History and Application

FIBER OPTICS A NEW TECHNOLOGY?

Using light for communications is not new. Sailors used lamps to communicate ship to ship by Morse code. In fact Navy signalmen are still required to demonstrate this proficiency. This is however, a long way from today's advanced optical communication systems.

Early experiments more than 100 years ago demonstrated the principles of guiding light through a transparent medium. This was done using water and bending the light to match the flow. Although crude, this same principle is repeated daily through complex communication systems.

A decade later, Alexander Graham Bell received a patent for a device called the photophone. Bell's device used unguided light to convey speech. This was accomplished using a series of lenses and mirrors to focus and modulate the light. Bell managed voice transmission of more than 600 feet.

It was almost one hundred years before the telephone companies ambitiously started construction of massive complex telecommunication systems. Significant advances had to take place to produce the lasers, semiconductor components, and glass fiber cable to take advantage of the many possible benefits of a fiber system.

New fiber optic installations are being deployed at a rate of 2,000 miles per hour. That's right, per hour according to statistics from Lucent Technologies. Trunk and branch applications are bringing fiber to the customer's premises, allowing for such applications as security, surveillance, access control and video distribution as well as telecommunications, information networking, industrial control and internet access. Today, fiber optics is leading the bandwidth hungry technology explosion.

THE ADVANTAGES OF FIBER

The most commonly asked questions about fiber systems revolve around "how far can a signal be carried?" and "how many signals can I put on one fiber?" These questions only highlight two of the many advantages fiber offers over conventional metallic cabling systems.

The use of coax is perhaps the most limiting part of any video or data transmission system. In terms of video, 1000 ft. is the quality limit of standard RG-59U. In truth, signal degradation starts at the point when a signal enters the cable. High frequencies are affected more than lower frequencies and results in loss of picture resolution. Therefore, distance is a very important benefit of fiber systems. It is possible to drive a video signal 3-5 km with a simple baseband system and there is virtually no degradation of a video signal. American Fibertek can offer a system that will allow a signal to travel sixty (60) miles with no repeater or loss of signal clarity.

Fiber cable has high bandwidth capacity. Once a backbone is installed, there is a tremendous increase in the potential to move information. American Fibertek provides equipment that takes advantage of this capacity. In fact, our product development strategy has always focused on saving fiber and utilizing existing cable. For example, if a single multimode fiber had been deployed in 1984, a customer–simply by changing electronics–would have been able to upgrade as follows:

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1984 MT-10 → MR-10
Video TX → Video RX
(1 - Video Signal)

1985 MT-15 → MR-15
Audio/Video TX → Audio/Video RX
(1 - Video & 1 - Audio Signal)

1987 MT-1400 — MR-1400
Video,RS422 →
← Return RS422
(3 Signals - Same Fiber)

1989 MT-1480 — MR-1480
Video, Audio, RS422 →
← Audio, RS422
(5 Signals - Same Fiber)

1991 MT-2480 — MR-2480
Video, Audio, RS422 →
← Video, Audio, RS422
(6 Signals - Same Fiber)

1995		
	MX200A	MX200B
	MT-588	MR-588
	MR-588	MT-588
	MT-534	MR-534
	MR-534	MT-534

2 Video →
2 Audio →
2 Data →
← 2 Video
← 2 Audio
← 2 Data

(12 Signals On the Same Single Fiber)

1998 - Using our new six channel multichannel and our proven 500 Series Modulators and Demodualtors, 18 signals could be sent on the same fiber that was installed more than 15 years ago.

This has increased transmission capacity by 18X in only 15 years and we see no reason for that to cease.

We provide electronic fiber optic solutions for complex system needs.

Other benefits of fiber include:

- Small size and weight.
- Complete protection from lightning.
- NEC (National Electric Code*) approval. *Please consult the NEC handbook.
- Total electrical isolation with no chance of ground loops or ground potential shifts, plus safety from sparking and shock.
- Immune to EMI and RFI.

Finally fiber optic systems are immune from any electronic "bugging." It is the most secure method of signal transmission available today.

MULTIMODE VS. SINGLEMODE

The glass fiber used in fiber optic transmission consists of a central core upon which the signal is carried and a surrounding cladding which has a lower refractive index to contain the signal within the core. The cladding in most fiber today has an outside diameter of 125 microns. In comparison, the diameter of an average human hair is 85 microns. There are two popular sizes currently for the core diameter, 62.5 micron and 9 micron. The 62.5 micron fiber is called multimode fiber, the 9 micron fiber is called singlemode fiber. Based on the names given these fibers, first impressions would be that multimode fiber would be more efficient than singlemode fiber. However, the reverse is usually true.

