double as areas where a fiber patch panel can be placed. Existing conduit should be analyzed to determine whether enough capacity exists to pull additional cabling. All ER and TR locations should have enough light, power and space for a technician to be able to work comfortably, and these closets or rooms should also have defined access control to ensure security.

3.4.3 Power Consumption

For cabling infrastructures, and in particular cabling infrastructures that have active (powered) components, an engineered power distribution design that is safely and professionally deployed is important. The key elements include distribution, a protection (or alarming) system, power conditioning and battery backup.

4 Design Criterion

4.1 New Build vs. Retrofit

The opportunity exists for a new build property to design the proper specifications and physical building characteristics that will enable a low voltage cable plant to be deployed properly and with minimal project surprises. Involve an RCDD (Registered Communications Distribution Designer) early in the construction process to help guide/consult with the General Contractor (GC) and property design teams on the most optimal delivery mechanisms. Properly marked drafting diagrams and construction takeoffs enable a trained cable deployment professional to install an infrastructure that works as intended, in concert with any fire code or municipal requirements. As the cabling project moves from the design phase to the deployment phase, a safety plan should also be developed. Much of the work in a new build may be completed while the property is still an active construction site, so the emphasis on safety should not be overlooked.

Cabling retrofit design and planning differs in that the property is or has been a working commercial business and quite possibly will continue to do business while the project progresses. Designers and project planners need to think about items such as occupancy and guest room disruptions as a real part of the project plan. Cable pathways, TR/ER and power considerations have to be designed within the existing form factor of the building. There is slightly less emphasis on safety in a retrofit project unless there is general construction or renovation occurring at the same time of the cable deployment. However, hotel security should be involved in the project.

4.2 Applications

Applications have a large role in helping the RCDD design the appropriately sized network infrastructure with an adequate number of cabling runs. Scalability, compatibility and bandwidth consumption need to be gauged and the network should be budgeted appropriately. Common hospitality driven applications include:

- TV/Premium In-Room Content
- Voice (Guest and Staff) - VoIP / SIP
- Cellular (3G/4G Offload)
- DAS
- Energy Management Systems
- Building Management Systems
- Video/Security Surveillance
- Guest Broadband Requirements
    - Wired

  - Wireless
- Administrative Broadband Requirements
- IP Minibar
- IP Access control (Locks)
- Any Other IP Guest Room Device

4.3 Space and Pathways

Cable termination areas in a property where cabling could be patched, spliced or cross-connected are officially labeled as "Telecommunications Spaces;" however, they are more universally known as the Entrance Facility (EF), ER or TR locations. Design criteria include forethought around environmental and power conditioning, accessibility, proper clearance to mitigate electromagnetic interference (EMI) and conduit/pathway positioning. Careful planning of these areas will result in more space available for guest rooms and other hotel needs. Fire and life safety requirements should be considered in voice design and security surveillance.

4.4 Conduit Requirements and Open Space

Both Uplink (Backbone) and Horizontal distribution need adequate space. The ITS (Information Transport Systems) Designer should concentrate on a robust design for the pathways first and the cabling distribution second. This will ensure that the pathways will support the cabling installation for the life of the property. It is also prudent for the pathway design to have some overhead to support changes, if needed. Types of pathways commonly found in properties include:

- Conduits
- Cable trays
- Ceiling pathways
- Cable slings
- J-Hooks
- Surface mounted raceways

4.5 Financial Budget

Detailed surveys onsite for an existing property should result in an accurate Bill of Materials and Statement of Work for the scope of the project being requested. These two components will allow for a fair projection of costs and provide tangible information in managing budgets. See section 13 for example documentation.

5 Optical Fiber Network Design

5.1 Cable Plant Routing and Design

One of the most important first steps and best practices is to start with an Engineering firm that has BICSI certified RCDD engineers on staff, ideally with experience designing fiber to the room build-outs. You will need to have available for the engineers a good set of architectural drawings. Drawings available as CAD, or BIM files are ideal for use and modification to document the network design. If possible, contact the architect and/or building contractor at the beginning phase of your cable plant project. Having access to them means you have someone to ask for information and advice.

Design of the optical fiber cable plant requires coordinating with everyone who is involved in the network in any way, including IT personnel, company management, architects, engineers, equipment and software vendors, etc. to ensure all fiber requirements are adequately considered at the same time.

If the building is still in the design stage, you may have the opportunity to provide input on the needs of the cable plant. Having input at this stage of the network design will help to ensure that location of equipment rooms, routing of cable trays and conduits, availability of adequate conditioned power and separate data grounds, sufficient HVAC and other needs of the network are properly accounted for and part of the infrastructure design. Your certified engineer will be a great asset in this process to help ensure that all needs and requirements have been considered.

For existing buildings, detailed architectural drawings will provide the ability to identify where the existing infrastructures run and where the new cabling and network equipment can be routed if using existing routes is not an option. A site survey will need to be done regardless and will help to identify any obstacles or challenges that will need to be addressed to facilitate the fiber installation. This is a critical step in the network design to be absolutely certain all steps have been taken to identify the actual routes and obstacles. The engineer will then markup drawings to reflect the route and obstacles to running cabling and hardware, and walls requiring fire stopping that may not be on the current drawings. For buildings under construction, a site visit by your engineer is good so that they can get a feeling of what the final structure will be like and to get to know the construction managers with whom they will be working. The construction manager will be a great source of information on the local authorities who will be inspecting the work and what their expectations are.

There are several items that will need to be identified and addressed as part of the overall design. The physical routing of the cable plant is affected by several factors, including the choice of communications equipment, alarm systems, video surveillance cameras, access systems, HVAC systems, in room systems and amenities, and the list goes on. They are all subject to and may be impacted by building codes and regulations. Again, your certified engineer will know what these are and is a vital member of your team.

5.2 Design and Deployment Considerations for Installing a Passive Optical LAN (POL)

Contrary to traditional network topologies, there is no single standard way to cable a POL. Designs will vary based on the requirements of the end user and the unique characteristics of the property. Design firms will take into consideration many factors such as Ethernet port density, aesthetics, conduit and pathways, cost, wired vs. wireless, purpose of the space and future expansion with technology, such as the Internet of Things and Distributed Antenna Systems. In practice, this may mean a zone architecture that eliminates Telecommunications Closets or it may mean a star topology that uses the closet as a consolidation point. The flexibility of the POL architecture is one of its key features. Unlike traditional architectures, this infrastructure will last the life of the building so it is important to select quality products from reputable manufacturers to ensure optimum performance and longevity.

Here are some examples of POL design considerations:

Centralized Home-Run Splitting

With a centralized splitting design, all of the splitters for the POL are located in a single location in the building, usually the Main Distribution Frame where the OLT is located. Some perceive that there is a benefit to keeping the single input strand to the splitter as short as possible in order to reduce the risk of taking down a whole group of users. On the flip side, this design requires more pathway space and a cable tray similar to other traditional home run designs. In multi-story establishments this can cause administration problems and MACs become difficult. Any home run cable that extends from the ER to the end user location creates the potential for expensive repairs in the event of cable damage.

Distributed Splitting

There are two main ways to accomplish this type of design. The first method is with optical fiber cables to the individual work area outlets or wall-mounted Optical Network Terminals (ONT). The second method is with multi-fiber cables that are terminated with MPO-style connectors to zoned distribution housings near the end users. Both methods may use rack or wall-mounted splitters in the ER/TR. The first method is a traditional star topology using pre-terminated or field-terminated single fiber cables that extend into the user environment using less cables and pathways than traditional architectures but more than the multi-fiber solution. The single fiber cables are small, lightweight and are often installed using inexpensive J-hooks or fit easily within existing cable tray. This installation is best used in an environment with few moves, additions and changes to admin offices, conference areas served by wireless access points or a check-in desk. The multi-fiber method blends a star topology with a zone topology. The fibers are typically bundled in a 12 fiber cable with 12 fiber MPO connectors terminating on cassettes in the TR and near the end user, which reduces cable bulk in the pathways. A distribution terminal is located in the user environment in order to distribute short single fiber cables to work area outlets or wall-mounted ONT's. This design increases flexibility with moves, adds and changes as the single fiber runs are very short. Since it mimics a zone distribution in increments of 12 fibers, it is less efficient in its use of splitter ports. This design lends itself to fiber to the guest room as well as conference rooms with many RJ-45 outlets. A conference space that primarily uses Wi-Fi would not benefit from this design. Both designs lend themselves well to upgrading to future generations of POL electronics, but are not the best option for those seeking physical path redundancy.

Zone Splitting

Zone splitting is the most widely deployed architecture as it is typically the most flexible and least costly of the 4 POL designs. With this design you are able to bypass the TR or you can use a small wall-mounted demark to provide an administration point. From here you use an inexpensive single fiber into the horizontal to serve a splitter located in the zone. These fibers and splitters can easily be bundled if requirements dictate. Using low cost single fiber cabling reduces the total cost of the project while providing the benefits of zoned cabling near the end users. Moves, adds and changes are inexpensive while the cost of providing future growth to an area is low. In MDU solutions this is a good way to retrofit an existing building with challenging pathways. A zone can be mounted in a variety of locations, such as in ceiling tile enclosures, under raised floors and inside modular office furniture. Zone splitting places the splitter closer to the group of end users. This is a great benefit as long as the density of users in the area matches up with the splitter density. This can be mitigated with creative designing, but sometimes it just doesn't work as desired. Zone splitting is especially effective in redundancy designs which will be discussed later, and is effective for upgrading to future generations of POL electronics.

Redundancy (FSAN-B)

While not a standalone design, some applications require automatic failover protection. This automatic failover redundancy is referred to FSAN-B in the POL world. The idea is that you have two separate PON ports on two separate PON cards either within the same Optical Line Terminal (OLT) chassis or in some cases, separate OLT chassis that each feed an input to a splitter that accepts two inputs such as a 2x4, 2x8, 2x16 or 2x32. When the primary fiber path is interrupted at any time, the management system detects the interruption and decides if the interruption occurred before or after the splitter. If it is after the splitter, usually only one ONT was disturbed and a help desk ticket is generated. If all of the ONTs lose connectivity, it is assumed that the interruption was caused by something between the OLT port and the splitter input. In that case, the OLT(s) switch over to the redundant port and restores service. This typically happens in less than 230ms, so fast that an IP phone call will not be interrupted. This FSAN-B feature, along with redundant system controller cards, redundant uplink cards and redundant external power supplies and fans, gives the POL a rating of nearly six nines (99.9994) of availability or uptime. Redundancy costs must be weighed against the benefits. Some critical applications such as securities trading floors, mission critical military and government applications, some healthcare applications and critical service operations require redundancy. For cable and component selections, it is recommended that all new construction designs incorporate 2x32 splitters to provide the option for redundancy, upgrades to future generations of POL electronics or a combination of both.

Upgrading to Future Generations of POL Electronics

Unlike traditional networks where you rip and replace stacks of switches and upgrade everyone on the network whether they need it or not, PON networks allow you to only upgrade those users that actually need the additional bandwidth. What separates PON from traditional architectures is that the technology leverages its use of optical fibers for its upgrade path. Traditionally, you could only have one technology running on your cable infrastructure at any given time. A change in technology meant a change in electronics and in cabling. With PON, you have voice, video, 1G, 10G and beyond all on the same fiber. It uses different colors of light to transmit each technology so they do not interfere with each other. This means you simply design your cabling for the number of users you want and the services are added as they are needed where they are needed. Installing a dual input splitter is a prudent decision as manufacturers are mixed on how they will deploy next generation speeds. Some manufacturers will use optical filters so you won't need the two inputs while others may deploy standalone devices that would require a dual input splitter. If you are installing a redundant network that uses the second input, you still have an upgrade path. You simply need to ensure that your manufacturer is going to use filters to provide multiple rates over the same fiber. Regardless, installing a 2x32 splitter up front provides a hedge for redundancy while safe guarding your upgrade path to 10G and beyond.

5.3 Installation Process

There are many different component types manufactured by different companies; each having a potentially different installation method for safety, performance and reliability. It is our recommendation to follow the specific installation specifications, guidelines and best practices provided by the manufacturer of the gear. Some companies may require a certification of training to ensure proper installation for warranty purposes.

In addition to manufacturer recommendations, it is the responsibility of the installer to adhere to all local, state and national codes where applicable. The Authority Having Jurisdiction (AHJ) has the final say regarding what is or is not acceptable.

In some cases, published specifications such as those published by EIA/TIA and best practices manuals such as those published by BICSI may be applicable and provide guidance for installation practices. For example, the BICSI Telecommunications Distribution Methods Manual (TDMM) 13th edition contains more information on installing a Passive Optical Lan (POL). There is also activity within the standards bodies to develop a specification or a section of a specification that directly applies to POL.

5.4 Testing

__Warning__: *Never look directly at the end-face of any connector, magnified or not, without first verifying that it is not connected to a live light source. The wavelengths used for optical fiber communication are invisible to the human eye, but can cause serious eye damage.*

There are numerous ways to perform verification testing on an optical fiber network. The three most common are to use a Light Source/Power Meter (LSPM), an Optical Time Domain Reflectometer (OTDR), or the built in source and power monitoring for the network. It is advised to contact the manufacturer of the passive gear to verify that your chosen testing procedure falls in accordance with the requirements specified in their warranty documentation.

The most advisable method is the use of an LSPM, especially in cases where the cable plant is installed at a different time and by a different party than the electronics gear. It is beyond the scope of this guide to specify makes and models of LSPM devices. Again, it is advisable to verify that the unit you plan to use is approved and acceptable by the passive products manufacturer for warranty purposes.

Light Source / Power Meter (LSPM)

When using an LSPM to test an optical fiber network, the single fiber pathway should be tested for applicable wavelengths, which are found on most single mode LSPM test sets. It is advisable to follow testing specifications given by the optical fiber manufacturer in order to comply with their warranty requirements if they differ from the procedure below. All 4 steps are beneficial to ensure that any faults may be quickly isolated and remedied, but the final test is likely going to be submitted for warranty and as-built purposes. All of these tests can be performed by a single technician. Note that the following steps are not intended to identify every step in the testing process. It is assumed that the installer is using best practices such as proper cleaning and appropriate jumper referencing. Entities such as BICSI, testing equipment manufacturers and passive components manufacturers can provide you with relevant testing procedures.

- **Step 1**: *OLT to Splitter* – Verify the cable plant from the location where the equipment cord from the OLT makes the first mating into an adapter or cassette to the point at which it mates to the input of the splitter. Each mated pair (two connectors and an adapter) shall be less than 0.75dB per EIA/TIA 568C. If you are testing an entire link that contains more than one mated pair, the allowable loss would be the number of mated pairs in the link multiplied by 0.75 plus the allowable fiber loss of 0.5dB per kilometer.

  Example: Your link has four mated pairs (8 connectors and four adapters) between the OLT and the splitter and the total distance is 300m (984ft). The allowable loss would be 3.15dB. The four mated pairs with a maximum loss of 0.75dB each allows a total of 3.00dB for the mated pairs. The distance of 300m is 0.3km (300m/1000m) and the allowable fiber loss for single mode being 0.5dB/km equates to 0.15dB (0.3 x 0.5 = 0.15) allowable cable loss.

- **Step 2**: *Measuring the splitter* (optional) – Not all LSPM test sets have the proper dynamic range to test through a splitter, especially those with a higher split ratio. Additionally there are two major types of splitters available on the market, fused coupler and the higher quality Planar Waveguide or PLC. The latter will typically have lower losses and tighter uniformity between output legs. A traditional mated pair loss calculation cannot be applied when testing a splitter. While the mated pairs do matter and factor into the calculation, there is an additional loss from the splitting itself. Each split ratio has a general loss value associated with it. When you add connectors to the splitter to form a module or cassette, those connections add additional loss. Check with the manufacturer of the splitter or reference the included test data to understand what the typical loss of your specific splitter as tested is.

  Note: If you are using a two input splitter, this procedure will have to be repeated for each input. The source side of the LSPM will be connected by a coupling adapter to the input of the splitter. The power meter unit of the LSPM will then be connected to output one of the splitters and a reading recorded. The power meter is then connected to output two and the reading recorded. This sequence is repeated in order until every output has been tested.

- **Step 3**: *Splitter to ONT* – Verify the cable plant from the splitter to the wall outlet or other final connection point excluding the equipment cord that connects to the input of the ONT. It is possible that the cable plant design includes a consolidation point (CP), a Multi User Telecommunications Outlet Assembly (MUTOA) or the like. In those cases you may choose to include these devices in the cable run or you might choose to verify them as separate sections. Each mated pair (two connectors and an adapter) shall be less than 0.75dB per EIA/TIA 568C. If you are testing an entire link that contains more than one mated pair, the allowable loss would be the number of mated pairs in the link multiplied by 0.75 plus the allowable fiber loss of 0.5dB per kilometer as was illustrated in Step 1 above.

- **Step 4**: *Testing the entire link, OLT to ONT* – Verify the cable plant from the location where the equipment cord from the OLT makes the first mating into an adapter or cassette to the point at which it mates, through the splitter and to the wall outlet or other final connection point, excluding the equipment cord that connects to the input of the ONT. This is the test that most manufacturers will require for warranty registration. Each mated pair (two connectors and an adapter) shall be less than 0.75dB per EIA/TIA 568C. If you are testing an entire link that contains more than one mated pair, the allowable loss would be the number of mated pairs in the link multiplied by 0.75, plus the allowable fiber loss of 0.5dB per kilometer.

  Example: Your link has eight mated pairs (16 connectors and eight adapters) between the OLT and the wall outlet, including the 1x32 splitter, and the total distance is 500m (1640ft). The allowable loss would be approximately 22.25dB. Each of the eight mated pairs with a maximum loss of 0.75dB allows a total of 6.00dB for the mated pairs. The distance of 500m is 0.5km (500m/1000m) and the allowable fiber loss for single mode being 0.5dB/km equates to 0.25dB (0.5 x 0.5 = 0.25) allowable cable loss. The typical splitter loss for a 1x32 splitter is approximately 16dB, excluding the connections because we have included them in the mated pair count. Per ITU G.984, current Gigabit Passive Optical Network (GPON) systems with standard Class B+ optics allow for a maximum channel loss of about 29dB.

Optical Time Domain Reflectometer (OTDR)

An OTDR can be a valuable tool to verify the cable plant of an optical fiber cable plant. An OTDR uses pulses of light to detect cable losses, splices, connections, break points and other anomalies. The OTDR is also a very accurate tool for measuring the length of the cable. Most OTDRs have a graphical depiction of every event in the link. OTDR measurements are not without inherent challenges. Not all OTDRs can properly handle the typical losses of higher splitter counts. When this happens, the OTDR sees the large loss and assumes that it is the end of the link. More modern OTDRs, and those that can and have had their software updated, can recognize the typical loss values of each split ratio and some will even insert a graphic of a splitter and ask you to confirm that it is indeed a splitter. They are great tools for trouble shooting and potentially highlighting hidden issues, but most manufacturers and end customers in North America will not accept OTDR traces as the primary acceptance criteria for warranty registration with traditional topologies. In Europe, Middle East and Asia, OTDR traces are an acceptable validation document, but it should be noted that the procedure they use differs from how most people use an OTDR in North America. It is up to the individual manufacturer whether or not they will accept OTDR traces.

When testing with an OTDR, you simply connect the dead zone cable or output cable from the source of the OTDR into the input of the location where the equipment cord from the OLT makes the first mating into an adapter or cassette. From there you can start the test. In this configuration you will see all of the paths as one combined trace. You can trick the OTDR into seeing an individual leg by attaching a long dead zone cable at the far end wall outlet. The ideal method would be to deaden the reflection on all splitter legs except the one that you are attempting to verify, but that is highly impractical from both a time and cost standpoint.

Another method of OTDR verification would be to connect the OTDR to the wall plate outlet of splitter output one and record the trace. Then you move to the wall plate outlet of splitter port two and record the trace. Repeat this sequence until all ports are tested.

Management System GUI

Most, if not all, of the manufacturers of active POL gear have a central management system that allows you to configure, manage and monitor the entire system. One of the features is the ability to monitor raw power readings. The management system can monitor the exact dBm output of a given OLT port and compare that to the exact dBm received by each ONT to determine the exact system loss or performance. Those values are stored in a .csv file that can be exported to Excel or Numbers. Some manufacturers may accept those values as system testing for warranty registration. It is advisable to verify this with the specific passive product manufacturer. This method is only recommended when there is a single integrator of the active and passive gear or if the cabling is installed at the same time as the active equipment.

Copper Cable Testing

As with traditional networks, you are normally not required to include the Category rated twisted pair equipment cords. There is an exception to this rule when using a cabling design where the ONTs are located in the TR or TR and solid conductor Category rated twisted pair copper cable is home run to each work area, camera, access point, etc. In cases such as this, the long distance copper cable is considered horizontal cable and must be tested and certified to the standards for that specific category of cable just as it would in a traditional network.

5.5 Certification and Documentation

Proper and accurate documentation is important for warranty registration, customer records and liability purposes. It is advised that the end customer and the manufacturer of the passive gear be contacted to verify each of their desired and acceptable forms of documentation. In some cases one set of documentation will satisfy both, while in other cases it may not. There may be a preference for electronic over paper documentation and in some cases paper documentation is not accepted at all. The most important part of the documentation is the accuracy of the location, data and labeling. Most manufacturers will also look to verify that reference values on the LSPM were set to 0dB.

