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edu Guide

Making sense out of complex Pro A/V and Broadcast technologies.

Why Digital Fiber Optics?

The Advantages of Transmitting Signals Digitally Over Fiber

CSI™ Communications Specialties, Inc.

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Introduction

For the past quarter century, fiber optic communication has been hailed as the superior method for transmitting video, audio, data and various analog signals. Fiber offers many well-known advantages over twisted pair and coaxial cable, including immunity to electrical interference and superior bandwidth. For these and many other reasons, fiber optic transmission systems have been increasingly integrated into a wide range of applications across many industries.

However, while fiber optic transmission has dramatically improved upon the standards obtained via conventional copper-based transmission mediums, until recently, fiber optic technology has continued to use the same analog-based signaling techniques as its predecessors.

Now, a new generation of products that employs pure digital signaling to transmit analog information offers the opportunity to raise the standard once again, bringing fiber optic transmission to a whole new level. Digital systems offer superior performance, flexibility and reliability, and yet don't cost any more than the older analog designs they replace. This Education Guide examines how digital signaling over fiber is accomplished and the resulting benefits, both from a performance and economic perspective.

Analog Transmission Over Fiber

To appreciate the advantages of digital fiber, let's first look at the basics of how traditional fiber optic communications work when transmitting an analog signal.

Analog fiber optic transmission systems are sold in both AM and FM versions. In both types of systems, the optical transmitter takes in an analog, baseband video, audio or data signal and converts it to an optical signal. At this point, the systems begin to vary.

In an AM (amplitude modulation) system, the optical signal is generated as a beam of light that varies in intensity with respect to variations in the original, incoming, electrical analog signal. Either a light emitting diode (LED) or a laser diode serves as the source of the optical signal. Unfortunately, both LEDs and laser diodes are nonlinear devices. This means that it is difficult to control the brightness of their light in a controlled linear continuum, from completely off to completely on with all variations in between.

However, in an AM system, this is exactly how they are used. As a result, various distortions to the transmitted signal occur, such as:

- Degradation in the signal-to-noise ratio, or SNR, as the length of the fiber optic cable is increased
- Nonlinear differential gain and phase errors of video signals
- Poor dynamic range of audio signals

Light Passing Through Two Fibers

In AM modulation, variations in the baseband signal are represented by varying the intensity of the transmitted light.

In FM modulation, variations in the baseband signal are represented by varying the speed, or frequency, at which light pulses occur.

In an effort to improve upon the performance of AM-based fiber optic transmission systems, FM design techniques were introduced. In these systems, the signal is conveyed by pulsing the LED or laser diode completely on and off, with the speed and duration of pulsing varying with respect to the original incoming signal.

For those familiar with FM transmission over mediums other than fiber, the term "FM" for this type of system may be a bit confusing. FM stands for "frequency modulation" and might be interpreted, within the context of fiber optics, to mean that the signal is transmitted by modulating the frequency of the light itself. This is not the case. A more accurate name for this type of system is PPM, which stands Pulse Position Modulation. However, across industries, "FM" – and not "PPM"– is the name associated with these types of systems. Just remember that the "F" in "frequency" refers to the frequency of the pulses instead of to the frequency at which the light itself travels.

While FM transmission systems eliminate many of the problems found in AM systems, which result from difficulties in controlling the varying brightness level of light emanating from the diode, FM systems offer their own unique set of problems. One distortion common in FM systems is called crosstalk. This occurs when multiple FM carriers are transmitted over a single optical fiber, such as when using a multiplexer. Crosstalk originates within either the transmitter or receiver unit and is the result of a drift in alignment of critical

filtering circuits designed to keep each carrier separate. When the filters do not perform properly, one FM carrier may interfere with and distort another FM carrier. Fiber optic engineers can design FM systems that minimize the likelihood of crosstalk occurring, but any improvement in design also means an increase in price.

Another type of distortion is called intermodulation. Like crosstalk, this problem occurs in systems designed to transmit multiple signals over a single fiber. Intermodulation originates in the transmitter unit and is most often the result of a non-linearity present in a circuit common to the FM carriers. The result is that the two (or more) original incoming signals interfere with each other before being combined into a single optical signal, causing reduced fidelity in the transmitted optical signal.

