By John Pfleiderer, MA, CTS-D

Fibre Basics

Optical Fibre technologies are now a ubiquitous technology deployed on college campuses, industrial complexes, high-rise office buildings, long line services, cable television and more. A basic understanding of this technology can allow audio-visual engineers and technicians to leverage these fibre optic infrastructures to move audio and video signals across campuses, between buildings or further.

While it is important to remember that optical fibre networks were most likely intended to move data; the individual links can be provisioned to also move audio and video. The basic design for moving video and audio across a fibre link is shown in Figure 1. This is shown in its most simple form for this discussion. But keep in mind that there are an array of fibre transmitters and receivers designed to move a variety of audio and video signals from the most basic two-channel audio and composite video signals to where some digital appliances even multiplex a number of audio channels and can deliver several video signals on one strand of fibre. Still others have the ability to move data in both directions. For example this appliance could be used to support the design of control links that requires return strings for needed confirmation.

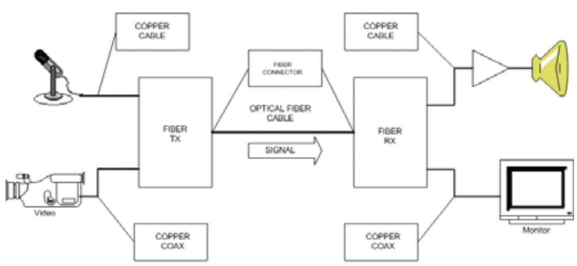


FIGURE 1
BASIC AUDIO / VISUAL
OPTICAL FIBER
POINT TO POINT DEPLOYMENT

WHY USE FIBRE?

The choices for interfacing a variety of AV signals with fibre are many: Everything from NTSC or PAL composite to HDTV are available in today's market. After choosing the signals we need to transmit and receive, there are other considerations as we begin to deploy the fibre appliances in the field.

BUDGETING

Also it is wise to do a thorough analysis of the optical transmission budget where calculating the length of cable, the amount of splices, connectorisation and patch bays needed for the entire circuit are listed and the losses (in db) are calculated over the entire run. To initiate the link budgeting- much of the budgeting information can be determined by a thorough analysis of the component and cable specifications.

SYSTEM DESIGN

In most cases, the transmission equipment will be deployed in a terminal room, but prior to getting to this location, the signals typically run over copper infrastructure. In this case, the copper interface needs to be terminated at the fibre equipment and then the deployment further requires the use of a fibre patch cable to link the transmitter or receiver to the fibre terminations. The patch panel is used to make this interface and there are a variety of styles and models of patch panels on the market. The important thing here is that the patch cable connectors much match up with the patch panel and the deployed fibre device. There are a variety of connector designs created for different environmental reasons and the age of the application. Be sure to check on which connector is being used in the design before deploying the fibre equipment.

CONNECTOR TYPE	ADVANTAGES	DB LOSS	CABLE
ST	Most popular of F/O connectors- Bayonet design LAN Standard Deployment	0.5 db	SM/MM
FC or FC-PC	Popular F/O connector- Precise Positioning Notch and Threaded Design	0.4 db	SM
SC	New connector style- low cost push on pull off design with a locking tab	0.5 db	SM
SMA	Older style - Threaded Cap and Housing design- less used today- ST is replacing this connector	0.9 db	SM/MM
D4	Threaded Coupling and Keying- similar to FC connector	~ 0.5 db	SM
FDDI	Keyed duplex designed to connect two fibers at once	~ 0.5 db	SM
Biconic	Older style -no longer deployed in new construction Poor repeatability and prone to vibration	1 db	MM

There are some very beneficial signal related aspects to employing optical fibre technology, but wide bandwidth is clearly the chief benefit for choosing this technology. The large carrying capacity of fibre over long distances (using single mode) without the need to refresh the signals is only the beginning. The overall resistances to electromagnetic fields that eliminate induced noise from EMF radiation of other nearby cabling are other benefits of this technology. Finally fibre networks operate using light pulses and can be modulated up into the gigabits. Modulation over fibre can be accomplished by analog or digital methods.