6 Sample Design Topologies

The following sections detail Passive and Active Optical Networks from a wiring design point of view. Due to the unpredictable nature of construction, available areas to route cabling and the number of required data connections, these designs are not exhaustive and do not necessarily cover every situation.

6.1 Passive Optical Networks

To better understand a Passive Optical Network design lets first look at an Active Ethernet design using Multimode Fiber (MMF) on the verticals (risers) and copper on the horizontals. This network design utilizes Ethernet switches distributed throughout the property to provide connectivity to the common areas, conference centers, guest rooms and the other areas needing coverage.

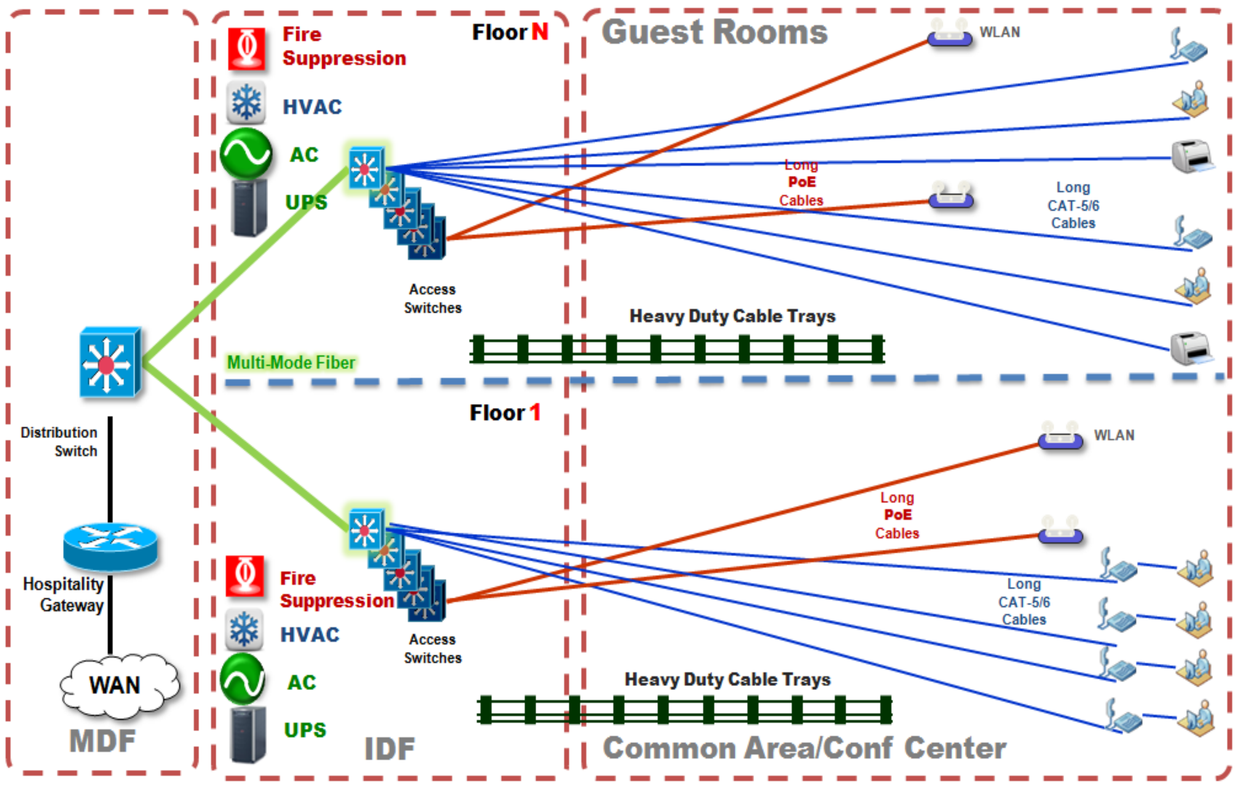


Figure 6-1

A typical network design looks like Figure 6-1.

In the ER there is WAN access connected to a hospitality gateway device and a core switch for the whole property. The core switch usually has Multi-Mode Fiber connecting to all of the TR closets.

In the TR, the MMF connects to one or more distribution switches. These switches require AC power and typically an Uninterruptable Power Supply (UPS). These devices can create a great deal of heat, so the closet must have air conditioning and fire suppression mechanisms. Copper Cat 5e / Cat 6 cables are used to connect devices in the hallways, common areas, conference centers and guest rooms. The distance limitation for the copper cables is 100 meters. Some of the devices supported from this closet are also powered from the distribution switches using Power over Ethernet (PoE). The longer the copper the more power loss, so typically the lines must supply extra voltage and wattage to compensate creating even more of a power draw inside the TR.

Common Area/Conference Center/Guest Rooms - Cat 5e or Cat 6 cables will connect directly to computers, telephones, Wireless Access Points, TVs and anything else requiring Ethernet connectivity.

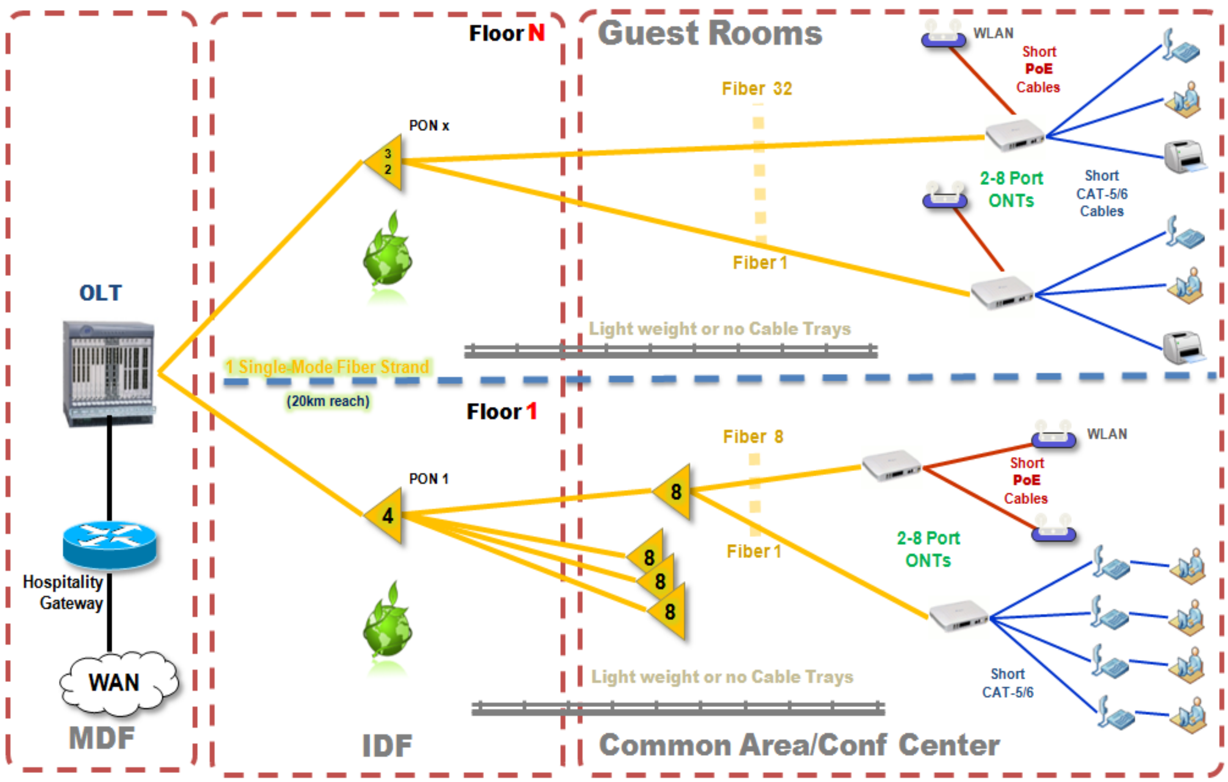


Figure 6-2

Figure 6-2 is a typical Passive Optical Network design for a multistory building. A single strand of Single-Mode Fiber (SMF) is all that is required for the infrastructure between the Optical Line Terminal (OLT) and each optical splitter and between the optical splitters to each Optical Network Terminal (ONT). It should be noted that fire suppression is still required even with only passive elements by NFPA 70.

In the ER not much is different from a typical copper-switched network. WAN access is required for Internet connectivity and a hospitality gateway would typically be used for guest services. The PON OLT is connected directly to the hospitality gateway or a core switch. A single strand of Single-Mode Fiber is all that is required for the connection from the OLT port to each optical splitter. However, structured cabling standards require at least two strands; the second strand to provide for future expansion and / or redundancy; and to accommodate a potential future application that is not compatible with PON.

Optical splitters can be located in the TR but since these are passive devices and are a relatively small form factor, they can be mounted on a wall in a house keeping closet or maintenance closet. In some cases, a single TR is shared amongst multiple floors. Splitters can be stacked as in the Common Area/Conference Center example above where a 1:4 splitter is used in the TR and then 1:8 splitters are connected to it.

Lobbies, business centers and conference centers may require one or more multiport ONTs to support the different services and different devices connected to it.

Every IP or Ethernet based service in the guest rooms can be connected to the ONT and supported by the SMF. There are even provisions for QAM TV utilizing the RF Overlay feature supported by the different PON technologies. Some ONTs provide Power over Ethernet (PoE) so VoIP phones and Wireless Access Points can be powered by the ONT. Some ONTs also have a connection for standard analog hotel phones so the property can have a VoIP switch but still use the lower cost analog telephones.

6.2 Active Networks

Another option for Fiber to the Room (FTTR) is to deploy an active fiber network. The topology is very similar to PON except active switches replace the passive splitters.

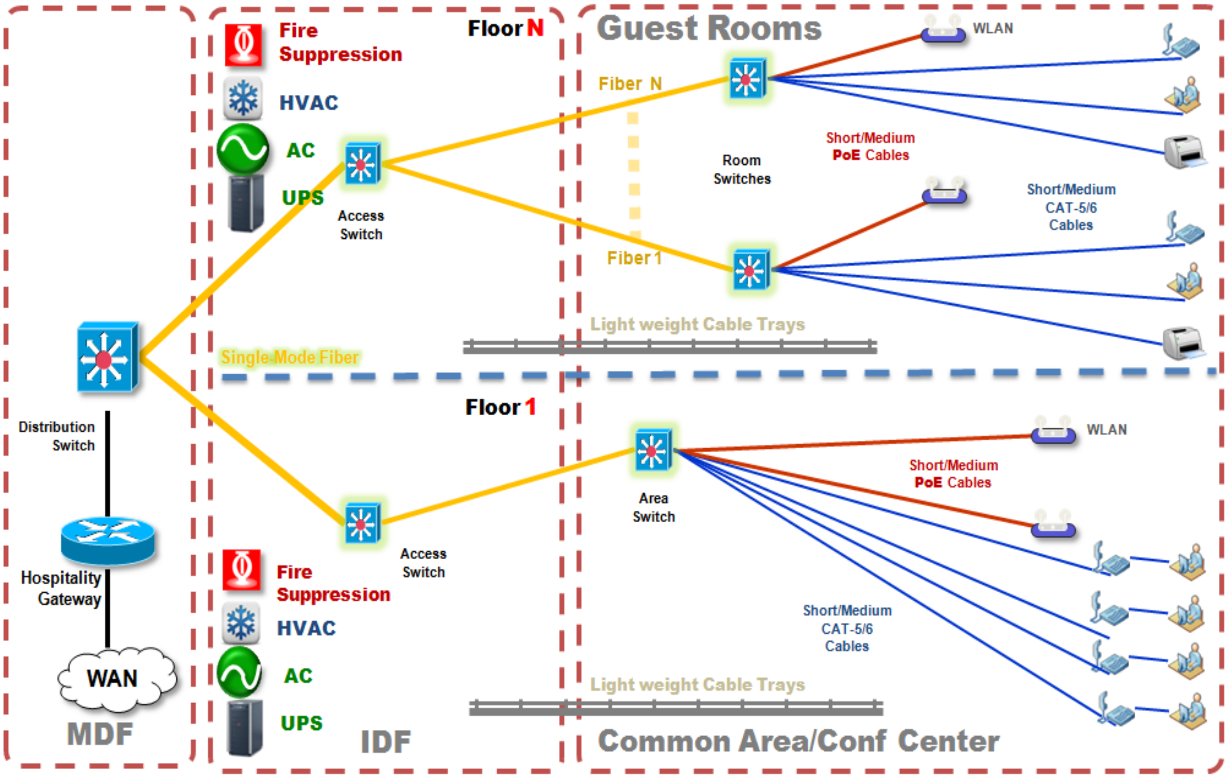


Figure 6-3

Figure 6-3 is an example of this network design.

In the ER there is WAN (wide area network) access connected to a hospitality gateway device and a core switch for the whole property. The core switch will have SMF connecting to all of the TR closets or the edge device located in the guestroom, an intermediate switch is not required though it is generally recommended to consolidate signals of multiple fibers into fewer fibers so the core switch does not have to be as populated.

If the TR is used on various floors, the SMF connects to a fiber distribution switch. This switch requires AC power and it is recommended to provide Uninterruptable Power Supply (UPS). The closet must have air conditioning and fire suppression mechanisms to satisfy the requirements of the National Fire Protection Administration (NFPA) as does every room within a commercial facility.

In general, a hybrid cable consisting of fibers and a copper pair for UPS power will be run from the TR to the guest room where an edge switch is located. This creates a scenario identical to a POL or Passive Optical Network (PON). From the edge device short runs of copper cabling connect to guestroom devices. Edge switches can provide Power over Ethernet (PoE) to devices as necessary and the dual fibers can provide redundancy.

A major advantage of AON includes multiple options for deployment bandwidth. Currently available on the market today 10 Gb/s uplinks to the edge switch are available. In addition these edge switches can provide 10 Gb/s RJ-45 copper ports as well to support extreme data applications such as Ultra High-Definition TV (4K). While uncommon, both AON and PON can use 40 Gb/s and 100 Gb/s uplinks. GBICs are also available at a premium price through the use of multiple fibers.

AON also provides options for redundancy with multiple GBIC ports and active management tools.

Generally speaking, AON are more expensive to deploy. While the cost of the cabling infrastructure is the same as PON, most of the time AON will be more expensive when the total cost of ownership is considered.

Common areas or conference centers can be cabled using distributed TR/TR rooms and copper cabling or deploying edge switches to strategic locations and providing shorter copper runs. Power over Ethernet (PoE) can be supplied to devices that require it.

7 Vendor Selection Process Considerations

The following questions should be answered appropriately during the selection process or through research conducted by the project owner. While these are important questions, they are not exhaustive.

7.1 Experience and Capabilities

Bid Compliance

- Does the bidder meet all criteria delivered in the RFP?
- Which bidder is closest to fulfilling all of the RFP requirements?

Number of Properties Designed and/or Installed

- How long has the bidder worked in the Hospitality vertical?
- How many completed cabling projects and in how many properties?
- Are the cabling projects installed at the same level of complexity?

Certified Professionals on Staff

- Do the low voltage cable teams have RCDD, PMP, or RTPM designations?

General Workmanship

- Was the contractor's daily quality assurance plan reviewed?
- What are the established quality guidelines during the installation process that the contractor adheres to?

Familiarity with Fiber vs. Other Media

- Is the vendor a fiber/copper low voltage specialist?
- Is the low voltage effort a small division of an electrical contractor?

References Align With Project Being Considered

- Is the vendor providing project references that have commonality with the job being specified?

Financials

- Does the project bid have a tangible return on investment for the property?
- Are all the elements of cost related to the job identified? This would include all hardware, materials, licensing, permits, extended warranties, labor, project management, core drills, etc.
- What would the total cost of ownership be over a certain number of years?

Hotel Brand Standards

- Does the bidder have familiarity with brand standards appropriate to the RFP?

7.2 Knowledge Base

Optical Fiber Components and Systems

- What component manufacturers are being represented and incorporated into the solution?
- Does the cabling vendor possess the required knowledge and certifications from the component manufacturers to install the product?

Installation Processes

- Has the vendor itemized each task of the project timeline and provided time intervals on task completion?
- Are there installation SLA's offered as part of the bid?

TIA, BICSI Best Practices Alignment

- Is the vendor following the best practice installation doctrines published by the industry organizations?

Local Codes and Regulations

- Are all local, municipal and federal codes being followed?
- Will the vendor apply for and file the appropriate permits needed to execute on the work?

7.3 Services – New Build

Survey, Design, Construction

- Does the bidder complete all aspects of the job?
- Are there any contract or third party experts needed to complete the work?
- Are all parties bonded and insured?

Backbone Distribution

- Will the backbone (or uplink) require a 1GB or 10GB connection?
- Will the cabling be multi-mode or single-mode?

ER/TR Build-outs

- Does the vendor also complete rack space construction?
- Are the cabinets open or lockable, and do they require a UPS?
- What is the height needed for the rack space and will it be free-standing or wall mounted?

Data Rack and Computer Room Construction

- Has the prospective vendor worked in or designed low voltage systems in a cable-dense environment?

Testing, Permits and Certifications

- See local codes and regulations.

7.4 Services – Retrofit

Cable MAC's and/or Upgrades

- What warranties/guarantees are offered on cable plant construction?
- How modular or upgradeable is the plant being designed?
- Will there be unused strands of copper or fiber pulled? If so, will they be terminated?
- Does the conduit have open capacity for additional cable media to be pulled?

Cable and/or Plenums Replacement or Removal

Does the bid include the removal of pre-existing cable, conduit, pathways, wire mold, racks, punch-down blocks, plenums, etc.? This is an often overlooked element of the job, and can push labor dollars significantly higher. Most large full-service properties will have the engineering department complete this work once the new network is operational.

8 Project Management

Project Management is a process of applying known techniques, skills and tools to achieve project objective(s). This is highly important in a cabling project due to the large number of moving parts involved.

8.1 High-Level Project Management (PM) Steps Involved

8.1.1 Initiating the Project

The initiation of the project starts with the stakeholder in an ownership or management role realizing and stating a need or desire for specific improvement, such as improving the bandwidth, reliability and longevity of the communications infrastructure to the guest rooms.

8.1.2 Building a Project Management Plan

Once the project is initiated and authorized, a project management plan needs to be created. The Project Management Plan is a core document defining all key aspects of the project, including planning, implementation, tracking and closing.

8.1.3 Project Implementation

Once the Project Management Plan is complete, it is time to execute the project. Project design documents need to be developed, vendors need to be selected, the site needs to be prepared for cable and equipment installation, materials need to be purchased and subsequently installed, cables need to be labeled and tested, and quality assurance needs to be performed for adherence to design documents and industry standards.

8.1.4 Monitor and Control the Project

Once the project has initiated all the key parameters need to be tracked, monitored and controlled.

8.1.5 Closing the Project

Once the installation is complete, all activities and paperwork need to be finalized. All closing documentation needs to be submitted, reviewed, approved and archived.

8.2 Key Areas of Management for the Project

8.2.1 Project Human Resources Management

Project Human Resources Management involves such processes as developing a human resources plan, acquiring a project team, developing a project team and managing the project team.

8.2.2 Project Scope Management

Project Scope Management involves such processes as collecting requirements, defining scope, creating a Work Breakdown Structure (WBS), verifying scope and controlling scope. The project scope is the work that needs to be done in order to deliver the desired outcome.

8.2.3 Project Integration Management

Project Integration Management involves such processes as developing a project charter, developing a project management plan, and directing and managing the project execution.

8.2.4 Project Time Management

Project Time Management involves processes needed to ensure that the project is completed on schedule. These processes are identified as Define Activities, Sequence Activities, Estimate Activity Resources, Estimate Activity Durations, Develop Schedule and Control Schedule.

8.2.5 Project Cost Management

Project Cost Management involves estimating projected costs of activities, creating budgets and controlling costs.

8.2.6 Project Quality Management

Project Quality Management involves identifying quality requirements, auditing quality requirements (verifying if proper quality standards are used) and performing quality control.

8.2.7 Project Communications Management

Project Communications Management involves identifying stakeholders, planning communications, distributing information, managing stakeholder expectations and reporting performance.

8.2.8 Project Risk Management

Project Risk Management involves planning risk management, identifying risks, performing qualitative risk analysis, performing quantitative risk analysis, planning risk responses, monitoring and controlling risks.

8.2.9 Project Procurement Management

Project Procurement Management involves planning procurements, conducting procurements, administering procurements and closing procurements.

8.3 Project Plan Development

8.3.1 Scope Breakdown by Work Elements

Scope Breakdown by Work Elements or Work Breakdown Structure (WBS) is a tool using hierarchical decomposition of the entire scope of work into smaller discrete elements.

8.3.2 Resource Allocation and Planning

Resource Allocation and Planning is part of the resource management. It is instrumental in assigning resources available for the project in a most economical fashion.

8.3.3 Safety Plan

The Safety Plan is important for any construction project. The safety plan shall include any measures the company involved in the construction project is undertaking. This includes, but is not limited to: appointing project safety leadership team, initial safety training, regular safety meetings, strict enforcement of safety rules, etc.

8.3.4 Permits

Construction/Building/Low Voltage permits are typically required by local Authorities Having Jurisdiction (AHJ) before work commences. The inspectors typically conduct the inspection during the construction/installation and after completion, to ensure code compliance.