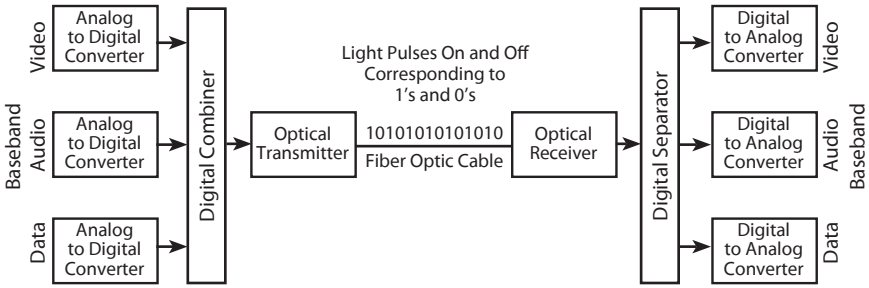
How Digital is Different

As in analog-based fiber systems, transmitters in digital systems take in baseband video, audio and data signals and the receivers output these signals in their original format. The "digital difference" occurs in how the signals are processed and transmitted between transmitter and receiver.

In a pure digital system, the incoming baseband signals are immediately run through "analog to digital" converters within the transmitter. This converts the incoming signal or signals to a series of 1's and 0's, called "digital streams." Then, if more than one signal has been processed, the transmitter combines all the resulting digital streams into a single digital stream. This combined stream is used to turn on and off the emitting diode at a very high speed, corresponding to the 1's and 0's to be transmitted.

At the receiving end, the process performed by the transmitter is reversed. The combined digital bit stream is separated into multiple bit streams, representing each of the unique, transmitted signals. These are then run through digital to analog converters, and the receiver outputs video, audio and data in the same, analog format in which the signals originated.

Digital Transmission System for Analog Baseband Signals



Pure digital processing offers many advantages over traditional AM and FM systems, ranging from improved performance and system flexibility to lower installation costs. Let's examine some of these in detail and discuss their direct benefits both to the system installer and to the user of the system.

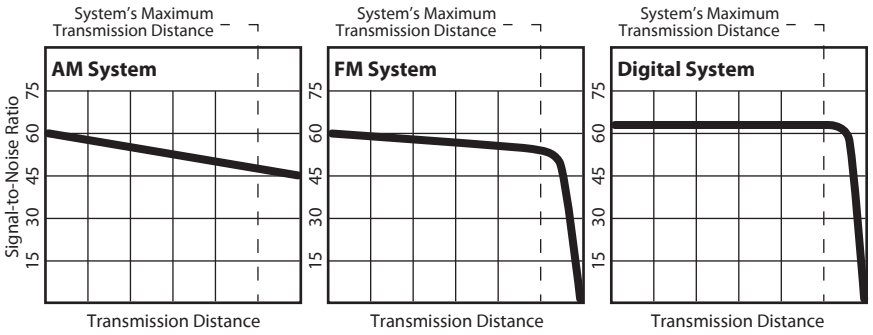
Performance Consistency

Unlike in AM and FM systems, pure digital transmission guarantees that the fidelity of the baseband video, audio and data signals will remain constant throughout the system's entire available optical budget. This is true whether you are transmitting one or multiple signals through the fiber, over short or long distances (up to the longest distance allowed by the system).

By contrast, analog systems using AM signaling techniques exhibit a linear degradation in signal quality over the entire transmission path. This characteristic, combined with the fact that AM systems can only transmit over multimode fiber, limits the use of these systems to applications in which a relatively short transmission distance must be covered. FM systems fare a bit better, with signal quality remaining relatively constant over short transmission distances, but decreasing dramatically at longer distances. And even at short distances, there is some signal degradation. Only systems that use pure digital transmission techniques can claim to have an absolutely uniform signal quality over the entire transmission path, from transmitter to receiver.

Consistent signal quality, or lack thereof, is also an issue when considering systems designed to transmit more than one signal over a single fiber (multiplexers). For example, a multichannel analog system designed to carry four channels of video or audio might restrict the bandwidth allocated to each signal in order to accommodate all the desired signals to be transmitted. Systems using digital transmission need not make this compromise. Whether sending one, four, or even ten signals over a single fiber, the fidelity of each signal remains the same.

Comparison of Signal Degradation in AM, FM and Digital Systems



Transmits Higher Quality Baseband Signals Relative to Price

Due to the inherent design of digital transmission systems, baseband analog signals maintain a higher fidelity when transmitted using d igital processing techniques. This is because the only signal distortion that occurs in a digital system is that resulting from the analog to digital conversion and back again. While no conversion is perfect, the state of today's A/D and D/A converter technology is so advanced that even the lowest cost converters can produce video and audio quality that far exceeds that attainable by conventional AM and FM based systems. Evidence of this can be seen by comparing signal-to-noise ratios and measurements of nonlinear distortions (differential phase and differential gain) between digital and analog products. Comparing systems designed to transmit similar signal types over the same fiber and at the same wave-length, digital systems will consistently offer higher signal-to-noise ratios and lower levels of nonlinear distortion.