Some older equipment use AM (Amplitude Modulation), which is basically where the light is varied in intensity. And FM (Frequency Modulation) is better characterised as a Pulse Position Modulation (PPM). Both the AM and FM analogue modulations have their downsides. With AM, there is a loss of dynamic range and signal to noise ratio. And in the FM modulation scheme requires that the filters maintain separation of the carriers. If there is a drift over age, there can be crosstalk interference generated in the FM signal.

Today there is the digital modulation techniques using A/D and D/A processing on the front-end of the transmission equipment and on the backside of the receiving equipment that allows for improved multiplexing, lower signal to noise ratios and improved distances over the transmission path. The digital technique relies on the creation of a high-speed stream of pulses (1s and 0s) originating from the LED or Laser light source. Regardless of which modulation technique is applied, the fibre cable link does not have to be physically altered to accept the different transmission techniques. However, the modulation technique applied at the transmitter has to be supported throughout the fibre path. So the type of cable used in the transmission path must match with the specifications of fibre transmitter and receivers selected. For example: if the cable supports multimode operation, than the transmitter and receiver must also be a matched pair of AM, FM or digital multimode equipment running at the chosen window of operating wavelengths-in this multimode example, the windows are 850 nm or 1310 nm.

There are several varieties of light sources built into optical fibre transmitters. They are typically Light Emitting Diodes (LED), employed more in multimode deployments because of the broader spectrum of light they emit. The LED sources are most commonly available in 850 and 1310 nm wavelengths and are less costly than lasers.

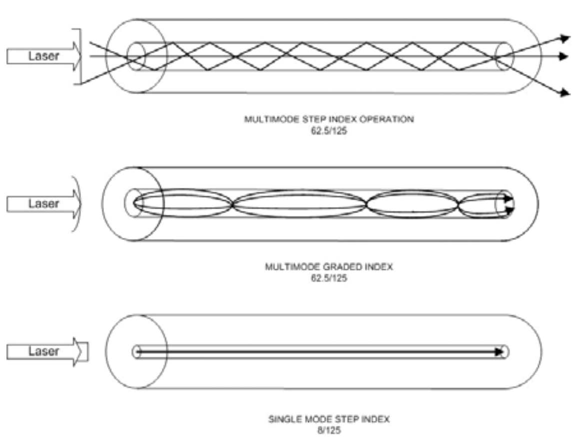
Another light source used in transmitters are the Lasers. There are two types of lasers that are typically used in the single mode fibre deployment because they are capable of a more finely-tuned wavelength. The first is the Fabry-Perot (FP) this laser is less expensive but exhibits sidebands that are not desirable for the most critical of applications. The Distributed Feedback (DFB) laser however has a well-tuned filter system that allows only the desired wavelength to be evenly delivered to the fibre optic cable aperture for transmission through the wave guide. As you can imagine, this laser system is more expensive and primarily used in single mode applications over the two wavelength windows of 1310 and 1550 nm.

A word of caution about using fibre optic equipment. The optical output of a laser can easily damage your eyes if you look directly into the fibre aperture (fibre end). Never look into the end of a lit fibre! When working with fibre optic systems, always power them down while you are making the connections to the patch bays, transmitters or receivers.

Optical Fibre cable is (in a practical sense) not a "cable" but more along the lines of a wave guide. In thinking about the construction of optical fibre - one should imagine the optical fibre as a tube with a reflective coating (cladding) on the inside of the tube. This wave guide or tubular structure assists and guides the transmission of the originating light source (LED or Laser transmitter) down the length of the wave guide or tube to the other end where the detector in the receiver "sees" or "detects" the modulated light. A basic cross-section of fibre would look like a group of concentric circles if one magnifies the cut end of the fibre cable. See Figure 3

Mode Propagation in Fibre Optics has much to do with to refractive indexes. In multimode fibre the step index differs from the graded index fibre in the index of refraction profiles of their core and cladding. In the step indexed multimode fibre, the properties of the core and cladding possess the ability to make an abrupt change in the refractive index. This is due to the reflection properties of the cladding. In the graded indexed multimode fibre, the fibre core decreases from the center outward. The refractive index in the cladding is uniform - causing bends in the light rays into a sign-wave like path because of the core's non-uniform refraction properties. The graded index multimode has a benefit of higher data rate than the step indexed fibre cable.