8.3.5 Project Time Tracking Methods

There are several tools available to Project Managers for tracking project time:

- Program Evaluation and Review Technique (PERT) – an estimating technique used when there is an uncertainty with the estimates for individual activity. It uses weighted average of optimistic, most likely and pessimistic estimates:

  Estimated Time = (Optimistic + Most Likely X4 + Pessimistic)/6

- Critical Path Method (CPM) – a scheduling technique used to determine how much flexibility exists on different logical network paths.
- Gant Charts – a graphical representation of the schedule-related information.
- Calendar – there are a variety of calendars which may be used for project management, including, but not limited to Google Calendar and Microsoft Office calendar.

8.3.6 Quality Checks

Quality checks need to be accomplished during all phases of the project, from checking initial design documentation to the final product. In some instances, a third party will conduct quality control on behalf of either party involved in the project.

8.3.7 On-Property vs. Remote Project Management

On-property project management is typically more beneficial for the project. When the project manager cannot be onsite continuously, they will have to rely on the information from the onsite supervisor. Even if project manager works remotely, it is common practice for them to visit the site regularly to have better understanding of the project progress.

9 Cabling, Materials and Component Guide

9.1 Cable Location

The first step in selecting an optical fiber cable is determining the environment in which the cable will be installed. Generally, there are three categories of cable for different installation environments: Indoor cables, Outdoor cables and Indoor/Outdoor Cables. Each of these types of cables is designed to operate in its specific environment.

9.1.1 Indoor Cabling

Indoor cables are designed to remain inside the building environment in Backbone or Horizontal pathways, as well as in patch cords. The key design element of an indoor cable is its Flame Rating. Different regions of the world have different requirements, but there are generally different levels of Flame Retardant capabilities built into the cable. In the United States, for example, there are two primary flame ratings used for in-building cables: Plenum rated and Riser rated. Plenum rated cables will have lower smoke and fume emissions in a fire than will a Riser rated cable. Plenum rated cables are generally more expensive than Riser rated cables, but are mandated in most jurisdictions for placement in air-handling (Plenum) spaces. If you have questions about the requirements for your location, you should check with your local building inspection office. These requirements may vary by locale.

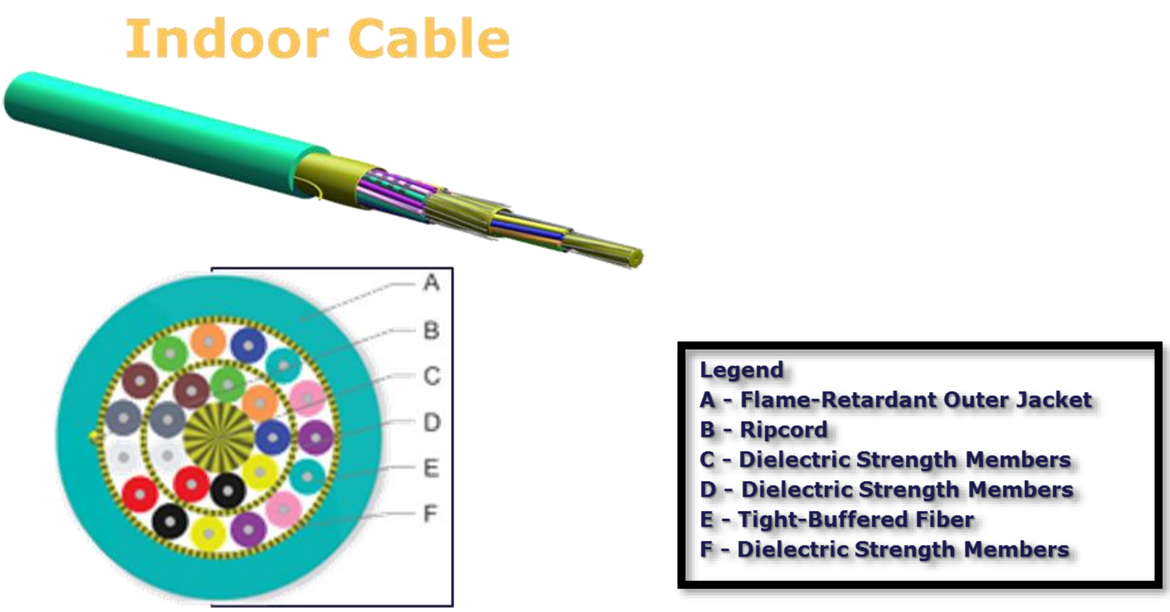


Figure 9-1

Figure 9-1 depicts the typical construction of an indoor cable.

In the United States, optical cables used indoors will be labeled during manufacturing (generally via a readable print statement on the cable) with a four-letter designation: OFxx. The first two letters stand for Optical Fiber. The next two characters are very important. The third character indicates the electrical conductivity capability of the cable and will be either “N” (nonconductive) or “C” (conductive). Since optical fiber and most of the materials used to place the fiber in a cable do not conduct electricity, “N” is the most common type. However, if a cable is armored with some type of metal protective layer, the cable will be labeled with a “C.” Cables that contain conductive elements must be grounded per the local regulations. The last digit indicates the Flame Rating. Typical Ratings are “P” for Plenum and “R” for Riser. These ratings are verified and tested by Underwriters Laboratories.

Common Designations:

- OFNP – Optical Fiber Nonconductive Plenum
- OFNR – Optical Fiber Nonconductive Riser
- OFCP – Optical Fiber Conductive Plenum
- OFCR – Optical Fiber Conductive Riser

It is important to understand the local regulations, since a building inspector that would see an OFNR cable in a plenum-rated space would likely require the offending cable to be removed and a new cable placed.

Color	**Fiber Type**	**Grade**	**Example**
Orange	Multimode	OM1 or OM2	
Aqua	Multimode	OM3 or OM4	
Yellow	Single-mode	OS1 or OS2	

Table 9-1

Indoor cables are colored according to the fiber type contained in the cable, as detailed in Table 9-1.

9.1.2 Outdoor Cabling

Cables designed for the Outside Plant (OSP) are designed to withstand wide temperature ranges and harsh conditions (rain, wind, freezing, etc.). The most common OSP cable is described as a Loose Tube Cable. In some cases, a steel armor tape is used to protect the cable.

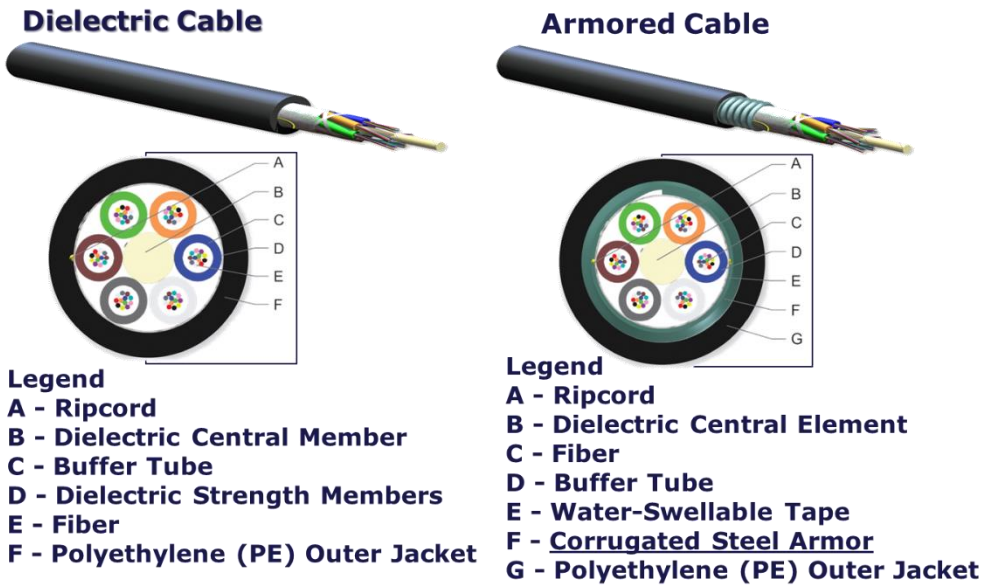


Figure 9-2

Figure 9-2 depicts the cabling differences between dielectric and armored cable.

The Loose Tube cable can be used in nearly all OSP installation scenarios. They are generally installed under the ground via a duct system or direct-buried, or above-ground on utility poles.

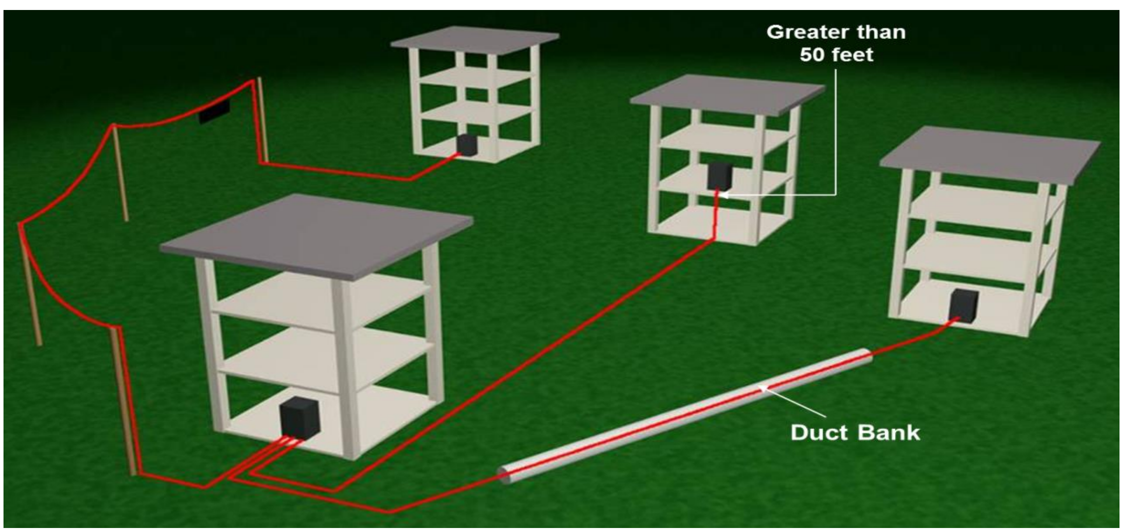


Figure 9-3

Figure 9-3 is a generic diagram of armored cabling and ducting in an outdoor environment.

9.2 Fiber Types

There are two primary fiber types: Single-mode (SM) and Multimode (MM). Single-mode fiber has one mode (stream) of light during transmission. Multimode fiber has multiple modes of light during transmission. Having more modes does not mean more bandwidth. Single-mode fiber has virtually unlimited bandwidth, but generally uses more expensive lasers for transmission. Multimode fiber has limited bandwidth and distances, but uses less expensive Vertical Cavity Surface-Emitting Laser (VCSEL) or Light Emitting Diode (LED) technology.

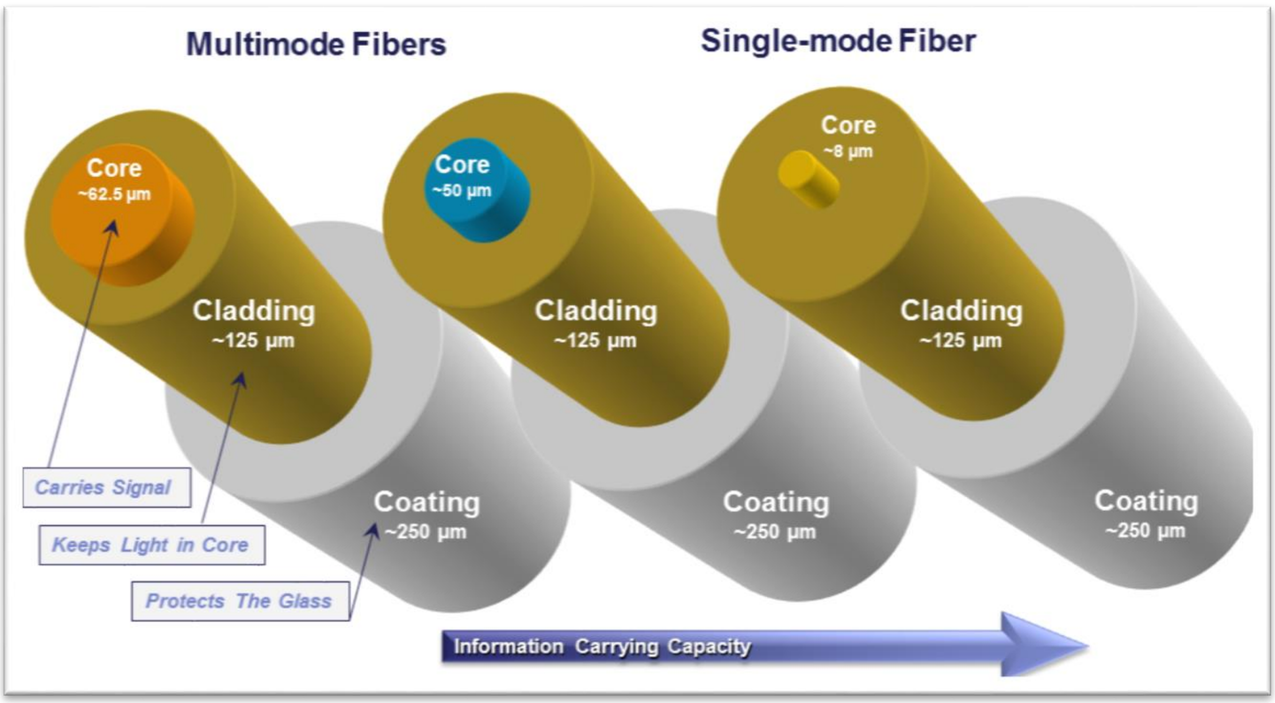


Figure 9-4

Figure 9-4 compares the cable construction and information carrying capacity of single and multi-mode fiber.

Another consideration is the "Bend Sensitivity" of the fiber. Bending an optical fiber too tightly will cause the light to leave the core of the fiber, failing to make it to the receiver at the end of the link. This is called Attenuation. This attenuation of the signal could cause problems in optical networks. To alleviate this problem, fiber manufacturers have developed several types of fiber that are less sensitive to bending, commonly referred to as Bend Insensitive Fiber (BIF).

Bend insensitive fiber is generally available in both SM and MM optical cables. Some manufacturers offer Bend insensitive fiber as their standard offering, while others have it as an option. Check with your manufacturer to see if they offer bend insensitive fibers.

Where is BIF required? Generally, BIF is not required in backbone or outdoor cables. These cables usually have multiple fibers, and a cable design that limits the bend radius of the cable. BIF is best-suited for the horizontal part of the network, where only a few fibers are in the cable, and the installed cable may be subject to tight bends.

9.3 Connectors

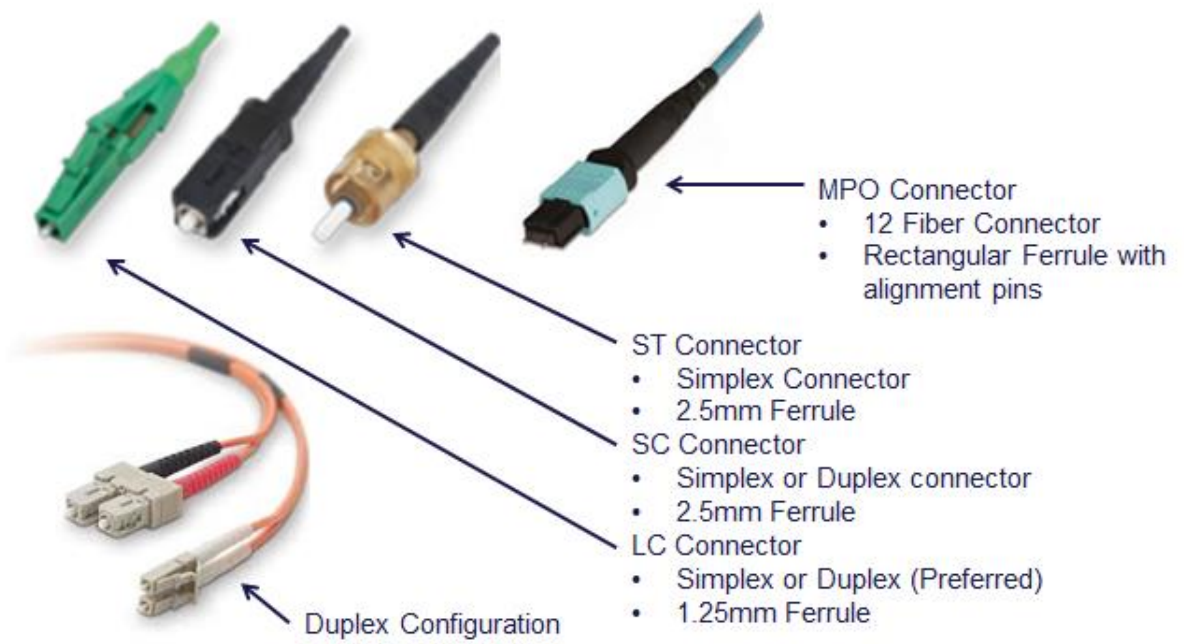


Figure 9-5

Figure 10-2 is a depiction of several common connector types used in optical fiber cabling.

10 Conduits and Raceways

Conduits and raceways provide guidance and shielding for cable systems. Connectors couple two optical fiber cables or electronics together to complete a circuit between each fiber and certain electronics such as an OLT.

10.1 Conduit Types

Additional information on the permissible conduit types can be found in Articles 340 through 360 in the National Electric Code (NFPA 70). Consult your local or regional electric codes for guidance (e.g. National Electric Code).

- **Aluminum conduits** – used to prevent corrosion, preferred in areas with a large amount of water; cannot be directly embedded in concrete without additional chemical coating.
- **PVC conduits** – lightest and typically lowest cost; resists moisture and corrosion but is non-conductive so an extra grounding connector must be passed into each conduit. PVC conduits also have a higher thermal coefficient, so it may expand and contract.
- **Galvanized steel tubing** – steel tubing with a wall thick enough to allow it to be threaded, which is most commonly used in commercial and industrial construction.
- **Electrical metallic tubing (EMT)** – made of steel, sometimes aluminum due to cost and weight. Some types can be bent to a certain radius and direction, unthreaded.
- **Electrical Non-metallic tubing** – thin walled corrugated, moisture resistant and flame retardant, can be bent by hand. Connectors between tubing can, but should not be bent.
- **Flexible metallic conduit ("greenfield of flex")** – recommended in dry areas, does not maintain permanent bend.
- **Liquid tight flexible metal conduit** – covered by plastic waterproof coating, can be used to direct burial; appropriate for concrete embedding and "site lighting" jobs. Recommended as a raceway for approved conductors with a nominal rating of 600 volts or less.

Please note: Rigid Steel Conduit is covered by article 344 of the national electric code, available in trade sizes ½ through six. Please consult your local electric code for guidance.

10.2 Raceways

Any cable management solution that creates a channel through which cables are run is considered a raceway. This includes open systems such as cable tray, J-hooks and cable/slings. There is not a single building in the world that does not make use of some kind of raceway and, for most applications; there is a possible raceway solution. Raceways are available for vastly different applications, from solid ducts to power and data distribution systems to crown molding types for decorative applications.

Raceways include surface-mounted systems that typically run along the perimeter walls and hallways. They are a means of routing, concealing and protecting cables. Most raceway systems are used to retrofit applications in buildings that are otherwise inadequate for wiring of new or increased data/power requirements. Original raceway systems were made of steel. Some vendors continue to offer steel products but have broadened their product line and now carry plastic (nonmetallic) and aluminum products as well.

Another benefit of raceways is to offer bend-radius protection for the cable. In the past two to three years, most major raceway manufacturers have begun offering such protection via bend-radius control fittings, which maintain or hold a cable so it cannot bend more than recommended.

Figure 10-1

Figure 10-1 is an example of plastic raceway.

11 Passive and Active Optical Networks

When comparing passive optical networks and active optical networks, similarities and differences are seen relative to network architecture, intelligence, bandwidth, protocols and management.

Architecture

Passive optical networks (PONs) are based on point-to-multipoint (P2MP) architecture and Active Optical Networks (AON) are based on point-to-point (P2P) architecture. This means PONs use a passive splitter to feed multiple end devices vs AON, which uses an aggregate switch.

Deployment Distance

PONs can reach 30km/18mi over a passive infrastructure using single mode fiber, thus allowing the option to reduce or remove equipment located in telecom rooms and telecom enclosures. AON architecture can span over 85km/50mi in a single run between repeaters (switch/router/firewall) up to 10 Gbit/s. Using optical amplifiers, DWDM and dispersion devices, AON can span thousands of miles at 10Gbit/s and hundreds of miles at 40 Gbit/s.

Intelligence

A PON's intelligence is centralized at the optical line terminal and in the network management system. PON is based on thin client end-points called optical network terminals that are designed to be un-managed, un-maintained and highly reliable. AON intelligence is distributed across the active network deployment. Thin provisioning is defined as the act of using virtual technology to give the appearance of having more network resources than are actually available. Thick provisioning attempts to match the appropriate resources with the deployment requirements. AON intelligence can be characterized as being a thick client at all end-points. PON can be characterized as being a thin client.

Bandwidth

AON delivers a fixed maximum bandwidth per connection port. This bandwidth is limited by the bandwidth of the slowest connection in the chain of that port. For example a core switch is connected at 10GBit/s to a distribution switch that is connected to an edge switch at 1GBits/s. The edge switch has copper ports of 1GBits/s connecting to the end device. The slowest connection is 1GBits/s so the end point device will never have more than a 1GBits/s connection. PON having P2MP architecture provides bandwidth to be software-defined and dynamically allocated based on real-time demands up to the maximum of the PON channel. PON can deliver gigabit speed service to the IP/Ethernet end-points. Both AON and PON can deliver up to 10 Gb Ethernet to the end-points.