In addition, digital design offers tremendous flexibility to fiber optic engineers who wish to scale the performance level of a product to meet the needs of different markets, applications and budgets. By changing the number of sampling bits used in the analog to digital conversion, engineers control the transmission bandwidth of a system – affecting the product's ultimate performance and price. However, regardless of the number of bits used, the other digital properties of the system remain constant, including lack of distortion and consistent performance up to the maximum supported transmission distance. This makes it easy for engineers to anticipate how different variations of a given system design will work if scaled for high-end and lower-end performance requirements. When designing analog systems, engineers are constantly struggling with ways in which price and performance may be balanced without compromising critical qualities of the transmitted signals.

Infinite Signal Extension

Another advantage of digital systems over their analog predecessors is their ability to regenerate a transmitted signal without incurring any additional degradation to the original baseband video, audio or data signal. This is accomplished by using a device called a repeater.

As light travels through a length of fiber, its optical power gradually attenuates. Eventually, not enough light remains to be detected by a receiver. By placing a repeater on the fiber at a point prior to where the light diminishes too much to be detected, the repeater can regenerate and restore the digital signal to its original form. This regenerated signal is then launched again on the same wavelength, with the same optical power found at the original transmission point.

It is important to note that the baseband video, audio or data signal is never actually recovered in a repeater; only the data stream representing the original signal or signals is processed. In this manner, the quality of the original baseband signal is not degraded, regardless of how many times the signal is repeated and over how great a distance.

The advantages this offers to the system designer are obvious. Not only can tremendous distances be covered that far exceed the capability of any AM or FM system, but the designer can also be assured that the quality of the received signal will always be consistent and meet the performance requirements of this application.

Lower Overall Cost

Given the many advantages that digital systems offer, one might think that they cost more than traditional analog systems. This should not be the case. In fact, users of digital systems save money on many levels. For starters, the cost of digital components has decreased greatly in recent years, resulting in the ability of fiber optic manufacturers to design and manufacture products that are priced similarly or even less than earlier generation analog products. Of course some manufacturers would like the public to believe that the superior performance of digital systems can only be obtained for a premium price, but in reality, they are simply choosing not to pass their own savings on to their customers. By competitive shopping, users of fiber optic transmission systems should be able to find products offering digital performance at the same price as analog systems.

Other factors also contribute to the economics of owning and operating a system. Most obvious is the expense of fiber optic cable. Digital systems allow for the transmission of more information over a single fiber, thus minimizing the required quantity of cable. This advantage is particularly evident in applications requiring the transmission of disparate signal types, such as video with audio, or audio with data. Fiber optic engineers can easily design affordable digital systems that accommodate a mixing and matching of signals types, such as two channels of video with four channels of audio, all over a single fiber. Using analog technology, this same signal transmission would most likely require two systems, or at least two fibers, for separate transmission of video and audio signals.

Even in situations where multiple channels of the same signal type are transmitted over a single fiber, digital designs offer more reliable, consistent performance. For example, a ten channel video multiplexer that uses digital processing and transmission can provide uniform transmission of all ten signals over the entire transmission path – something impossible in an analog system. Another cost factor to consider is the amount of maintenance and

repair that a system is likely to require throughout its years of use. Once again, digital systems provide a clear advantage. First of all, digital systems require no adjustments in the installation process. Transmitter, cable and receiver are simply connected together and the system is ready to go. By contrast, analog systems often need tuning and adjustments to accommodate for transmission distance and signal strength. Additional setup time translates to additional costs. Then, once a system is fully operational, digital systems are far more likely to perform consistently and reliably over time. This is because by design, digital systems have far fewer components that may break or malfunction. There is no possibility for the system to require retuning or adjustments. And, the user is likely to spend less time troubleshooting because the digital design makes it immune to interference, crosstalk, drifting, and other performance issues that plague traditional analog systems. Lower transmitter and receiver costs; lower cable costs; lower maintenance costs. Digital fiber optic transmission systems provide a clear economic advantage at every level.

Summary

Just as fiber optic transmission offers many advantages over traditional coax or copper wire, digital fiber optic transmission brings the medium of fiber several steps further, offering users a whole new set of benefits.

Characteristics unique to digital systems include consistent signal quality over the entire transmission path, absolute minimal signal distortion (including immunity from crosstalk and intermodulation), and the potential to regenerate and extend the distance of a transmitted signal indefinitely with no degradation to the original baseband signal. Because of these qualities, baseband analog signals that are transmitted digitally over fiber maintain a level of fidelity not possible if the transmission were to occur via an analog system.