The term multimode comes from the fact that light can travel in more than one path through the core of this fiber. The relatively large core allows light to travel both straight down the center or to bounce from side to side in a zigzag pattern. Light traveling from side to side takes longer going down the fiber than light traveling straight so the signal at the end of the fiber is dispersed. This dispersion effect does not become significant until the signal has traveled long distances such as a mile or more, or when data bits are packed close to each other.

The relatively small core found in singlemode fiber only allows one path of light directly down the center of the core. This keeps the signal intact for distances in excess of tens of miles.

Since singlemode fiber is half the cost of multimode fiber and it has more efficient signal transmission, the obvious question is why use multimode? The answer is that the overall cost of an application is generally less expensive when done In multimode. This is because the transmitters and receivers required to convert electronic signals to fiber optic signals are three times more expensive in singlemode than in multimode.

Camera and control systems used in most security and surveillance designs typically use multitmode optics. The low speed data used in these systems allows for distances to three miles with the lower cost optics. Intercom and contact closure used for gates and alarms can also be transmitted up to three miles on multimode fiber. For long distance projects such as traffic management and distance learning, the extended range and increased bandwidth of singlemode optics is the transmission of choice.

Therefore, when designing a high data throughput for long distance application, a singlemode system is preferred. When designing an application with moderate data throughput, multimode is more economical.

THE FIBER OPTIC SYSTEM AND LOSS BUDGET

The Fiber Optic Transmission System is made up of three components:

- Transmitters
- Receivers
- The Interconnect

Transmitters have a measured optical output power, while receivers are measured in sensitivity. To calculate the system gain or loss budget, simply subtract the receiver sensitivity from the transmitter average output power. We have calculated this number for you and listed it on our product sheets under Optical Loss Budget. This is the maximum allowable loss between a transmitter and receiver. The system loss budget must be adjusted for several factors. These include:

- Operating margin
- Repair margin

The operating margin allows for conditions of temperature change and component aging.

The repair margin accounts for any potential damage that a cable may incur. American Fibertek recommends that 3dB of system margin be left to cover any of these circumstances.

The interconnect consists of the fiber optic cable, connectors and any splices that are required to complete a fiber system installation. Standard cable attenuation is published as part of the performance specifications of cable. Connector losses for systems planning may vary by connector type. We strongly recommend the ST type connector for multimode and the FC/PC type connector for singlemode.

Splices may vary according to the type chosen. The lowest loss would be incurred using a fusion splice. A good one is almost transparent. The highest loss would be experienced when two connectors are mated in a passive coupler. Coupler loss can exceed the 1dB range. Please see the following chart on Loss Budget Parameters.

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Fiber	850 nm	1300 nm	1550nm
Multimode	3dB/Km	1.5dB/Km	I.OdB/Km
Singlemode		0.5 dB/Km	0.35 dB/Km

Splices

Passive Coupler	1 dB
Mechanical	0.5 dB
Fusion	<0.2 dB

Connectors 0.5 dB

To calculate a system loss budget let's use the following example:

The ten video cameras in Building A are being transmitted to Building B's control room. Building B is located 2500 meters from Building A. One (1) kilometer of cable is of buried armored construction and the other 1.5 kilometers is of aerial construction. Buildings A and B both have patch panels located where the fiber enters the building and patch cords or jumpers are used to connect the transmitters and receivers to the fiber backbone. The transmitters are modules, American Fibertek part #MT-10 and the receivers are rack mount, American Fibertek part #RR-10. The connectors are ST type. There is a mechanical splice where the aerial and buried cables are connected.

SAMPLE CALCULATION

LOSS BUDGET (SYSTEM)	17 dB
Operating Margin Allowance	(-3 dB)
AF recommends -3 dB	
CABLE ATTENUATION	
Armored Burial @ 3 dB/Km	(-3.0 dB)
Aerial Cable @ 3 dB/Km	(-4.5 dB)
SPLICE LOSS	
Patch Panel Building A	(-1.0 dB)
Mechanical	(-0.5 dB)
Patch Panel Building B	(-1.0 dB)
CONNECTOR INSERTION LOSS	
AF Part # MT-10 Transmitter	(-0.5 dB)
AF Part # RR-10 Receiver	(-0.5 dB)
MARGIN	3 dB

The system still has 3 dB of available budget before you approach the operating margin. Calculating a system loss budget requires knowledge of the transmitter and receiver specifications as well as the cable infrastructure. Cable length, installation technique, number and type of splices, and equipment connector type must all be considered to engineer the system. Specifying the components you need to build a fiber system can be tricky given the wide range of solutions available.

American Fibertek, Inc. is committed to providing the best fiber optic equipment, training and technical support available. **We encourage you to contact us.**