Protocols

AON and PON utilize IP/Ethernet centric protocols. Today's GPON transmission utilizes IP/Ethernet centric ITU G.740 Generic Frame Procedure (GFP) encapsulation method and EPON carries Ethernet frames based on IEEE 802.3ah. Both AON and PON support the same long list of IP/Ethernet centric IEEE protocols at the network and services end-point interfaces.

Management

Centralized management is ideal for PON's P2MP architecture, centralized intelligence and software-defined bandwidth that are dynamically allocated based on real-time demand. Thus, all PON manufacturers have optimized their network, element and service management to a graphical user interface for server based or web based control. AONs are managed at any location on or connected to the network equipment through user interface whether virtually or physically connected.

11.1 Passive Optical Networks

Passive Optical Networking is emerging from the "Carrier/CATV" provider industry into the world of switching. PON technology is an option telecommunications carriers use to bring video, phone and data services to the home. The progression to GPON (Gigabit Passive Optical Network) has allowed this technology to replace traditional copper cable and switching methods in the office and commercial environments. In that the hospitality industry provides both a home away from home and often serves as an office for many travelers, the industry could benefit greatly from the consistent, secure and economical delivery of video, data and voice services to guest rooms and convention sites.

The PON system consists of two main components, the OLT (Optical Line Terminal) and the ONT (Optical Network Terminal). The OLT is the head-end consolidation switch located in the ER/MTR and interfaces with the voice, router and television provider equipment. The ONT is a small device located at the end location or guest room. It can provide from 1 to 24 10/100/1000 Mbps Ethernet ports, analog voice ports and coax connections. Devices (telephone, data, TV) are connected to the in-room ONT via traditional patch cables (CAT 5e/6 or coax).

Figure 11-1

On the left, Figure 11-1 depicts varying sizes of OLT devices. On the right, you'll see an example of several ONTs with several ports including voice and RF video capabilities.

11.1.1 Benefits

The benefits of PON in the hospitality industry are plentiful. Below are just a few.

Physical Infrastructure Cost

In a traditional copper network environment, a typical guest room generally requires, at minimum, 1 CAT 5e/6/6a cable for a secure data connection, 1 CAT3/5e/6/6a cable for a Phone and 1 RG6 Coaxial cable for delivery of TV services to the room. These cables traditionally would be installed from the guest room back to a telecom closet within 295' cable distance. This closet would contain Ethernet switches, telecom distribution blocks, video splitters, amplifiers, as well as copper and fiber backbone cable to the systems head-end. Higher end hotels may need more cables for voice and video applications.

In a PON environment, all these services are delivered via a single strand of single-mode fiber to the room (however, it is a best practice to install two or more strands). The closets and all their equipment are eliminated entirely or replaced with smaller fiber enclosures that do not require power or cooling. In addition, these closets can be spaced at distances much greater than the 295' limitation on traditional copper. PON can have user outlets spaced up to 12 miles from the active head end gear. The cost saving advantages to a resort-style site with multiple buildings would be even greater than those of a standalone location.

It should be noted that BICSI TDMdM 13th Edition has a section dedicated to PON design and implementation best practices; and recent TIA 568.C.0-2 updates includes PON-specific content.

Valuable Space Savings

The elimination or reduction of telecom closets will free up valuable space for additional rooms, storage or guest services while replacing of all the copper cables to the rooms with a single strand of fiber will save space in the ceilings and greatly reduce the weight and support requirements associated with it.

Consistent Delivery of Services

In a PON environment, services are delivered from the head-end equipment via the PON system. This delivery is done over a fiber backbone and passive optical fiber splitters. A single strand of fiber from the PON head-end (OLT-Optical LAN Terminal) can be (theoretically) split up to 128 times, providing services to 128 guest rooms via that single PON port and fiber, although 64 or fewer splits are much more common. However, each vendor's electronics will have varying capabilities, and signal loss budgets should be accounted for. The split of signal is equal at the output of the splitter and, because the loss in fiber is measured in much greater distances than copper, the signals at the guest rooms are more consistent room to room.

Electronic Infrastructure Savings

The passive nature of PON allows the replacement of traditional electronic Ethernet switches with passive optical fiber splitters. There is no power required or maintenance to perform; and there are no switches to upgrade or replace.

11.1.2 Design Considerations

In planning a PON deployment in a hotel environment, the following should be taken into consideration.

How will video services be delivered?

With PON comes the option to deliver video services to the guest room via IPTV or overlaying the video signal onto the optical fiber cable. In the video overlay method, the video signal is injected onto the fiber at a different wavelength than that carrying the data and voice services. This overlay does not utilize any of the bandwidth available to the delivery of data and voice services.

In an IPTV environment, video is carried over the data network. This will have minimal impact on data and voice bandwidth. Any impact can be reduced or eliminated by adjusting the planned split ratio.

How many rooms to service via a single PON port?

As mentioned previously, a single PON port can deliver services to up to 64 room locations by utilizing an optical fiber splitter. In the enterprise world, splitters come in many options from 1x2 up to 1x64. In applications requiring port redundancy, 2x2 up to 2x64 optical fiber splitters are available.

In the GPON environment, a single PON port on an OLT provides 2.4 Gbps downstream and 1.2 Gbps upstream. In a 1x32 split environment, each guest room could have guaranteed bandwidth of 70 mbps downstream and 30 mbps upstream and, through the use of dynamic bandwidth allocation, the ability to burst up to 1Gbps. Guaranteed guest room bandwidth can be increased by lowering the split ratio used, but considering carriers are utilizing higher split ratios to provide TV, high speed internet and phone services to the home, a 1x32 split is a good assumption in a video overlay environment and a 1x24 in an IPTV environment.

Where do I place distribution enclosures or closets?

In a PON environment the designer has many options when it comes to the placement of distribution enclosures/closets as well as the option to not have them at all. The designer may choose to have all horizontal fiber from the guest rooms run directly back to the ER/MTR or have planned areas of consolidation of guest room horizontal fiber. It is a good practice to place your splitters at the termination point of the horizontal fiber.

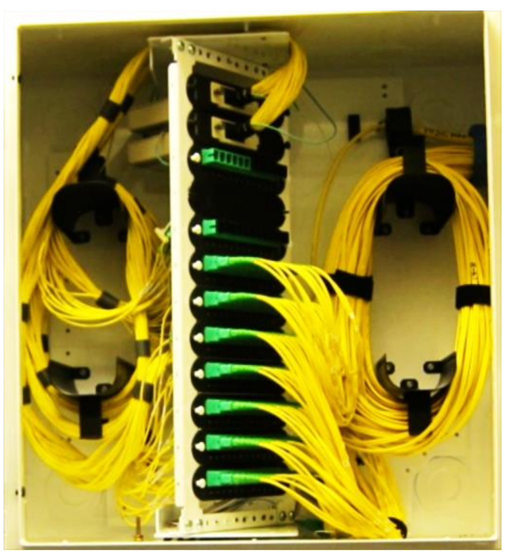


Figure 11-2

Figure 11-2 depicts a fiber enclosure showing Backbone Fiber from the OLT at the top, while individual room fibers are connected at the bottom.

This allows for the use of less backbone fiber. For example, a 30-story hotel with 10 rooms per floor may choose to have a fiber consolidation enclosure on every tenth floor serving 5 floors above and five floors below. Including the floor of the enclosure, you would have 11 floors totaling 110 rooms. By placing your 1x32 splitters at this location you can now provide service to 128 rooms via only 4 single strands of backbone from your ER/MTR. This is also a good practice to reduce the length of the horizontal fiber drops, thereby reducing the amount of horizontal fiber required.

How is "In-Room" cabling distributed?

In many hotels today, most services are provided on the same wall, i.e. a flat screen television and a desk with a network connection and telephone. In this instance, the ONT would be mounted behind the desk or television stand and patch cords would be installed to the TV, telephone and data connection from the ONT. For security reasons, the ONTs should be in a concealed and locked cabinet.

If the TV is wall mounted, an in-wall extension from a faceplate behind the TV to a faceplate near the ONT would be used, much like what many of us have in our homes. The same would apply if multiple phone or network jacks were to be deployed in the room. This would contain all copper cabling to the guestroom.

Distribution Methods

As mentioned in the previous sections, there are several options available to the designer when it comes to the distribution methods used in PON infrastructure. A single fiber from a PON port is typically split 32 times. This does not have to be done only as a 1x32 split.

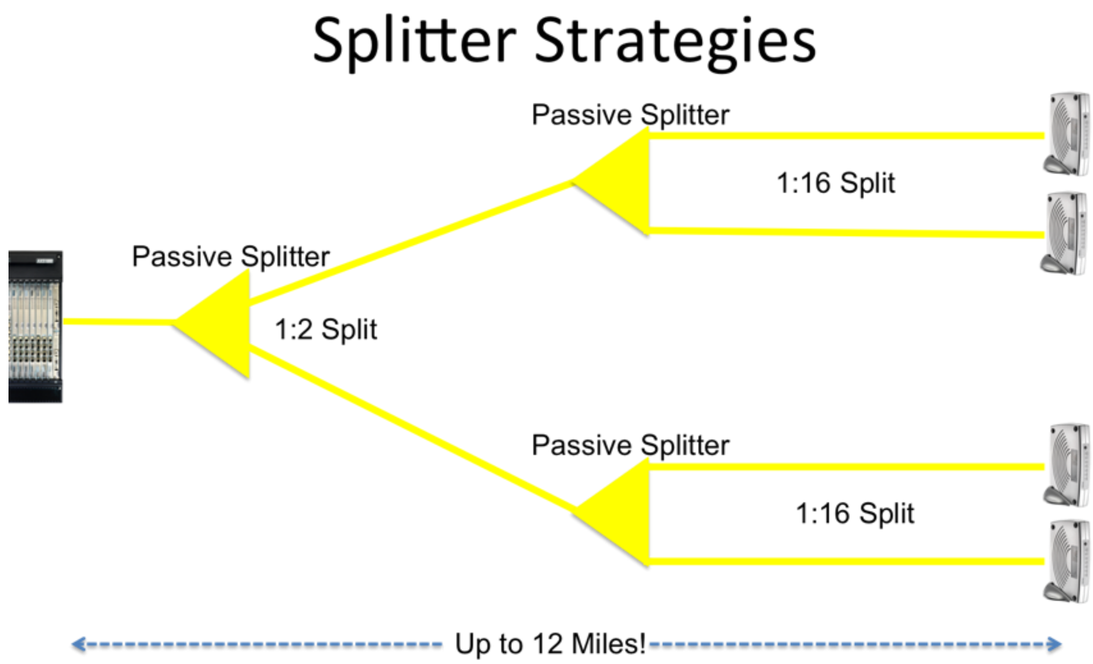


Figure 11-3

Figure 11-3 is an example of how to further divide PON networks with additional splitters, as well as the possible length of wire that could be achieved.

For example, in a resort-style hotel with 2 buildings with 12 rooms each, PON architecture would allow for the installation of a 1x16 splitter to be installed in Building 1 to service the guestrooms in that building. One of the outputs of that splitter could then be patched to a single fiber to Building 2, where a second 1x16 splitter would be installed to provide services to the rooms in Building 2. This could also be done by stacking 1x4, 1x2, 1x8 or 1x16 splitters, as long as the end result does not exceed the planned split ratio on each PON port.

This distribution method should only be used in certain situations and it is important to keep the infrastructure "structured" for the purposes of logistics, record keeping and maintenance. The consolidation of splitters, backbone and horizontal cabling allows for concentrated locations for testing and troubleshooting, as well as MAC work (moves, adds and changes).

Pathways and Spaces

Advances in fiber technology have brought to market "bend insensitive" fiber. These advances allow the horizontal fiber to the room to be installed in a similar manner as traditional copper. Using the Bend Insensitive fiber enables installers to follow traditional pathways to the room, as well as using traditional installation procedures within the room, up to the ONT. Unlike copper, fiber is not affected by electromagnetic interference EMI. As a result, additional pathway options are available.

Backbone Cabling

The recommended backbone fiber counts are determined by the number of splitters required, type of splitters required and additional non-PON equipment. PON utilizes single-mode fiber terminated with SC/APC Connectors:

- 1 Strand Per Splitter + 1 or 25%, whichever is greater.
- Additional strands as required for Security or Wireless Lock Systems that may be independent of the site network.
- As a best practice, extra strands should be considered for future growth.

Horizontal Cabling

It is recommended that “bend insensitive” fiber be used from the ER/MTR or Consolidation Enclosure. Install a 2-strand (or more) single-mode fiber to each proposed ONT location terminated with SC/APC connector and install in faceplate with an SC/APC coupler.

More information about pathways, backbone and horizontal cabling can be found in BICSI TDMM 13th Edition and TIA 568.C.0-2.

Peripheral Devices

When planning ONT locations, it is important to consider non-guestroom technology. A remote ONT located in a closet or ceiling space is recommended for Wireless Access Points, IP CCTV, house phones and common area televisions. For example, a hotel with three wireless access points and a house phone per floor could have a 4 Port ONT installed on a wall in a closet or in a ceiling enclosure. Traditional copper cables would then be installed from these devices back to the ONT.

11.1.3 Summary

PON technology in the Hospitality industry is poised for an emergence. The combination of consistent delivery of quality services, initial and ongoing cost savings, as well as space savings makes PON the best option today. The well-planned future progression of PON technologies will make it the best option in the future. Unlike the progression of traditional copper, the cable infrastructure will not need to change to accommodate its progression. With this in mind, a solid, well thought-out infrastructure plan will be the key to initial and future success of the solution.

11.2 Active Optical Networks

Active Optical Networks (AONs) utilize a very similar infrastructure to PON networks with the advantage of increased distance, speeds and throughput when compared to copper networks. Copper networks have been the standard for many years and continue to be a leader in the network connectivity of most Ethernet networks around the world. Active Optical Networks replace the copper component with fiber optic cabling to remove the copper bandwidth and distance limitations. Active fiber optic networks are available with switching technology of 10 Gbps at each port and 40 Gbps in the backbone readily available; and speeds exceeding 100 Gbps available at a premium price.

An active optical network can utilize various levels of switching; most commonly three: core, distribution and edge switches. The core switch resides in the data center or MDF and is the centralized hub of the network. It connects the servers, equipment and routers to the rest of the network, and also manages connections within the network. The distribution switches reside in the Telecom Rooms or IDFs and manage local traffic to the edge switches. The edge switches reside in or near the guest rooms and allow for connections to the in-room devices.

Active Optical Networks are fully compliant with all TIA/EIA and BICSI standards.

In a typical hotel backbone, fiber optic cabling from the MDF to the floor serving Telecommunication Rooms (TR) would be provided. From the TR, one or two strands of fiber optic cable would be run into the guestroom. At the MDF, the fiber would be cross connected to the core switch for connectivity to phone service, TV (in the form of IPTV) data service and any other service provided. In the TR, the fiber would be cross connected through the distribution switch to create a communication pathway from the data center to the edge switches in the guestrooms. The fiber would be terminated on the edge switches, which connects to the in-room devices including phones, Set Top Boxes (STBs), TVs, Wireless Access Points (WAPs), wired data jacks and any other IP service. The edge switch can provide Power over Ethernet (POE) to power local devices if required. Copper outlet connections would be connected to the edge switch, keeping the copper cabling to a minimum and reducing the capital investment significantly.

11.2.1 Physical Infrastructure Cost

An Active Optical Network eliminates the bandwidth and distance limitation problems found in copper networks. IPTV accounts for the majority of network traffic on any hotel network. As stated before, Active Optical Networks can easily provide 10 Gbps off the shelf today. The fiber infrastructure will help to future proof the property as the optical transceivers are upgradable from 100 Mbps to 10 Gbps (assuming the switch ports support these line rates). This is true of the core, distribution and edge switches. Concerns about 4 K IPTV bandwidth are valid with most network deployments because they are expected to consume as much as 80 Mb/s per channel. A system with 50 channels of 4 K IPTV channels would consume 4 Gbps of bandwidth. In addition, consumer demand for Internet bandwidth is always increasing. If 10 Gbps to the room is required, AON is one of the solutions that can provide this. With a 1Gbps copper connection, these demands cannot be met. Active Optical Networks are one way to provide the future-proof bandwidth requirements and technology compatibility in a hotel.

11.2.2 Valuable Space Savings

Active Optical Networks can be deployed with or without intermediate Telecommunication Rooms (TRs). Without the TR, fiber is directly connected from the data center to the edge switch. This eliminates the distribution switch and sends all traffic through the core switch. At smaller properties, this does not present any issues. Larger deployments should utilize distribution switches even if they also reside in the data center.

Another option is to reduce the size of the TR. The elimination of copper cabling can reduce the space required in the TR. In an Active Optical Network, it might be difficult to remove the TRs because there are so many systems outside of voice, data and video that utilize these spaces. Other systems that might require connectivity in a TR include fire and life safety systems, BMS (Building Management Systems), BAS (Building Automation Systems), security and surveillance, DAS (Distributed Antenna Systems), and wireless services, just to name a few.

11.2.3 Consistent Delivery of Services

In an active switched optical network environment, services are delivered from the head end equipment via standards-based structured cabling systems over a fiber backbone and optical fiber cable to the guestroom. A single strand of optical fiber from the MDF core switch can carry 100 Gbps of data to dedicated switches or stacks of distribution switches in the IDFs which, in turn, connect to edge switches in the guest rooms. The number of rooms they can serve is limited only by the desired bandwidth to be provided to each guest room.

Care should be taken to make the backplane of the distribution switches and the connection to the core switch is large enough to provide the bandwidth necessary for each guest room. This link is typically the bottleneck for the in-building network. For example, an IDF with a 10 Gbps connection to the MDF and serving 50 guest rooms would be able to provide 200 Mbps to each guest room if all rooms were downloading at their top speeds simultaneously. In this example, an increased connection speed would be advised in addition to the use of a combination of multicast and single cast to significantly increase the available bandwidth.

11.2.4 Design Considerations

As with any network deployment, there are many issues to take into consideration for an Active Optical Network. Following are some of the major issues to be addressed:

How will video services be delivered?

For video services to be delivered over the Active Optical Network, the video must be encoded into Internet Protocol Television (IPTV) at the head end or possibly delivered to the property as IPTV. Free-to-guest (FTG) TV (live TV channels) is multicast streamed in real time through the network switches directly to TVs or to Set Top Boxes connected to the TVs.

Multicast streaming is the most efficient method to deliver the FTG video services since a video stream (TV channel) is only sent to the switches that have TVs watching that channel. Additionally, that video stream is only sent once, thus adding to the efficiency of the technology. Pay per view (PPV) video services are referred to as Video on Demand (VoD). These video streams are unicast so each video stream is sent individually to each TV requesting that specific video. For example, if 50 TVs are requesting the same video, that video stream is sent 50 times. This is not as efficient as multicast video but is required for VoD and care must be taken to provide enough bandwidth to support a unicast channel for each TV on the network.

How much fiber should be put in the backbone?

Active Optical Networks being deployed today generally utilize either 10 Gbps or 40 Gbps backbone speeds on the fiber. To increase the backbone speeds, more fibers are required. Therefore, it is prudent to have spare fibers (dark fibers) between the MDF and the IDFs. This will allow for future growth as the network demands increase over time. It is recommended to use a fiber cable with at least 12 fiber cores in the cable. It is common to use a fiber cable with 24 fiber cores since the cable is typically the same size as the 12 fiber core cable and the cost is not much more. Both cables use standard terminations including SC, ST, LC and MPO.

Where do I place distribution enclosures?

TIA/EIA and BICSI (TIA 568c) require telecommunications station cabling to be no longer than 90 meters for copper cabling and 300 meters for multimode fiber optic cabling (MMF). Single mode fiber optic cabling (SMF) distances are measured in kilometers, which is typically not an issue in the hospitality market. Enclosures for the edge switches should be located either in the guest room or in the hallway just outside the guest rooms. Inside a hotel room, the enclosure is generally in the closet to keep it out of the public view and to obtain the blessing of the interior designer. If the enclosure is placed in the hallway, it is typically hidden and locked so access is only by authorized personnel. The advantage of the enclosure being located in the hallway is the edge switch is always accessible.

How is “in-room” cabling distributed?

In-room cabling should be approached no differently than a traditional copper or hybrid copper/fiber cabling distribution. Copper outlets should be placed around the room as needed and connected back to the switch location. The switch can be located in the hallway, behind the TV, in the closet or above the bathroom ceiling. If the services are all provided on the same wall, with connections for TV, data and phone all together, then patch cords can be connected directly to the switch.

11.2.5 Summary

With the advantages of bandwidth and future-proof infrastructure, Active Optical Networks are a logical step for deployment in hospitality. In addition, the existing base of network engineers and Information Technology professionals in hospitality has nothing new to learn with fiber deployments. The switches utilize the same protocols, programming language and support services that are in place with established relationships. The deployment is standards-based and supported around the world by TIA/EIA and BICSI.

Active Optical Networks can utilize much of the existing infrastructure in retrofits and are very efficient in new construction, using less space, pathway and capital investment than traditional copper networks. Active Optical Networks meet the needs of a demanding future without changing platforms and staff education. They are scalable for future needs and can be integral to the success of hospitality networking going forward.