Figure 2
Mode Propagation



The smaller aperture on the single mode cable only allows for one light ray path down the length of the cable. Single mode fibre allows for higher speed data transfer because there is less dispersion and losses off the cladding whereby only propagating in a single mode. Therefore, because there is less attenuation over distance, signal reproduction is more accurate.

FIBRE CABLE SELECTION

In selecting fibre cable for your application there are several basic specifications to generally keep in mind:

- Operational Wavelength - windows are typically at 850 nm (multimode), 1310 nm (single mode and multimode), 1550 nm (single mode)
- Mode of Operation - Multimode or Single Mode
- Physical Environment of Application - Direct Burial, Arial, Duct Installation, etc.
- Fibre Attenuation - db/km @ operation wavelength
- Number of fibres needed to be deployed
- Optical Fibre Diameter - for example 62.5/125 multimode where the first number is the core measurement/second is the cladding measurement. Sizes are measured in microns
- Type of material used in the construction - pure glass, plastic clad silica (PCS), plastic

There are two basic optical fibre constructions that can be deployed in a fibre network. Each one has its benefits and they are deployed in sections of the network where they will be the best use and will best suit the environment in which it is deployed.

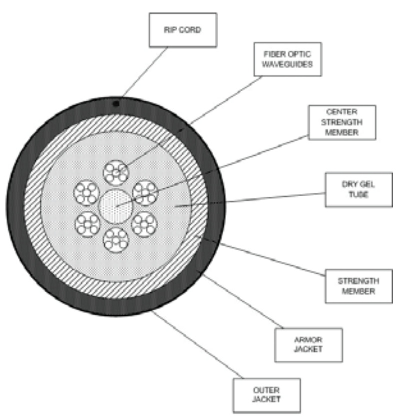


FIGURE 3
TYPICAL CROSS SECTION
OF INDOOR / OUTDOOR
LOOSE TUBE
MULTI FIBER CABLE

Loose Tube Cable - used in the majority of outside plant deployments. Environments for this cable includes direct burial, aerial and duct installations. The cable is typically jacketed in polymer and if used in direct burial applications, will have an armor layer to guard against rodents chewing through the cable bundle. The cable core will have a yarn to act as a tensile centre strength member and the fibre optic wave guides will be packed in a buffer gel to allow some ability to flex as the cable is being installed and pulled into place. Each separate fibre will have an identifying colour to keep the circuitry organised as the installation proceeds and the splicing and termination process begins.

Tight-Buffered Cable - This cable is typically deployed inside buildings. The multi-fibre cable designs are used as riser cables, general intra-building cables and plenum applications. The Tight-Buffered Cable interfaces with the outside cables (Loose Tube) at the terminal equipment rooms and links the various network devices with the fibre network. The tight buffering design and a yarn placed in the core provide the rugged cable structure to protect the individual fibres during installation and terminal connectorisation.

As with Loose-Tube Cable all optical specifications and environmental operational ranges should be employed as the network design is completed.

SUMMARY

What is really great about the current models of digital fibre optical equipment is that once the fibre is deployed across a campus, between buildings or between floors in a building, there is a fairly simple rollout of end point equipment to do the job needed. In the terminal room, you can either install a permanent solution using the mainframe designs offered by several manufacturers, or you can lease the fibre strands and do a deployment using standalone fibre transmitters and receivers to do a temporary set up for special events. Either way, the set up or testing is not extremely time consuming and since many of the newer models are set up at the factory to meet video standards, there is little in the way of tweaking in the field to get the signals to test properly. Most of the heavy lifting is done in the proper design of the fibre link, so once all is in place, and meets the specifications for the type of fibre deployed and you (or the network design team) have (has) done the work to properly prepare your patching standards and completed the interface with your copper audio and video links beyond the fibre - the transmission of high quality AV signals should be yours to enjoy.

About the writer...

John Pfleiderer, CTS-D is the Videoconferencing Engineer and Video Infrastructure Designer for Cornell University. He is the Current Chair of the ICIA Technology Managers/End Users Council and has been a member of that council since 1997. He is also a member of the ICIA Professional Education and Training Committee (PETC) and Membership Committee. He can be reached at jap85@cornell.edu.