11.3 Passive vs. Active

There are three main considerations in bandwidth to the guestroom: voice, data and video. Video is the largest bandwidth user today. Calculations will have to be done based on the encryption used to encode video and distribute it. The encryption method can greatly affect the bandwidth required per a video stream.

- Data considerations are typically minimal because the connection to the ISP in most cases will be significantly less than the in-building network bandwidth.
- Voice services pose very low bandwidth demands but they rely heavily on Quality of Service to work properly.
- Equipment and facility fault tolerance is an additional question that should be asked. PON requires only one fiber but it is prudent to provide spares for redundancy and future growth. ONT's generally do not have redundant uplink ports while switches generally can have a second GBIC added for redundancy. Redundant uplinks on switches and ONTs generally add cost to each unit.
- The PON standards specify four different types of redundancy/backup. There is equipment redundancy at the head end and/or the remote ends, cabling redundancy, and splitter redundancy available. Typically redundancy isn't required for a PON since the equipment usually has 5 9's reliability with Mean Time Between Failure rates greater than 15 years and the fiber optic cable has a life span of 50+ years.

- An AON can have both equipment and structured cabling redundancy/backup. A switch can have dual uplink ports, primary and secondary. Generally fibers are run in pairs with two fibers creating each link. The disadvantage for an AON is this requires four fibers and two switch ports for redundancy but is a truly redundant uplink as there is no single point of failure. Various grades of AON equipment can be deployed, up to and including five nines of reliability.

As explained, AON and PON are very comparable and both are capable of delivering today's bandwidth demands as well as tomorrow's with the possibility of only swapping out electronics as technology advances. The two biggest differences between AON and PON is the number of switched ports and the sharing of bandwidth. For the Active Optical Network, there must be a dedicated switch port for every guest room while Passive Optical Networks can aggregate 32 or even 64 guest rooms onto a single switch port. All of the guest rooms on a single PON switch port share the available bandwidth while each guest room has a dedicated connection to the distribution switch in an Active Optical Network. The data is still shared in an AON but it's on the connection between the core switch and each distribution switch.

Costs vary between architecture and cabling types, and the most prudent way to compare costs of a particular technology is to get bids utilizing two different technologies for the same property.

11.4 Optical Fiber Roadmap

Next Generation PON (NG-PON) is actually here today. There are several technologies on the roadmap.

XG-PON1

(NG-PON1 or 10GPON) – ITU-T G.987

This technology is available today and manufacturers began making product in 2013. It functions exactly like GPON but the line rates are 10 Gbps downstream and 2.5 Gbps upstream. The wavelengths used by 10GPON are 1577nm for downstream and 1270 nm for upstream. These are different wavelengths than GPON, so both technologies can actually ride on the same fiber without interfering with the other. This lends itself perfectly for a system to be migrated from one technology to the other.

NG-PON2

WDM-PON (No standard defined yet)

This technology will support 32 different light waves to transmit from the OLT to the ONT. Each ONT will have a dedicated light wave. Each ONT is tuned to a separate wavelength and has a transceiver to transmit and receive at a particular wavelength. The initial data rate will be 1.25 Gbps per light wave, thus providing a dedicated 1.25 Gbps to each ONT. One way to picture this is 32 point-to-point networks over a common infrastructure. Today's splitters will not support WDM-PON. It will require an arrayed waveguide grating filter (AWG).

Looking even further down the road the talk is to increase this speed to 10 Gbps per light wave.

Active Optical Networks

AON technology is continually pushing the envelope. With DWDM, CWDM and dispersion compensation for long haul fiber at speeds in excess of 100 Gbps (symmetrical – upstream and downstream), the future looks very fast. The past has shown us that developments for long haul fiber have led to breakthroughs in short haul deployments, primarily in the bandwidth and speed arena.

12 Power Considerations

Powering of the in-room device (e.g. ONT, WAP, radio antenna, etc.) is a detail that is often forgotten and sometimes left out when considering a fiber to the room network. This single item can make the cost difference between a fiber to the room solution being less expensive or twice the price of a traditional copper solution. Several factors should be taken into account when choosing the right power solution. The biggest factor is the criticality of the devices connected to the network (or in the guest room). If HSIA is the only service carried over the POL, then choosing a local AC power source without any Uninterruptable Power Source (Battery Backup) will be the right choice. However, if the phones are converged over a fiber optic network, local and federal laws or brand standards may dictate the phones stay operational for a specific amount of time during a power outage. In this case, a remote power source with a UPS will be the required choice. Careful consideration needs to be taken when making this decision. Typical power distribution ranges from 42-57 volts. For simplicity purposes, this section will refer to 48 volt power distribution, since it is most common.

12.1 Power Delivery Models

There are four industry power delivery models:

1. Local Common Power (via jointly used AC outlets)
2. Distributed Power (may be multiple forms of power)
3. Centralized Power (may be multiple forms of power)
4. Hybrid Centralized – Distributed (combinations of 2 and 3)

Table 2 – Power Model Options

Power Model	Description	Discussion
Local (Room)	AC branch circuit (typically shared among other electrical appliances) in-room powers ONT; no back up unless UPS is co-located at the ONT. Only fiber is run to each guest room.	This very simple approach uses an AC adapter in each room. When required, back-up must be provided in each room. Challenges are guest room access for servicing and the periodic need (every 2-3 years) to change out batteries for the UPS in each room.
Distributed (TR)	Power is dedicated and provided via a Technical Room (TR). Power may be in the form of a dedicated AC circuit, low voltage (e.g. 48V) DC, Power-Over-Ethernet, or newer Pulsed Power. Typically it originates from a power supply device or a UPS located in the TR. AC Power source in the TR typically drives to power supply devices.	This solution overcomes room access concerns and concentrates a group of rooms ("tens" of rooms; 1-3 floors, depending on layout) back to one power supply. Multiple power supply locations (in TRs) are still needed throughout the facility. Backup is via battery, UPS and/or generator. Wiring will vary based on the type of power to the room, such as small gauge (CAT5) or standard AC power wiring within metal conduits.
Centralized (ER)	Power is dedicated and provided via an Electrical Room (ER)/Main Distribution Frame (MDF). Power may be in the form of a dedicated AC circuit, low voltage (e.g. 48V) DC, Power-Over-Ethernet, or newer Pulsed Power. Typically it originates from a power supply device or a UPS located in the ER/MDF. AC Power source typically drives to power supply devices.	All solutions require dedicated wiring from the central location to each room. When considering DC or POE-based solutions, the distance limitations must be taken into account. In DC applications, large gauge conductors may be required to maintain the required power levels. Pulsed Power allows longer reach (see Table 12.-1 for examples) and can utilize smaller gauge conductors. In each scenario, local power conversion (AC-to-DC, DC-DC, etc.) may be required depending on the type of fiber devices chosen within the room.

Hybrid Centralized-Distributed	Variations on Distributed and Centralized may be applied, such as centralized AC UPS or generator circuits provided to the TRs, where the Distributed solutions are applied. This approach provides for the flexibility of leveraging existing backup power solutions along with alternative distributed powering options such as Pulsed Power. Consider this approach when available wiring in a facility is limited and new wiring runs are challenging.	This approach can be a cost-effective alternative because it allows implementers to utilize the best available technologies based on the characteristics of a properties wiring topology.

12.2 Standards & Code Recognition

Remote power solutions generally align with either NEC Article 725 or Article 830. Compliance with IEC60950 and/or IEC62368 are generally recognized in the industry as indicators of desirable performance and safety characteristics. IEC (UL) 60950-21 in particular recognizes Remote Telecom Feeding Voltage-limited (RFT-V) and Current-limited (RFT-C) powering methods. RFT-V solutions are of particular interest because they define power delivery characteristics and fault detection requirements that well match the needs for remote communication power in hospitality properties. Numerous local codes exist, and parties to an installation must be aware of their requirements.

12.3 High & Low Voltage DC Solutions

Both high and low voltage remote power solutions can be used in hospitality applications such as a fiber to the room solution, and supported devices in both guest rooms and common areas.

- Low Voltage DC Solutions consist of a power supply (rectifier) that converts AC power to DC (nominally 48VDC) for distribution to each edge device. Power can originate in the ER or TR, though the TR is the most common origination point. LVDC performs well with distances of a few hundred feet and can extend further by increasing wire size to mitigate voltage drop, albeit at additional expense for the larger wires. Generally, as power limited solutions, the maximum power is limited to less than one hundred watts per circuit (conductor pair), which works well with individual edge device (or network appliance), but is more challenging for larger devices or groups of devices. LVDC also makes a good “last hop”, as in the Hybrid Model for distributing power to devices that natively require low voltage.
- High Voltage DC Solutions consist of a power supply (rectifier) that converts AC power to DC (48VDC) and then steps that voltage up to as high as 380VDC between conductors (or a maximum of 190VDC to ground). The conversion step to 48VDC also allows 48V back up batteries to be used. The recently introduced pulsed electricity option is also an example of a HVDC solution. The much higher voltage of these solutions means that more power (six to seven times as much) can be transported over a given wire size,

compared to LVDC. Codes and standards generally require these solutions to include basic fault interruption capability, but as power limited circuits, they are usually limited to a maximum of one hundred watts per circuit as are the LVDC solutions. Both HVDC and LVDC solutions may use power aggregation techniques to deliver more than one hundred watts to a device or a group of devices.

12.4 Next Generation Power Technologies

As networks evolve to provide added capabilities, optical fiber and power go hand-in-hand. Fiber provides increased capacity (bandwidth), while the fiber-based devices must be powered. The reach of fiber places these devices – or groups of devices (e.g. network appliances) – at significant distances from sources of power, thus the need to carefully consider how these devices will be powered. Newer technologies, known as pulsed power, provide promising new techniques to deliver power over longer distances. These approaches are desirable because they can increase the distance that power can be delivered and can utilize a range of different wire gauges, including telecommunications grade wiring in cable trays including CAT3, CAT5, and more.

Pulsed electricity solutions are a new approach to power transport in which high voltage DC is pulsed on and off, with extensive fault detection during the off period of the duty cycle. This solution has achieved IEC60950 third party certification for safe operation by delivering great power (up to 1000W per conductor pair or 2000W per link) to thousands of feet in distance. Pulsed electricity can be used to remote power both low and high power devices in one of two ways:

- In “bridge mode”, a pulsed electricity link, consisting of a transmitter and receiver, transmits power using pulsed HVDC. At the receiver, the power is converted back to high voltage DC (about 335VDC) and takes advantage of certain electronics that utilize internal rectifiers designed to accept and convert 240VAC to usable power internally. Thus, the receiver can power this type of device directly. When used this way, the electronic devices powered should be assessed carefully to assure they operate in a way that will bridge the high voltage internally.
- In “hybrid mode”, using the hybrid model described in Table of Power Models, the receiver can power a Class 2 LVDC distribution device. This device converts the bulk power from the RX to multiple power-limited LVDC circuits. These circuits can power groups of lower power devices, such as the in-room device in a surrounding area, like a group of guest rooms. The circuits leverage the high bulk power delivery capability of the solution to support many devices.

It is important to note that the use of pulsed power technology typically needs to be installed under certain safety requirements. Examples include:

- UL / IEC 60950-1: IT Equipment Safety Part 1: General Requirements
- Canadian Electrical Code, Part I, CSA C22.1-12

- General Requirements – Canadian Electrical Code, Part II, CSA C22.2 No. 0-10
- National Electrical Code, NFPA 70-2014
- National Electrical Safety Code, IEEE C2-2012 Article 645 of the National Electrical Code
- ANSI/NFPA 70 requirements

The following chart provides examples of typical distances one could expect when utilizing pulsed electricity solutions with different cable gauges (or effective gauges via multiple pairs) to deliver certain power levels at the end point (receiver).

		Cable Gage								
Power Consumption at End Device	No. of Pairs	26	24	23	22	20	18	16	14	12
50 Watts	1	1,083	1,799	2,327	2,925	4,317	6,000	6,000	6,000	6,000
	2	2,166	3,598	4,655	5,850	6,000	6,000	6,000	6,000	6,000
	3	3,249	5,397	6,000	6,000	6,000	6,000	6,000	6,000	6,000
	4	4,332	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
100 Watts	1	542	900	1,164	1,462	2,158	3,616	5,827	6,000	6,000
	2	1,083	1,799	2,327	2,925	4,317	6,000	6,000	6,000	6,000
	3	1,625	2,699	3,491	4,387	6,000	6,000	6,000	6,000	6,000
	4	2,166	3,598	4,655	5,850	6,000	6,000	6,000	6,000	6,000
150 Watts	1	361	600	776	975	1,439	2,411	3,885	6,000	6,000
	2	722	1,199	1,552	1,950	2,878	4,821	6,000	6,000	6,000
	3	1,083	1,799	2,327	2,925	4,317	6,000	6,000	6,000	6,000
	4	1,444	2,399	3,103	3,900	5,755	6,000	6,000	6,000	6,000
300 Watts	1	181	300	388	487	719	1,205	1,942	3,042	5,050
	2	361	600	776	975	1,439	2,411	3,885	6,000	6,000
	3	542	900	1,164	1,462	2,158	3,616	5,827	6,000	6,000
	4	722	1,199	1,552	1,950	2,878	4,821	6,000	6,000	6,000
600 Watts	1	0	0	0	0	0	0	0	0	0
	2	181	300	388	487	719	1,205	1,942	3,042	5,050
	3	271	450	582	731	1,079	1,808	2,914	4,564	6,000
	4	361	600	776	975	1,439	2,411	3,885	6,000	6,000
1,200 Watts	1	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0
	3	135	225	291	366	540	904	1,457	2,282	3,788
	4	181	300	388	487	719	1,205	1,942	3,042	5,050
1,500 Watts	1	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0
	3	108	180	233	292	432	723	1,165	1,825	3,030
	4	144	240	310	390	576	964	1,554	2,434	4,040

Figure 4 Pulsed Electricity Distances

12.5 Power Considerations & Related HVAC Impacts

The Fiber to the Room Power Advantage (at the Closet):

One of the key advantages of optical network is a substantial reduction in environmental cooling costs in the IT equipment room. A traditional hotel IT equipment room with PoE network equipment to support Phones, Internet Wired/Wireless and TV has significant power usage and cooling requirements that n dedicated cooling and exhaust strategies to maintain the equipment within the manufacturer's operational temperatures. The electrical and mechanical designers should include dedicated power in the IDF.

Typical Calculation for IT Closet Power and Cooling:

If a high-rise hotel with an IT Closet supports 4-floors with (15) rooms per floor, the total (60) rooms and a converged Ethernet network where Phones and HSIA are converted into one PoE port and IPTV is on a second dedicated port, the standard design will require (5) 24- Port Ethernet Switches.

Traditional IT Closet Wattage Load:
3 x 250 Watt (non-PoE) and 5 x 640 Watt (PoE) = 3,450 Watts
3,450 watts = 11,800 Btu/hr & approximately 1 Ton of dedicated cooling equipment
Construction Cost impact: Dedicated cooling unit and (2) dedicated Power circuits

Table 12-2 Traditional IT Closet HVAC Calculation

The PON Power Advantage:
In a Fiber PON solution, the distribution of Ethernet data is via a non-powered PON splitter device that has no power requirements. Since there will be no power utilization in the power distribution plant, it will eliminate the need for cooling and power (except in the case of distributive DC deployment to power the in-room or edge device such as an ONT or a WAP).

12.6 Fiber to the Room Equipment Powering Schemes

The ONT (Optical Network Terminator) end-node device in the guest room will require DC power to operate. The consideration of the power delivery method is an important design element for the deployment of PON. There are four (4) basic solutions:

1. Local AC Power (Figure 12-1) - Local AC/DC power converter at the Local ONT in-room device.
2. Distributive DC Power (Figure 12-2) - DC Power Plant in the (per floor) IT closet with a copper conductor home-run in parallel with the fiber to the ONT.
3. Centralized DC Power (Figure 12-3) - A centralized DC Power Plant in the ER core IT Room (Main Distribution Frame) with a copper conductor home-run in parallel with the fiber to the ONT.
4. Centralized-Distributive DC Power (Figure 12-4) - A centralized DC Power Plant in the ER core IT Room (Main Distribution Frame) with copper conductor pair/pairs run to Power Converters in the TR where copper conductor pairs will be run to the ONTs.

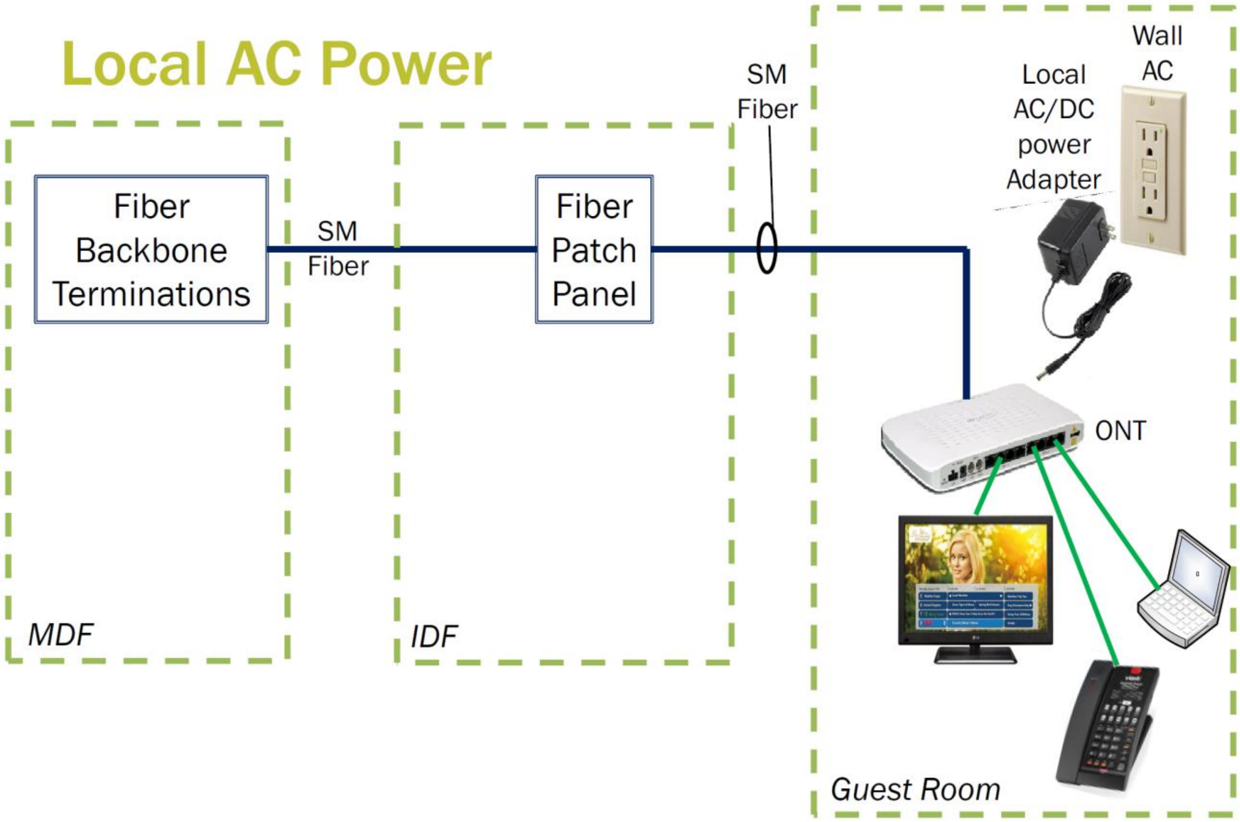

Local AC Power
Fiber Backbone Terminations
SM Fiber
Fiber Patch Panel
SM Fiber
Local AC/DC power Adapter
Wall AC
ONT
MDF
IDF
Guest Room

Figure 12-1

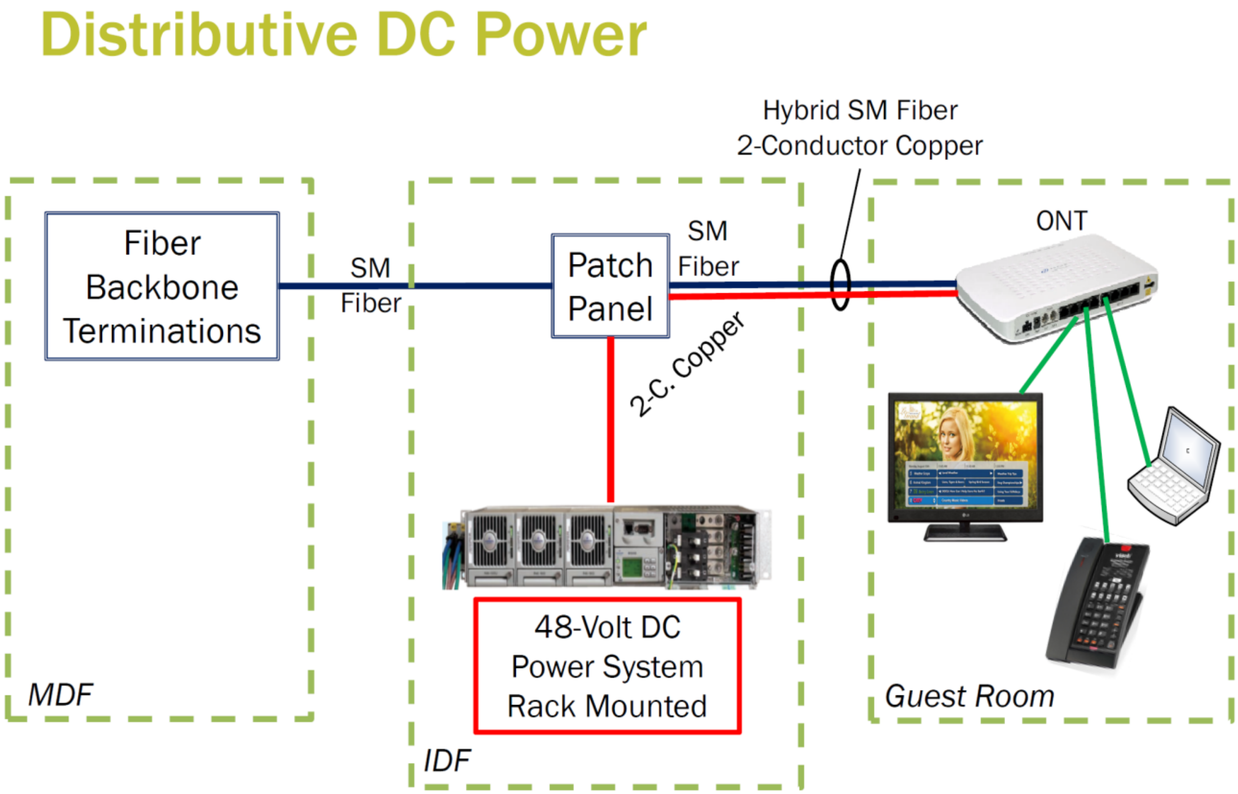


Figure 12-2

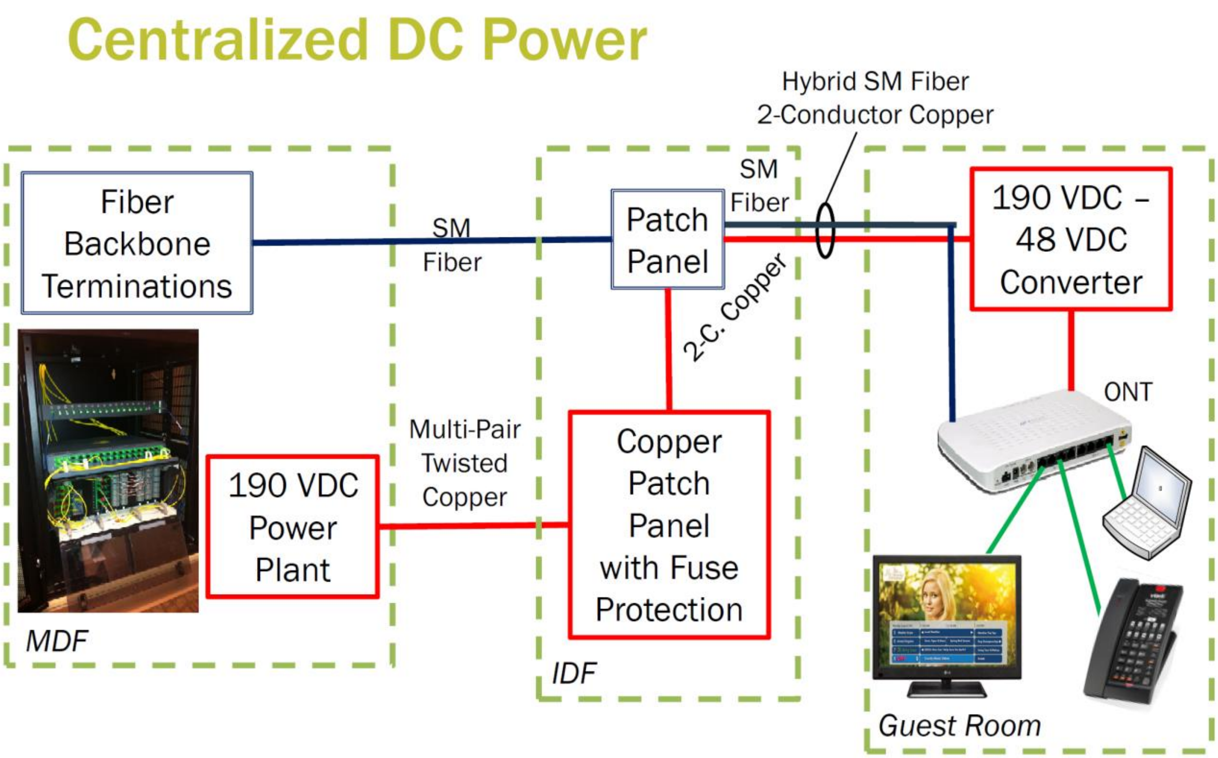


Figure 12-3

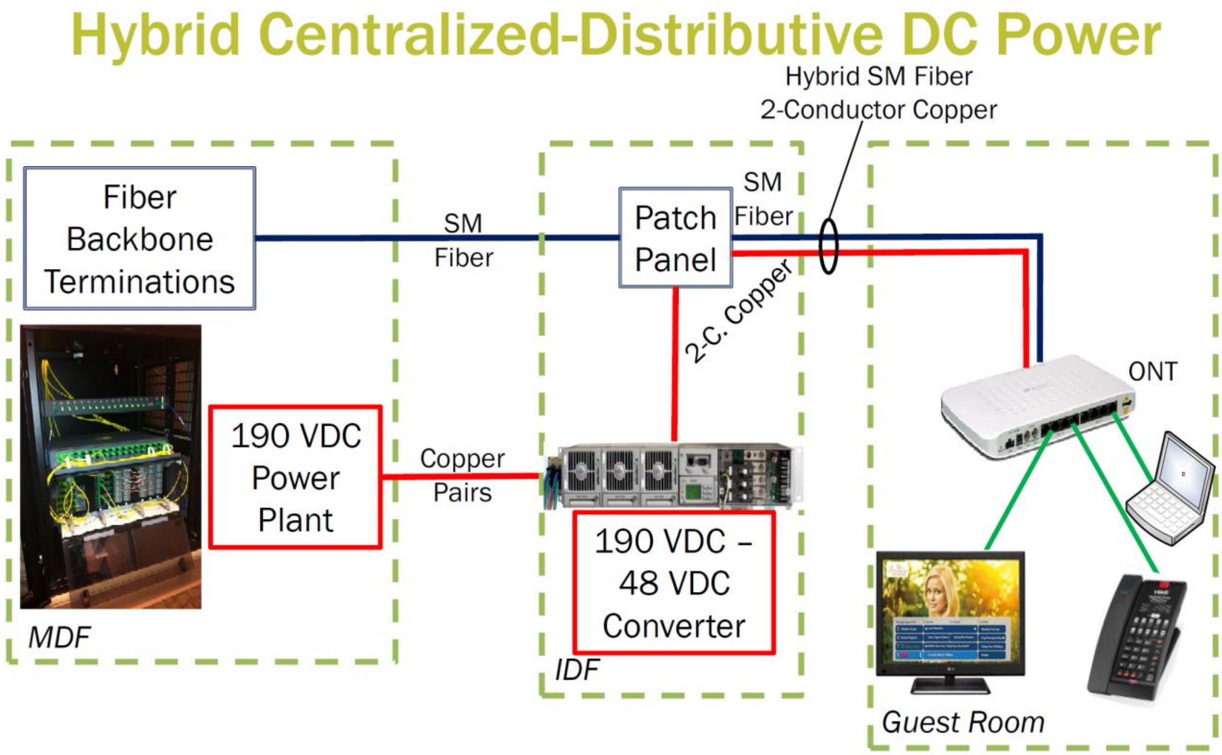


Figure 12-4

The DC power design solution is dependent on several factors:

- The hotel property layout and cabling distances from the ER, IT closets and guest rooms
- High-Rise vs. Campus or Resort Layout
- Space provisions available in the IT Closets

In an emergency condition with a power outage, none of the communication will be operational unless the in-device is connected to a UPS and then the batteries must be tested and replaced typically every 3-5 years. Distributive DC power is recommended if:

- Backup or UPS power is available to the power distribution plant
- The guest rooms are within 100-meters or 300-feet from the power distribution plant
- Cooling, power provisions and space are available in the power distribution plant

Centralized DC power is ideal for powering the whole network including PoE devices from one central location. Centralized-Distributive DC Power provides the advantage of a single power source combined with the benefits of using traditional copper cabling from the TR to the in-room device.

13 Documentation

13.1 Sample Project Plan

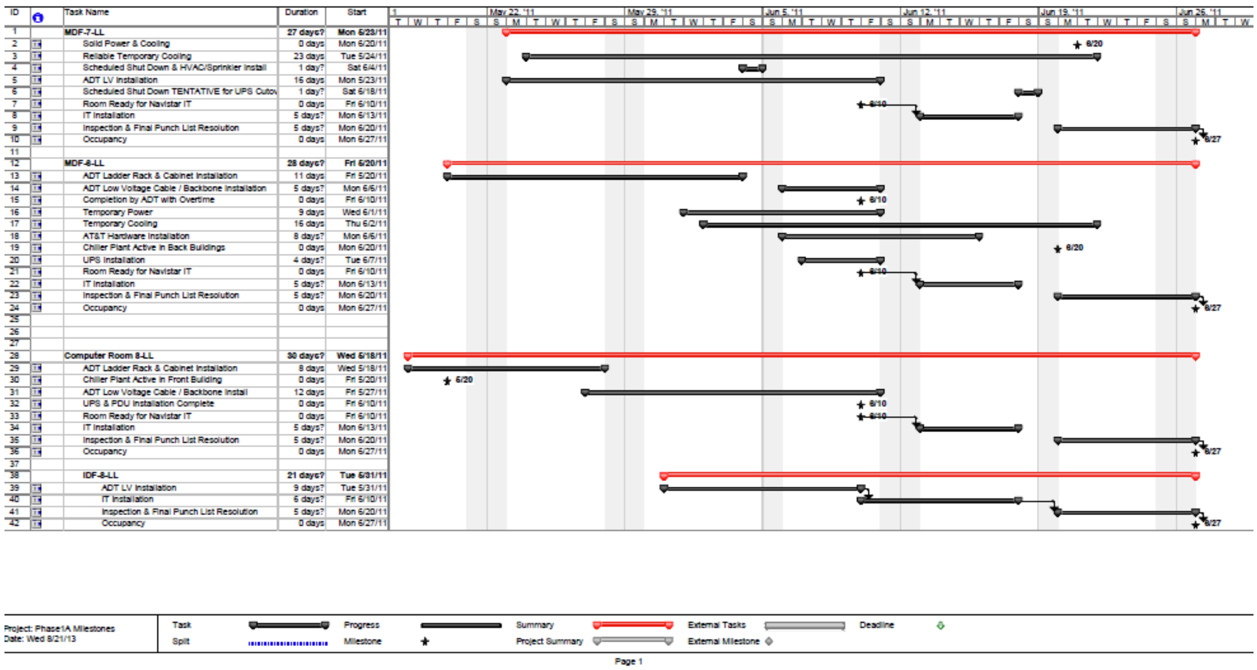


Figure 13-1

Figure 13-1 is an example Gantt chart that describes an optical fiber installation.

Design Phase

1. Confirm hotel design parameters: TV, Phone Entertainment, In-Room Controls, Locks, Security, Audio Visual, etc.
2. Confirm Project Completion Milestones
3. IT Equipment Room Location and Size Verification
4. 75% Design Completion Review Submittal
5. 100% CD Submittal Review
6. Bid/Tender to Qualified Contractors
7. Bid Scope Review
8. Project Award

Construction Phase

1. Contractor Kick-off Meeting
2. IT Equipment Room Ready for Delivery to Low Voltage Cabling Contractor (LVCC)
3. IT Equipment Room Turn-over to Operator and Technology Vendors
4. Construction Substantially Complete

5. Punch List Verification

Commissioning Phase

1. AsBuilt Document Verification
2. Perform Punch List Completeness Verification
3. Systems Demonstration and Training by Technology Vendors
4. Quality Control Review of All Systems
5. Project Close-out Documentation Delivery (AsBuilts and O & M Manuals)

13.2 Statement of Work Example

The Statement of Work below is generic, and is based on a single building example. In this sample, it was assumed that a single building with multiple floors would have a PON network installed. For multiple buildings, the fiber split strategies would take the OSP pathways into consideration.

1.1 SUMMARY

A. This section provides the requirements for the installation of optical fiber systems. It includes product requirements for the equipment, optical fiber cables, termination hardware and required support apparatus. In addition, installation and testing requirements for optical fiber systems are included in this section.
B. Contractor shall install all structural cabling elements in accordance with the most stringent requirements of the NEC, local building codes, ANSI/TIA/EIA commercial building wiring standards, ANSI/NECA/BICSI 568.2006 standard for installing telecommunications systems and all relevant BICSI manuals including 12th Edition.
C. Contractor must submit shop drawings and receive approval from Owner for any deviations from standards or drawings due to field conditions.
D. Completely coordinate with work of other trades.

1.2 REFERENCES

A. NFPA 70 National Electric Code
B. Local Building Codes
C. UL® for wiring: UL® Standard 910 “Test method for fire and smoke characteristics of cable used in air handling spaces.” Provide products that are UL® listed and labeled for such use. UL® testing bulletin. Underwriters Laboratories (UL®) cable certification and follow up program. UL® Standard 1666 “Test for Flame Propagation Height of Electrical and Optical – Fiber Cables Installed Vertically in Shafts.”
D. American National Standards Institute/Telecommunications Industry Association/Electronic Industries Alliance ANSI/TIA/EIA, including associated

Addenda:

1. ANSI/TIA/EIA-568-C.1 - Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements
2. ANSI/TIA/EIA-568-C.3 - Commercial Building Telecommunications Cabling Standard, Part 3: Optical Fiber Cabling Components Standard
3. TIA-569-B - Commercial Building Standard for Telecommunications Pathways and Spaces
4. ANSI/TIA/EIA-606-A - Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
5. ANSI-J-STD-607-A - Commercial Building Grounding, Earthing and Bonding Requirements for Telecommunications
6. ANSI/TIA/EIA-526-7 -Measurement of Optical Power Loss of installed Single- mode Fiber Plant Cable
7. ANSI/TIA/EIA-526-14A - Optical Power Loss Measurements of installed Multimode Fiber Cable Plant
8. ANSI/TIA/EIA-758 - Customer Owned Outside Plant Telecommunications Cabling Standard
9. ANSI/TIA/EIA-568-B-2001 - Optical Fiber Cable Color Coding
10. ANSI/TIA-942 - Telecommunications Infrastructure Standard for Data Centers

E. National Electrical Manufacturers Association (NEMA)

F. ANSI/NECA/BICSI 568-2001 Standard for Installing Commercial Building Telecommunications Cabling:
   1. American Society for Testing Materials (ASTM)
   2. Institute of Electrical and Electronic Engineers (IEEE)

1.3 SUBMITTALS

A. Product Data:
   1. The contractor shall submit product data sheets and samples for all products specified under this section.
   2. Products requiring submittals shall include but are not limited to the following:
      a. All equipment needed for a complete installation
      b. All cabling and wire
      c. Patch cables
      d. All connectors and required tools
      e. All termination system components for each cable type
      f. All equipment room and telecommunications room horizontal cable management
      g. All grounding system components
      h. All fire-stop systems (including manufacturer published installation requirements)
      i. All cable raceway and support hardware
      j. Other apparatus required for a complete and functional system

k. Provide copies of all manufacturers training certificates on all installers that will be working on this project
l. Provide manufacturers factory service agreements for the owner to review and approve

3. Products requiring samples shall include but are not limited to the following:
   a. All cabling and wire
   b. Patch cables
   c. All connectors and required tool
   d. All termination system components for each cable type
   e. All equipment room and telecommunications room horizontal cable management
   f. All grounding system components
   g. All fire-stop systems (including manufacturer published installation requirements)
   h. All cable raceway and support hardware

B. Drawings: The contractor shall submit shop drawings.
   a. Project Closeout Test Data: The contractor shall provide test documentation.
   b. As-Built Documentation: The contractor shall submit as-built documentation.
   c. Warranty: The contractor shall provide a warranty.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Specified Optical Network Terminal (ONT)
B. Specified Optical Line Terminal (OLT)
C. Specified Plug and Play SC APC Splitter Modules

2.2 CABLE: Single-mode optical fiber strands as required

2.3 CONNECTORS: Single-mode fiber connectors will be SC APC, Field terminated

2.4 PATCH CORDS

A. The contractor shall provide each of the following patch cords to the Owner/Project Manager at such time as required for Owner installation of network and/or workstation equipment.
B. All patch cords are to be factory fabricated.
C. All patch cords are to be the recommended series intended by the manufacturer to integrate with the installed cable segments and termination hardware. All patch cords are to be manufactured by the same vendors as the optical fiber cable and hardware.
D. Contractor shall provide patch cords in the quantities indicated in the drawings.
E. Contractor shall provide a schedule of all cords indicating the planned lengths,

quantities and colors to Owner for approval prior to placing any orders for cords.

PART 3 - EXECUTION

3.1 GENERAL

A. Home run the single mode fiber backbone cable from the ER to the nearest TR. It shall be terminated on fiber patch panels in the TR and cross-connected to the guest room cable for a complete path from ER to each room.

B. The ONT locations shall be terminated with a SC APC connector onto a single strand of single-mode fiber.

C. Optical fiber cabling shall be from the same manufacturer and shall be of the same type.

D. Design shall allow for migration of the pull-through, interconnect or splice implementation to a cross-connection implementation. Sufficient space shall be left in the telecommunications room to allow for the addition of patch panels needed for the migration of the pull-through, interconnect or splice to a cross-connection. Sufficient cable slack shall exist in the telecommunications room to allow movement of the cables when migrating to a cross-connection.

E. Fiber cable shall have enough cable slack at the termination point to allow for routing cable through the termination hardware and back to a work table for fiber terminations, plus an additional 3 meters.

F. Slack storage shall provide bend radius control so that the fiber bend radius limitations are not violated. Fiber slack shall be stored in a protective enclosure and slack cable may be stored on walls, cable trays or enclosures within the telecommunications room/area.

G. All cabling shall be labeled per specifications.

H. All armored and non-armored optical fiber cable shall be run in conduit/innerduct. Multiple fiber cables may be run in a single conduit/innerduct. (OPTIONAL)

I. Contractor shall adhere to manufacturer requirements regarding bend radius, maximum tensile strength and maximum vertical rise.

J. All optical fiber cabling shall be terminated with either SC or LC connectors unless a vendor specifically requirement requires a different type of connector for a specific and limited application.

K. The following installation practices shall be followed:

1. Optical fiber cable sheaths are not permitted to be deformed. Use only approved cable fasteners such as hook and loop.
2. Do not pull optical fiber cabling with copper cabling.
3. Do not exceed the optical fiber cable maximum pulling tension.
4. In multiple optical fiber pulls, pull optical fiber cables of the same weight and design.
5. Do not exceed the maximum pulling tension of the lowest rated optical fiber cable.
6. Do not pull optical fiber cable over existing cables. Friction could be excessive

and cause damage.

7. Do not pull optical fiber cable around sharp corners such as support brackets, rods, etc.
8. Protect optical fiber connectors when using pre-fitted cables. Use approved pulling grips.
9. The use of lubricants is recommended for all optical fiber cable pulls. Lubricants should be approved for use with the optical fiber cable type. Never use detergent- based lubricants when installing loose tube optical fiber cable.

L. Optical fiber cables are not permitted to provide support for other cables or hardware. Never secure other cables or hardware to optical fiber cabling.

O. Cable that is individually supported may be taped or tied together every 3 meters for cable management but not for support.

P. When routing optical fiber cabling along walls to the termination or splice enclosure, protect optical fiber cabling by installing in innerduct. Place optical fiber warning signs along innerduct. Ensure there is enough cable slack to be able to move the optical fiber termination hardware to any potential installation area in the room.

Sample Equipment List

Manufacturer	Description	Product ID	U/M
Company A	LC Splicing 12 Fiber Pigtail OM3 Assembly for MM Cables	Product ID A	each
Company A	Composite Cable for PON (1SM & 1 20 Ga 2 Cond)	Product ID A	feet
Company A	2 Strand SM Fiber for Distribution to Fiber Splitters	Product ID A	feet
Company A	SC/APC Connector Pigtails 2M for Utilized Fibers	Product ID A	each
Company A	SC/APC Splicing 12 Fiber Pigtail Assembly 2 M Long	Product ID A	each
Company A	Cable for PON (6SM & 4 16 Ga 2 Cond)	Product ID A	feet
Company A	Cable for PON (6SM & 6 16 Ga 2 Cond	Product ID A	feet
Company A	Cable for PON (6SM & 12 16 Ga 2 Cond)	Product ID A	feet
Company A	SC Splicing 12 Fiber Pigtail Assembly 2 M Long	Product ID A	each
Company A	12 Strand OS1 SM Optical fiber Plenum I/O Cable	Product ID A	feet
Company A	24 Strand OM3 MM Optical fiber Plenum I/O Cable	Product ID A	feet

Manufacturer	Description	Product ID	U/M
Company A	24 Strand OM4 MM Optical fiber Plenum I/O Cable	Product ID A	feet
Company A	Heat Shrink Fiber Splice Protector 60mm long	Product ID A	50 Pack
Company A	2 Meter Single Strand SM Fiber	Product ID A	each
Company A	LC Connectors for MM Cables	Product ID A	each
Company A	LC Connectors Bulk Pac for MM Cables	Product ID A	25 Pack
Company A	SC Connectors for SM Fibers	Product ID A	each
Company A	SC Connectors for SM Fibers Bulk Pack	Product ID A	25 Pack
Company A	SC/APC Connectors for Utilized Fibers	Product ID A	each
Company A	SC/APC Connectors for SM Cables	Product ID A	each
Company A	SC/APC Connectors for Utilized Fibers	Product ID A	Bulk Pack
Company A	SC/APC Connectors for Utilized Fibers	Product ID A	Bulk Pack
Company A	SC/APC Connectors for SM Cables Bulk Packs	Product ID A	25 Pack
Company A	6 Fiber SC/APC Coupler Panel	Product ID A	each
Company A	SC 12 Fiber Coupler Panel	Product ID A	each
Company A	12 Fiber SC/APC Coupler Panel	Product ID A	each
Company A	LC 12 OM3 Fiber Coupler Panel	Product ID A	each
Company A	2 X 8 Fiber Splitter	Product ID A	each
Company A	2 x 32 Fiber Splitter	Product ID A	each
Company A	Fusion Splice Tray for 12 Heat Shrink Fusion Splices	Product ID A	each
Company A	2RU Fiber Shelf Holds 4 Coupler Panels	Product ID A	each
Company A	4RU Fiber Shelf Holds 12 Coupler Panels	Product ID A	each
Company A	OM3 2 Meter Patch Cords LC to LC	Product ID A	each
Company A	2 x16 Splitter	Product ID A	each
Company A	6 Strand MIC Single Mode Plenum Armored Fiber	Product ID A	feet
Company A	4RU housing holds 12 Splice and Adapter Units	Product ID A	each
Company A	2RU housing holds 6 Splice and Adapter Units	Product ID A	each
Company A	SC to SC 1 Meter SM Patch Cord	Product ID A	each
Company A	2 Strand SM MIC Plenum Cable (314 Runs)	Product ID A	feet
Company A	SC/APC No Polish Mechanical Connectors	Product ID A	each
Company A	2x16 Splitter	Product ID A	each
Company A	2x32 Splitters	Product ID A	each

Manufacturer	Description	Product ID	U/M
Company A	12 Port SC/APC Connector Housing	Product ID A	each
Company A	6 Strand SC/APC Pigtail Cassette	Product ID A	each
Company A	6 Strand SC Pigtail Cassette	Product ID A	each

Table 13-1

13.3 Sample Project Permits

CITY OF CHICAGO
DEPARTMENT OF BUILDINGS
Electrical Permit Application

USE BLACK INK—DO NOT WRITE IN SHADED AREA

ELECTRICAL PERMIT APPLICATION NO.:

1. BUILDING PERMIT APPLICATION NO. (If applicable):

2. DATE: ____________________

3. ADDRESS OF INSTALLATION:

Street ____________________
Unit No. __________ Floor No. __________
Zip ____________________

4. NUMBER OF STORIES: ____________________

5. ELECTRICAL CONTRACTOR:

Co. Name ____________________
Supervising Electrician ____________________
License No. ____________________
Address ____________________
City __________ State __________ Zip __________
Phone ____________________
E-mail ____________________

6. BUILDING OWNER:

Name ____________________
Address ____________________
City __________ State __________ Zip __________
Phone ____________________
E-mail ____________________

7. CLASSIFICATION BY OCCUPANCY:

	A. Residential		F. Mercantile
	B. Institutional		Garage
	C. Assembly		J. Miscellaneous Building
	D. Open Air Assembly		Technology Center
	E. Business		

8. TYPE OF CONSTRUCTION:

	New Construction		Addition
	Remodel / Rehab		Fire Repairs
	Electrical Only		Other

9. TYPE OF ELECTRICAL WORK:

	Service		Emergency System
	Feeder		Electrical System Maint.
	Req. Fire Alarm Sys.		Other
	Circuits		

10. DESCRIPTION OF WORK:

11. VIOLATION / TICKET NOTICE:

	Number	FEE
Violation ICN		
Permit Ticket		

12. BRANCH CIRCUITS:

Amperes	1 Phase	3 Phase	FEE
15 A			
20 A			
Over 20A			

13. LIGHT/RECEPTACLE OUTLETS ON EXISTING:

	Type	Number	FEE
Lighting			
Receptacle			

14. SERVICES:

	Volt.	Phase	Wire	Amps	FEE
Svc 1					
Svc 2					
Svc 3					
Svc 4					
Em Svc					
Fire Pump					
Other Svc					

15. POWER AND EQUIPMENT:

	Number	Total HP/VA	FEE
Motors/ Appliances			
Inside Signs			
Other			

16. COMMUNICATIONS/DATA/LOW VOLTAGE SYS.:

Type	Floors	Units	FEE
Telephone			
Security Alarm			
Network/ Data			

APPROVED BY:

DATE: **TOTAL ELEC. FEE:**

Figure 13-2

Department of Construction and Permits

BUILDING PERMIT

For Work at: 1235 W BELDEN AVE

Description of permitted work:

ERECT A NEW 3 STORY MASONRY SINGLE FAMILY RESIDENCE WITH BASEMENT AND 2 CAR MASONRY GARAGE PER PLANS (CONDITIONAL PERMIT SUBJECT TO FIELD VERIFICATION IN ADDITION THIS PERMIT CAN BE VOID IN 30 DAYS IF WRECKING PERMIT IS NOT ON SITE)

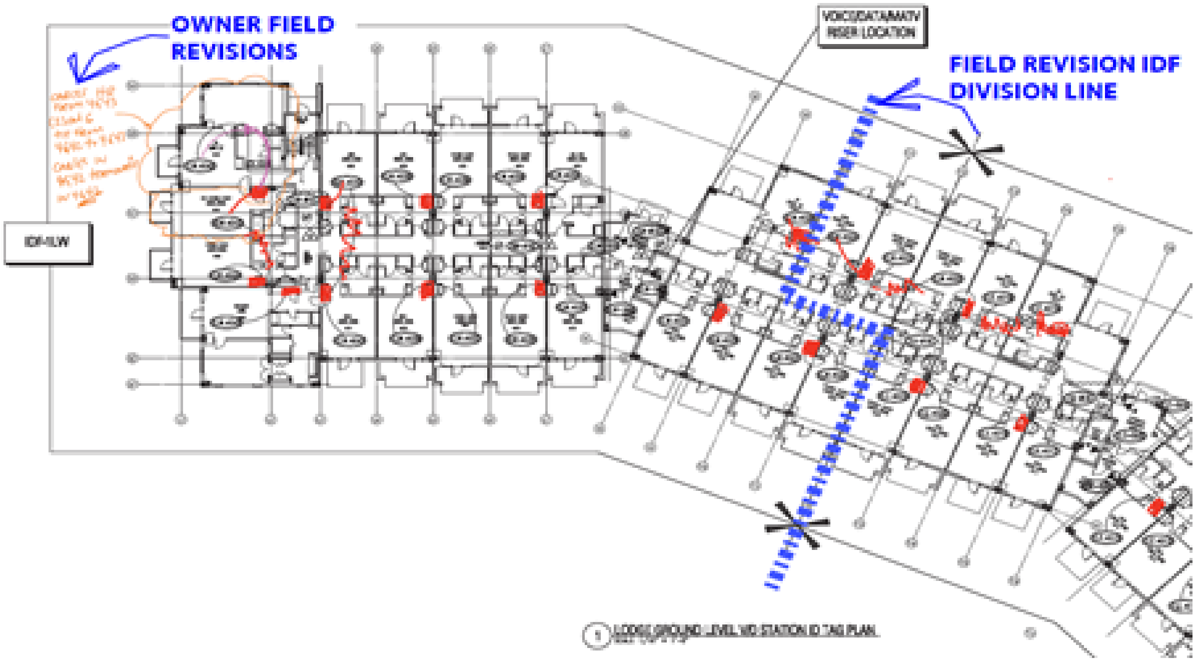
In an Emergency Contact: REAL ESTATE CITY VIEW (773)528-7008 x

Owner: REAL ESTATE CITY VIEW [illegible] CHICAGO, ILLINOIS 60647

Contractor: CITY VIEW REAL ESTATE GROUP, I P.O. BOX [illegible] CHICAGO, IL [illegible]

Figure 13-3

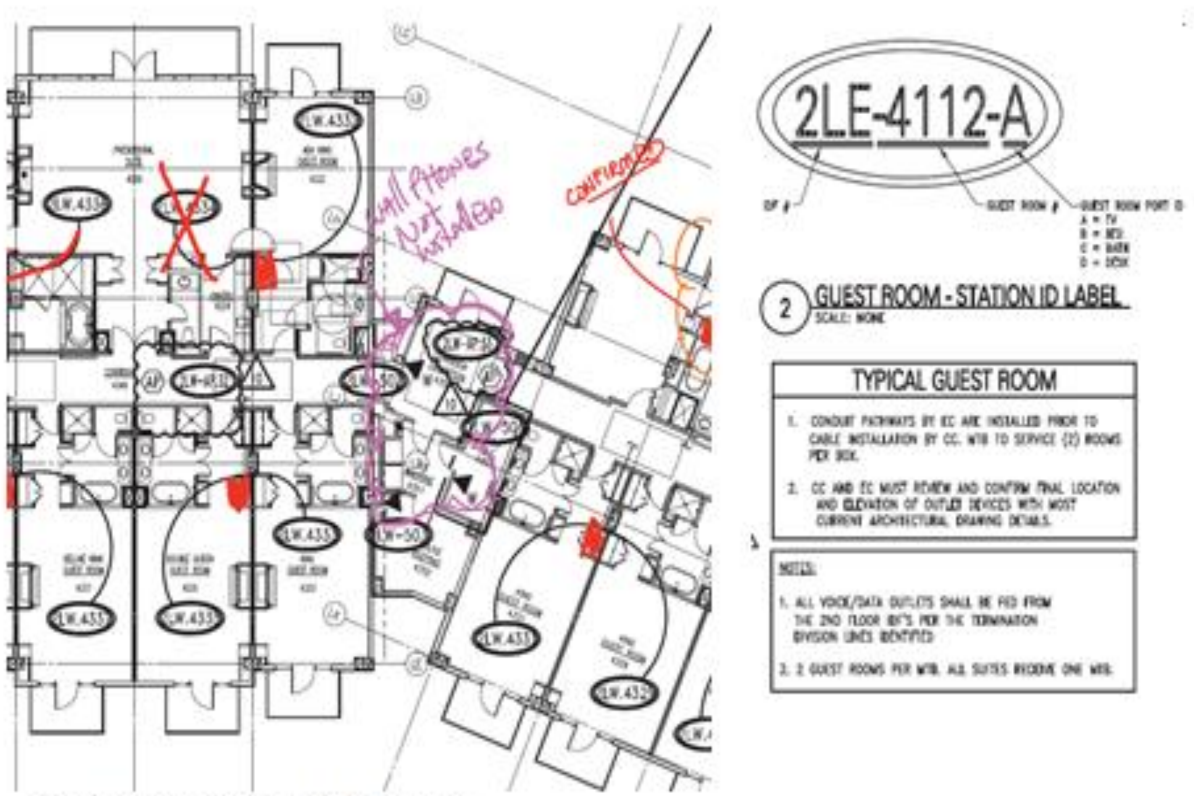
13.4 Sample Cabling AsBuilts



Cabling Station ID Outlet ID Example:

This diagram represents a plan view of all guest rooms and the associated data cabling outlet port locations. During the construction process, changes occur and the As-Built drawing has the field annotations that identify the correct conditions as installed. Also identified here is what ports are fed from which IT equipment closet. This is critical to the operation and maintenance team to troubleshoot and repair guest network issues.

Figure13-4



Cabling Station ID Outlet ID Example:

This diagram represents a close-up view of the Data Port Identification Tags and the field annotations that reflect the actual installed conditions. Also included is the Station ID Label detail that confirms the naming convention of the cabling.

Figure 13-5

13.5 Sample Cabling Test Results

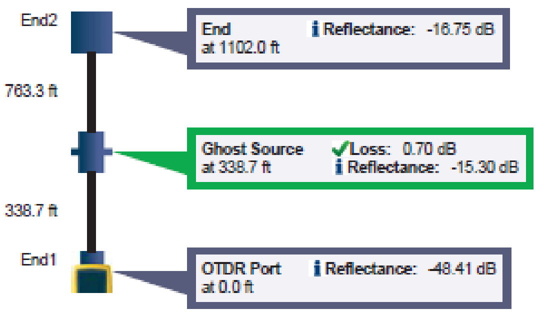
Cable ID: 002
Date / Time: 07/17/2013 10:28:38 AM
Cable Type: OM3 Multimode 50
Backscatter Coefficient: -68.0dB (850 nm)

n = 1.4820 (850 nm)
n = 1.4770 (1300 nm)
Backscatter Coefficient: -75.8dB (1300 nm)

Test Summary: PASS
Modal Bandwidth: 2000MHz-km (850 nm)
Modal Bandwidth: 500MHz-km (1300 nm)

EventMap

Fiber Length: 1102.0 ft
Overall Loss: 1.20 dB



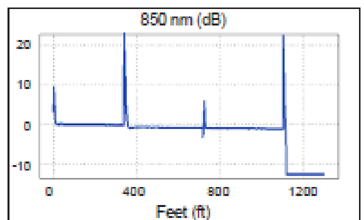
OTDR End1 PASS
Date / Time: 07/17/2013 10:28:38 AM
Test Limit: ANSI/TIA-568-C
Limits Version: 1.7
Operator: BRANDON BEALL

Tester: OptiFiber Pro (2076123 V1.1 Build 4)
Module: OFP-QUAD (2203050)
Calibration Date: 04/09/2013

No Launch Compensation

Overall Results	850 nm	1300 nm	Limit
Overall Length (ft)	1102.0		6562
Overall Loss (dB)	1.20	0.73	
ORL (dB)	18.91	17.57	

Events		Loss (dB)			Reflectance (dB)		
		850 nm	1300 nm	Limit	850 nm	1300 nm	Limit
1102.0 ft	End	N/A	N/A		-16.75	-17.39	
724.1 ft	Ghost	N/A			-51.40		
722.1 ft	Ghost	0.02	N/A		-53.83	-53.55	
338.7 ft	Ghost Source	0.51	0.70	0.75	-15.30	-16.58	
0.0 ft	OTDR Port	N/A	N/A		-48.41	-49.29	



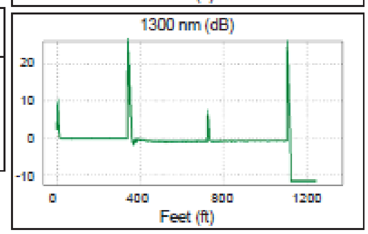
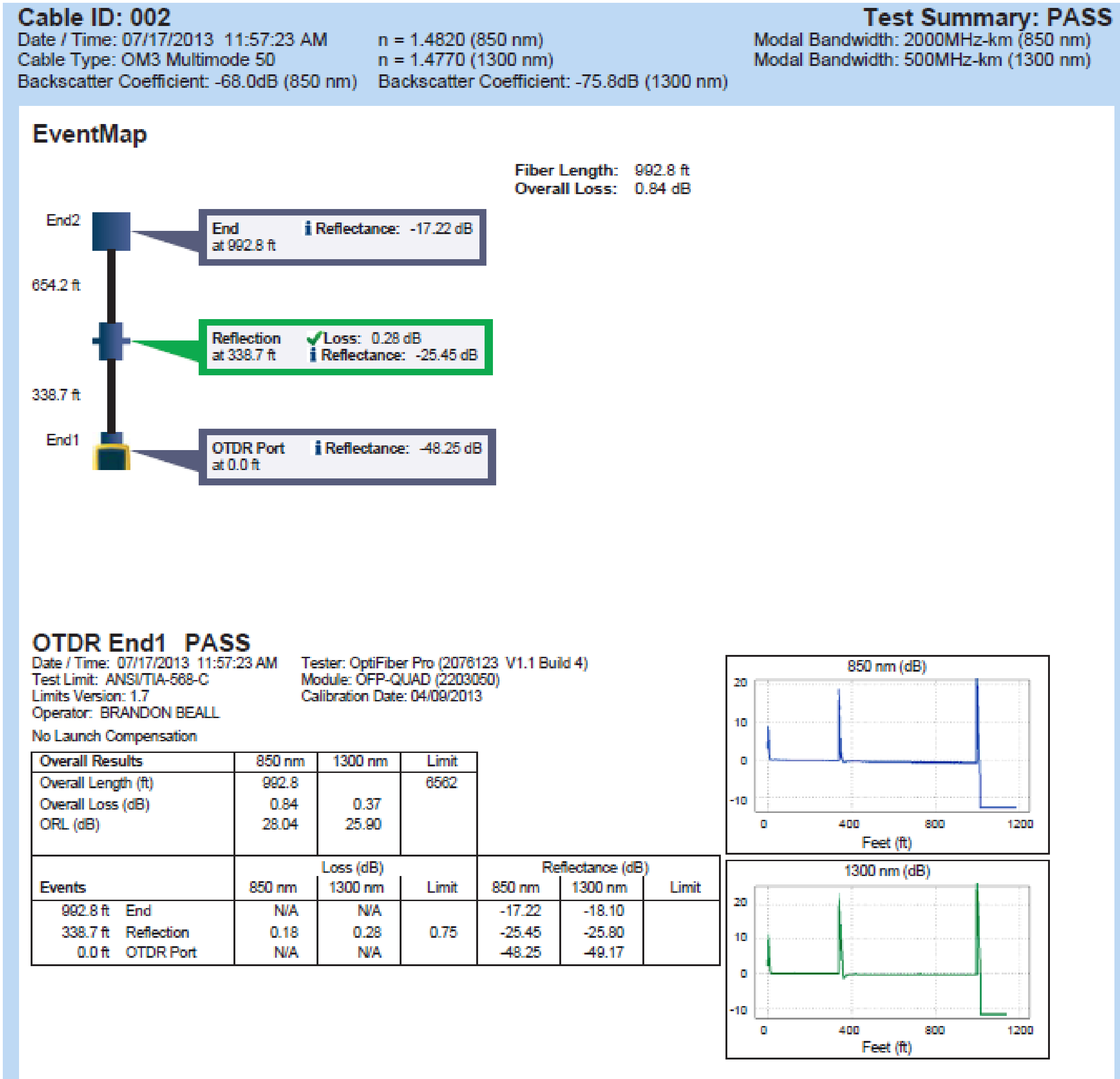


Figure 13-6



Cable ID: 002
Date / Time: 07/17/2013 11:57:23 AM
Cable Type: OM3 Multimode 50
Backscatter Coefficient: -68.0dB (850 nm)
n = 1.4820 (850 nm)
n = 1.4770 (1300 nm)
Backscatter Coefficient: -75.8dB (1300 nm)

Test Summary: PASS
Modal Bandwidth: 2000MHz-km (850 nm)
Modal Bandwidth: 500MHz-km (1300 nm)

EventMap

Fiber Length: 992.8 ft
Overall Loss: 0.84 dB

OTDR End1 PASS
Date / Time: 07/17/2013 11:57:23 AM
Test Limit: ANSI/TIA-568-C
Limits Version: 1.7
Operator: BRANDON BEALL
Tester: OptiFiber Pro (2076123 V1.1 Build 4)
Module: OFP-QUAD (2203050)
Calibration Date: 04/09/2013

No Launch Compensation

Overall Results	850 nm	1300 nm	Limit
Overall Length (ft)	992.8		6562
Overall Loss (dB)	0.84	0.37	
ORL (dB)	28.04	25.90	

Events		Loss (dB) 850 nm	Loss (dB) 1300 nm	Loss (dB) Limit	Reflectance (dB) 850 nm	Reflectance (dB) 1300 nm	Reflectance (dB) Limit
992.8 ft	End	N/A	N/A		-17.22	-18.10	
338.7 ft	Reflection	0.18	0.28	0.75	-25.45	-25.80	
0.0 ft	OTDR Port	N/A	N/A		-48.25	-49.17	

Figure 13-7

14 Appendices

14.1 Codes

The applicable codes include, but are not necessarily limited to, NFPA 70 NEC (National Electric Code), IEEE C2, National Electric Safety Code, Local Codes and Building Codes. Governing bodies and codes in worldwide locations should be observed without exception.

All parties involved in the design, installation and management process shall have working understanding of the governing codes to decrease potential liability issues and avoid costly rework and delays.

14.2 Standards

The applicable standards include, but are not necessarily limited to, TIA/EIA standards, such as:

- TIA/EIA – 568: Commercial Building Telecommunications Cabling Standard
- TIA/EIA – 569: Commercial Building Standard for Telecommunication Pathways and Spaces
- TIA/EIA – 606: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
- TIA/EIA – 607: Commercial Building Grounding and Bonding Requirements for Telecommunications
- IEEE 802.3av: CSMA-CD access method and physical layer specifications. Amendment 1: physical layer specifications and management parameters for 10 Gbps passive optical networks

14.3 Organizations

Telecommunications Industry Association (TIA)

As stated at the TIA website, "The Telecommunications Industry Association (TIA) is the leading trade association representing the global information and communications technology (ICT) industry through standards development, policy initiatives, business opportunities, market intelligence and networking events. With support from hundreds of members, TIA enhances the business environment for companies involved in telecom, broadband, mobile wireless, information technology, networks, cable, satellite, unified communications, emergency communications and the greening of technology. TIA is accredited by ANSI."

www.tiaonline.org

The Fiber Optic Association (FOA)

The FOA defines itself as an "International non-profit educational organization that is chartered to promote professionalism in optical fibers through education, certification and standards."

www.thefoa.org

BICSI

In their own words, "BICSI is a professional association supporting the information and communications technology (ICT) community. ICT covers the spectrum of voice, data, electronic safety & security, integration and audio & video technologies. It encompasses the design, project management and installation of pathways, spaces, optical fiber and copper-based distribution systems, wireless-based systems and infrastructure that supports the transportation of information and associated signaling between and among communications and information gathering devices."

www.bicsi.org

IEEE

The Institute of Electrical and Electronics Engineers is a Professional Association that is dedicated to advancing technological innovation and excellence for the benefit of humanity.

www.IEEE.org

APOLAN

The Association for Passive Optical LAN is a non-profit organization composed of manufacturers, distributors, integrators and consulting companies who are actively involved in the Passive Optical LAN marketplace. Members support the growth and education of the Passive Optical LAN industry and are focused on formulating solutions on how best to market, install, educate and support this burgeoning field.

www.apolanglobal.com

14.4 Glossary

For the purpose of this document the following terms have been defined as follows:

Term	Definition
Acceptance Testing	Testing provided to determine if the requirements of an installation have been met, including performance testing.
Access Points	Wireless communication devices that operate over radio waves.
Adapter – Optical Fiber Duplex	An adapter that has a fiber for both transmission and reception.
Aerial Plant	Telecommunications cables that are attached to poles in the air. Optical fiber cables, specifically, may use cables containing a suspension strand.
AFEXT	Alien far-end cross talk - interference on an optical fiber cable caused by bundled cables measured at the opposite end from the transmitter.
America Wire Gauge(AWG)	A measurement of the diameter of round, solid, nonferrous conductive wire.
ANEXT	Alien near-end cross talk - interference on an optical fiber cable caused by bundled cables measured at the same end as the transmitter.
ANSI/TIA/EIA	American National Standards Institute \ Telecommunications Industry Association \ Electronic Industries Alliance
Applications Specific Cabling	Communications or protocols specifically assigned to a PIN typical of a copper cable
Armoring	Metal clad cable which provides its own ground.
Array Connection	Fiber bundle/strand connectors typically designed to shield and isolate electromagnetic interference.
AsBuilt	A snapshot (post-deployment) immediately after the installation was finished. A virtual profile of the infrastructure. A listing of every powered and passive cabling element, complete with location, IP addressing, port assignment installed/deployed during a project. Updated after any change is made to the infrastructure to reflect the current environment.
AsBuilt Drawings	Drawings depicting an installation "as-is" or how the installation occurred in the real world, rather than planning phase drawings or designs.
Attenuation (or Fade)	Transmission loss due to the reduction in intensity of the signal as relative to distance.
Backboard	Typically made of plywood, a color coded (based on what the cables are used for) base for telecommunications wiring termination.
Backbone Cabling	A system of cabling that connects the entrance facilities, equipment and telecommunications rooms.
Backscatter	A reflection of light waves/signals back to origin of the wave/signal.
Balanced Cable	A type of cable that effectively reduces cumulative dispersion to zero (fiber). Or two wires kept close together generally by twisting with a consistent distance between cables.
Baseboard Pathway	An enclosed sheathing system typically run along a wall at the point of connection to the floor for cable routing.

Bend Radius	As measured by the inside curvature of the bend, the minimum radius at which an optical fiber cable can be bent or turned safely without damaging the cable, generally not less than 15 times the diameter of the cable.
BFOC	Bayonet Optical fiber Connector - a type of optical fiber connector.
BIC	Backplane Interface Connector, typically used to connect wiring to switch infrastructure.
BIM	
Boring	Drilling a pathway for cabling through non-porous substances.
Break-Out Cable	Optical fiber cable containing several fibers, each with its own jacket, surrounded by a common jacket.
Buffer Coating (Tight)	A protective layer (PVC) applied over fiber cladding.
Building Entrance Terminal	A point of cross connect between outside fibers and internal wiring.
Bundled Cable	An assembly of multiple cables into a single, generally non-flexible group.
Cabinet	Electronics infrastructure storage, typically secure and fire rated.
Cable	Metal and/or glass wire that transmits electrical current or light waves.
Cable Assembly	Cables and/or wires that are bound together in some way, including cable ties, conduit and other means.
Cable Rack	Cable sorting in the TR/ER that supports and cleanly separates cables for easier access and identification.
Cable Sheath	Protective coating made of various materials shielding fiber and/or copper cables from the elements and, in some cases, electromagnetic interference.
Cable Tray	Cable support for safe routing through an installation.
Campus Backbone	Fiber connections between campus buildings which define a single pathway for communication.
Campus Environment	Physically separate yet geographically close buildings typically on a contiguous plot of land.
Category 3,5,5e,6,6a,7	Types of twisted pair cabling generally categorized by speed and cable construction. Higher categories are faster speed rated. (add throughout specific information, in MHZ, and mb/gb, including IEC spex, using the word CLASS).
Ceiling Distribution System	Structured Cable pathways in the ceiling.
Centralized Fiber Cabling	A network design from which all data electronics and passive optical splitters are housed in a single location and optical fiber cables provide direct connections to every workstation outlet in the network.
Change Order	A process whereby changes in the Scope of Work agreed to by the Owner, Contractor and Architect are implemented.
Chase Nipple	Used on the end of a conduit to protect the cable during installation. It reduces the pull tension on the cable.
Cladding	A covering or coating on a structure or material.

Code	A systematically arranged and comprehensive collection of laws.
Communications Riser Cable	Cable used in vertical tray applications such as cable runs between floors through cable risers or in elevator shafts. These spaces cannot be used for environmental air. These cables must self extinguish and must also prevent the flame from traveling up the cable in a vertical burn test.
Conduit	A tube or trough for protecting electric wiring.
Condulets	It is a special corner fitting for joining two pieces of conduit while providing access for pulling wires around the corner.
Connecting Hardware	A device, used to terminate an optical fiber cable with connectors and adapters that provides an administration point for cross-connecting between cabling segments or interconnecting to electronic equipment.
Connector	A mechanical device used to align and join two fibers together to provide a means for attaching to and decoupling from a transmitter, receiver or another fiber (patch panel).
Convergence	The combination of multiple functions on the same physical infrastructure. Constitutes the reduction of the cable infrastructure as IP Phones, IPTV etc are transmitted on the same infrastructure. VOIP, IPTV, High Speed Internet, MiniBars, Back-of-House Applications, Front-of-House Applications, Security Cameras, Digital Signage; all on the same network.
Converter (Media)	A component used in Ethernet, although it is not part of the IEEE standard. The IEEE standard states that all segments must be linked with repeaters. Media converters were developed as a simpler, cheaper alternative to repeaters.
Core (Fiber)	The central region of an optical fiber through which light is transmitted.
Coupler	An optical device that combines or splits power from optical fibers.
CPE	Customer Premises Equipment: Terminal, associated equipment and inside wiring located at a subscriber's premises and connected with a carrier's communication channel(s) at the demarcation point (demarc), a point established in a building or complex to separate customer equipment from telephone company equipment.
Cross-Connect	Connections between terminal blocks on the two sides of a distribution frame or between terminals on a terminal block (also called straps). Also called cross-connection or jumper.
Demarcation Point	The point at which the public network ends and connects with the customer's on-premises wiring.
Direct-Buried Cable	Direct-buried cable is a kind of communications or transmissions cable which is especially designed to be buried under the ground.

Directional Coupler	A coupling device for separately sampling (through a known coupling loss) either the forward (incident) or the backward (reflected) wave in a transmission line.
Dispersion	The cause of bandwidth limitations in a fiber. Dispersion causes a broadening of input pulses along the length of the fiber. Three major types are (1) modal dispersion caused by differential optical path lengths in a multimode fiber; (2) chromatic dispersion caused by a differential delay of various wavelengths of light in a waveguide material and (3) waveguide dispersion caused by light traveling in both the core and cladding materials in single mode fibers.
Distributed Fiber Cabling	A network design from which all data electronics and passive optical splitters are housed and distributed through the property.
Distribution Patch Panel	A wiring board that patches fiber and/or copper terminations end-to-end and is typically housed in rack space in the TR/ER.
Duct	A flexible enclosed pathway for cables to be routed.
EPON	Ethernet based Passive Optical Network (PON). Another term sometimes used to refer to a BPON.
Ethernet	A system for connecting a number of computer systems to form a local area network, with protocols to control the passing of information. Ethernet is a standard for using various transmission media, such as coaxial cables, unshielded twisted pairs and optical fibers.
Fading	An optical fiber's light source that gradually grows faint and disappears.
False Ceiling	A dropped ceiling is a secondary ceiling, hung below the main (structural) ceiling.
FC Connector	A threaded optical connector that uses a special curved polish and angled tip on the connector for very low back-reflection. Used with single-mode or fiber only.
FDDI	Abbreviation for Fiber Distributed Data Interface. 1) A dual counter-rotating ring local area network. 2) A connector used in a dual counter-rotating ring local area network.
Fiber Optics	Light transmission through optical fibers for communication signaling.
Fill Ratios	The fill ratio formulas are used in estimating the number of optical fiber cables that can be installed in ductwork. Key element used in the design of a network.
Firestop System	A specific construction consisting of a fire-rated wall or floor assembly.
Floor Plan	A scale diagram of the arrangement of rooms in one story of a building.
FOTP	Standards developed and published by the Electronic Industries Association (EIA) under the EIA-RS-455 series of standards.
FOTS	Fiber-Optic Transmission System: a communication system using optical fiber cables.

FSAN-B	Full Service Access Networking working group, founded by major telecom providers and system vendors, instrumental in the provisioning of the original fiber to the home protocols, now a major industry proponent of GPON technology
Fusion Splice	A permanent joint produced by the application of localized heat sufficient to fuse or melt the ends of the optical fiber, forming a continuous single fiber.
Gigabit Ethernet	A network technology that transmits Ethernet frames at a rate of a gigabit per second (1,000,000,000 bits per second), as defined by the IEEE 802.3-2008 standard.
Graded Index Fiber	An optical fiber whose core is designed to accept several rays of light, at different angles, and have all rays arrive at the same time.
Grommet	Grommets are flared or collared rings inserted into a hole in material. Grommets are often installed in desks and tables to allow the passing of electrical and communication cables.
Guy	A steel cable used to stabilize utility poles. Guys attach to the ground to oppose the tension from cable weight and keep the pole upright.
Hand-hole	An in-ground enclosure in which cable can be pulled. Hand-holes are similar to maintenance holes, but are not large enough for a person to fully enter.
Header Duct	Sometimes called a trench duct or feeder duct, a header duct is rectangular cable raceway, installed within a floor to bring cable from a service closet to distribution ducts.
Home Run	A pathway or cable between two locations that does not contain a splice, consolidation point or transition point.
Horizontal Cable	The telecommunications cabling infrastructure that connects a telecommunications outlet to the TR (Intermediate Distribution Frame) or telecommunications room on that floor.
Horizontal Cross-Connect	Also known as a floor distributer; horizontal cross-connects are a group of connectors, such as patch panels or punch-down blocks. A horizontal cross-connect allows equipment and backbone cabling to be cross-connected with jumpers or equipment cords.
Hybrid Cable	A cable assembly which contains two or more different types of cables. All cables are enclosed in one sheath or jacket.
Hybrid Coupler	A component used to combine two communications signals or equally split a signal amongst its ports.
IDF	Intermediate Distribution Frame. Also known as telecommunications room, an IDF is a space housing telecommunications equipment, cross-connect cabling and cable terminations for a building floor or section.
Infrastructure	A collection of telecommunications components, excluding equipment, which enables the transmission of voice, data and video throughout a building or campus environment.

Innerduct	Located within a conduit or sheath, innerduct is a flexible, non-metallic raceway used to route, separate and protect cabling.
International Electro-technical Commission	A global standardization organization that publishes standards and conformity assessments for electric and electronic products, systems and services.
J-Hook	A rigid metallic support, shaped like the letter "J." J-Hooks are mounted to some building structures to support horizontal cables.
Ladder Rack/Ladder Cable Tray	A rigid metallic structure, resembling a ladder, used to support and route cables within a building.
Laser	A device that produces highly amplified and coherent light radiation on one or more frequencies.
LC Connection	A small form factor, optical fiber cable connector, used with both single-mode and multimode fiber.
Loose Tube	A type of optical fiber cable, where fibers are laid loosely in a protective sheath, often filled with gel.
Maintenance Hole	An underground vault used to install, terminate and maintain cables. Maintenance holes are large enough that a person is able to fully enter and perform work.
MDF	A Main Distribution Frame (MDF) is a space used to interconnect and manage telecommunication wiring between itself and any number of intermediate distribution frames, in addition to the cabling from the network it supports.
Mechanical Splicing	A method of joining two optical fiber cables, through mechanical means.
Media Converter	A hardware device that converts the signal from one type of cable to another; for example, from twisted pair to optical fiber.
Modular Jack	A female telecommunications connector, used to connect equipment with the use of patch cords.
MT-RJ Connector	A small form factor optical fiber connector that contains two to twelve fiber strands.
Multimode Fiber/Single-Mode Fiber	The two major types of optical fiber cable. Single-mode fiber carries a signal on a single path for long distances. Multimode fiber is able to carry numerous signals over one strand, by injecting light at different angles, for shorter distances.
Nanometer	The most commonly used unit of measurement, for measuring optical fiber wavelength. 1 nm (nanometer) is equal to 1 billionth of a meter (0.000000001 m).
National Electric Code	A safety standard that regulates the use of electrical wire, cable, electrical and optical communications cable installed in buildings.
Near-End Crosstalk	The undesirable signal interference between pairs of a twisted pair copper cable, closest to the point of transmission.
Noise	Undesirable signal on a cable that interferes with the quality of the expected communication signal.

Nonzero Dispersion	A type of optical fiber cable, constructed to allow a small amount of signal loss without having the light cross the zero point in its wavelength.
Numerical Aperture	In an optical fiber, numerical aperture is a number that characterizes the angular spread of light from the central axis of the strand.
OF	Optical Fiber is a communications medium that transmits information as light pulses along a glass or plastic wire.
OFC	Optical Fiber Conductive cable – Optical fiber cable that has a metallic sheath for protection.
OFCG	Optical Fiber Conductive General purpose cable – General purpose optical fiber cable that has a protective metallic sheath; designed for installation in non-air handling spaces.
OFCP	Optical fiber Conductive Plenum cable – Optical fiber cable that has a metallic sheath for protection and an outer jacket designed for installation in air handling spaces.
OFCR	Optical Fiber Conductive Riser cable – Optical fiber cable that has a protective metallic sheath; designed for installation in non-air handling spaces.
OFNR	Optical Fiber Nonconductive Riser cable - Optical fiber cable that contains no conductive material and an outer jacket designed for installation in non-air handling spaces.
OM1 to OM4	The four categories of multimode optical fiber cable. Each category has distinct design and performance characteristics.
ONT	Optical Network Terminal - A media converter that converts optical fiber light signals to electric signals, which can be transmitted over copper cabling.
ONU	A generic term for an optical fiber termination panel. Optical Network Units are wall or rack mounted enclosures, housing and protecting optical fiber terminations.
Optical Fiber Ferrule	A mechanical fixture, generally a ceramic tube, used to protect and align a fiber in a connector. Generally associated with optical fiber connectors.
Optical Receiver	A receiver that converts an optical signal into an electrical signal.
OTDR	Optical Time Domain Reflector – An optical cable measuring instrument that can estimate overall cable length, measure attenuation and provide testing results on the integrity of the fiber run or strand.
Overhead	Planned over-capacity design to ensure future proofing of raceways and conduits.
PageFormat	Designed by the Construction Specifications Institute, PageFormat is a model describing the recommended arrangement of text, articles, paragraphs and subparagraphs for design and construction documentation.
Passive Optical Lan (POL)	Evolving technology that can potentially revolutionize the way networks are built. It can reduce direct deployment

	costs, cabling costs, and ongoing costs of ownership significantly vs traditional copper based networks.
Patch Cord	Often called a patch cable or equipment cable, a patch cord is an electrical or optical cable with male ends on each side, used to connect one device to another, routing signals.
Pedestal	A protective above-ground outdoor enclosure, used to splice cables or for administrative terminal location.
Performance Bond	A written financial bond from a third party guarantor, ensuring the contractor will abide by the design specifications. Performance bonds ensure payment of a stipulated sum of money in the event the contractor fails in the full performance of the contract.
Physical Topology	The physical layout of cabling and equipment on a network.
Plastic Optical Fiber	Optical fiber cabling that is manufactured using plastic, versus glass.
Poke-Thru	Penetrations through the floor of a structure, allowing the installation of telecommunications, audio/visual and/or power cabling.
Power over Ethernet (PoE)	Describes a system to pass electrical power safely, along with data, on Ethernet cabling. IEEE 802.3af-2003[2] PoE standard provides up to 15.4 W of DC power, IEEE 802.3at-2009[7]. PoE standard, also known as PoE+ or PoE plus, provides up to 25.5 W of power.
Project Management	The discipline of planning, organizing, securing, managing, leading and controlling resources to achieve a specific goal, typically within a specific time frame and within a budgeted/contracted cost.
Pull Cord	A cord, string, wire or fish tape that when connected to cable, will pull the cable through a pathway or conduit.
Pull Point	An opening or break in the pathway that allows connection to a pull cord.
Pull Tension	The amount of tension that can be applied to a cable while pulling it through a pathway.
Raceway	Any open or enclosed channel, pipe, conduit or tray for holding cabling.
Reflection (Fresnel)	Optical light reflection at a discrete interface with refractive discontinuity. Also known as Fresnel Reflection or Fresnel Loss.
Refraction	The change in direction of an optical beam produced at the interface between two dissimilar media.
SC Connector	Subscriber Connector - A common optical fiber connector used to connect fiber terminations.
Schematic Design	Done typically after preliminary planning and scope development, a planning phase for a project that typically includes a Schematic diagram, which is a projected illustration of the low voltage cable plan.
SCS	Structured Cabling System.
SFF Connector	A generic term representing "Small Form Factor" connectors. SFF connectors are the trend in deployments

	as they allow more low voltage connections in a smaller space.
Sleeve	As It relates to structured cabling, a sleeve is: (1) An opening that allows for the passage of cables or (2) A larger-circumference tube or pipe that slides over existing conduit to hide or cover an opening ("Slip Sleeve").
SMF	Single-Mode Fiber - In fiber-optic communication, a single-mode optical fiber (SMF) (also known as mono-mode optical fiber, single-mode optical waveguide or unimode fiber) is an optical fiber designed to carry only a single ray of light (mode).
Splice	Weaving the strands of cabling together. Optical splicing includes fusion splicing and mechanical splicing.
Splice Case	Enclosure used in optical splicing to cover and protect the splice.
Splice tray	A fiber splice tray houses and protects a fusion or mechanical optical splice.
Splitter	Low voltage copper (or fiber) device that provides multiple outputs to a group of devices.
Star Coupler	In optical fibers, and especially in telecommunications, a star coupler is a passive optical device used in network applications. An optical signal introduced into any input port is distributed to all output ports. Because of the way a passive star coupler is constructed, the number of ports is usually a power of 2; i.e. two input ports and two output ports (a "two-port" coupler, customarily called a directional coupler, or splitter); four input ports and four output ports (a "four-port" coupler); eight input ports and eight output ports (an "eight-port" coupler), etc.
Step-Index Fiber	For an optical fiber, a step-index profile is a refractive index profile characterized by a uniform refractive index within the core and a sharp decrease in refractive index at the core-cladding interface so that the cladding is of a lower refractive index. The step-index profile corresponds to a power-law index profile with the profile parameter approaching infinity. The step-index profile is used in most single-mode fibers and some multimode fibers.
Straight Splice	Two pieces of cabling connecting in-line from opposite directions.
Strand	A single unit of wire that, when bundled together, create a cable.
Telecom Closet	An enclosed (typically secured) space that is purposed to house telecommunications equipment, cable terminations, server racks, points of entry, etc.
Tie Cable	The Tie Cable is used in a backbone cabling environment and is the interface between the inter-building (campus) or intra-building cable connections in the equipment rooms/telecommunications closets, AND the distribution (horizontal) connections.
Tight Buffered Optical Cable	Type of fiber cabling that has increased coating and protection, and allows for more workability, bending, etc.

Transition Point	A transition connection between a round cable and a flat rug cable.
Trench Duct	Sometimes called a header duct or feeder duct, a trench duct is rectangular cable raceway, installed within a floor to bring cable from a service closet to distribution ducts.
Trunk Cable	This is usually a telephone company term. It refers to the main bundle of cable(s) coming out of a central office or other centralized telephone switch (computer). It is based on the way a tree grows: there is the trunk, then the branches.
Uplink	In computer networking, an uplink is a connection from a device or smaller local network to a larger network.
Value Engineering	Value engineering (VE) is a systematic method to improve the "value" of goods or products and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value can therefore be increased by either improving the function or reducing the cost. It is a primary tenet of value engineering that basic functions be preserved and not be reduced as a consequence of pursuing value improvements.
WDM	Wavelength Division Multiplexing - In fiber-optic communications, wavelength division multiplexing (WDM) is a technology that multiplexes a number of optical carrier signals onto a single optical fiber by using different wavelengths (i.e. colors) of laser light. This technique enables bidirectional communications over one strand of fiber, as well as multiplication of capacity.