In addition, digital fiber optic transmission systems are available at prices similar to analog systems, and actually cost less overall to own and operate when considered within the context of an entire installation, including fiber, setup and maintenance costs.

For your next fiber optic transmission project, don't spend valuable time weighing the advantages of digital versus analog systems. That choice is clear. Digital systems will serve you better on every level. Instead, limit your search to digital systems and evaluate carefully which line of digital fiber optic products best meets your needs. Even among digital systems, you will find tremendous variation. Some questions you might consider are:

1. Is the system easy to install?
2. If the transmitter and receiver units are user-configurable, is this process simple and trouble-free?
3. Is the design compact, sturdy and mechanically reliable?
4. Are units available as both box units and for use in a rack?
5. Are systems available for use with both single mode and multimode fiber?
6. Does the manufacturer have a history and reputation for designing quality products?
7. Is the price competitive with traditional analog systems? (Digital designs cost no more to manufacture than analog systems and should not cost a premium.)

With a little investigation and comparison shopping, you are bound to find a digital fiber optic transmission system that will serve you well now and for many years to come.

Other issues in the eduGuide Series

Introduction to Fiber Optics
Undisputably, fiber is the future. Learn all about the benefits of fiber optic technology in this easy-to-read guide.

Advantages of Digital Fiber Optics
Examine how digital signals over fiber are accomplished, the phenomenal results they achieve, and how cost-effective it is.

Fiber Optic Cables, Connectors and Integration
Learn how easy it is to terminate and fabricate your own fiber optic cables, what types of fiber and fiber jackets are available and how to design and integrate a fiber optic system.

Scan Converters Buyer's Guide
Everything you need to evaluate and decide on the perfect Scan Converter.

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About Communications Specialties, Inc.

Communications Specialties, Inc. (CSI) is an award-winning, Long Island based company that manufactures and sells a variety of products for the distribution, conversion or transmission of television and computer video signals, including fiber optic transmission systems, scan converters and video scalers.

The company was founded in 1983 by veterans of the broadcast industry. Since then, CSI has managed to consistently design innovative products that are used worldwide by Fortune 500 Companies and Government Agencies in a variety of markets such as Broadcast, Professional A/V, Videoconferencing, Education, Home Theater, Security, ITS, Industrial Monitoring, Digital Signage, Government/Military and more!

The **Pure Digital Fiberlink®** line offers an extensive and affordable family of fiber optic transmission systems for the Professional A/V marketplace and includes several ground-breaking products for the transmission of high-resolution RGB signals. Systems for point-to-point and point-to-multipoint signal distribution make these products highly desirable for any Pro A/V applications.

Our premier product line, the **Scan Do®** family of computer to video scan converters, has redefined industry standards in computer video to NTSC/PAL technology with unsurpassed performance in its price range. All models support high resolutions and refresh rates and are VGA and Mac® compatible. The feature-rich and versatile Scan Do family offers the widest range of scan converters on the market.

The award-winning, **Deuce®** video scalers convert NTSC and PAL to high-resolution, non-interlaced video and offer a far superior and affordable alternative to line doubling and quadrupling. The new generation of Deuce products offer a wide range of non-interlaced resolutions and refresh rates for every application, from professional A/V installations to home theater, including a model designed especially for use with HDTV displays.

In addition, CSI manufactures a comprehensive selection of distribution amplifiers, VGA monitor, keyboard and mouse extenders and accessories for our entire product line.

Communications Specialties and its products have been the recipient of numerous industry awards. In 2005, the Pure Digital Fiberlink® 7220 Series for high-resolution RGB and Stereo Audio was honored as one of the AV industry's best technological innovations of the year by receiving a "rAVe Radical Product of the Year" award as "Best New Analog Signal Processing Product". The rAVe email newsletter is published by professional audiovisual industry veterans and is read industry-wide.

Among CSI's many other awards are AV Video Magazine's Platinum Award (given to Scan Do® Ultra and Deuce®) and the Video Systems' Vanguard Award (given to Deuce).

The company is headquartered in the United States on Long Island, New York, with Sales Offices in Florida, Indiana and Virginia. Research, development, design, engineering, manufacturing and customer support operations are performed at the New York headquarters. Other locations include Communications Specialties Pte Ltd (CSPL) - a wholly owned subsidiary office in Singapore that provides support to distributors in the Far East and Pacific Rim.

Our in-house sales department handles complete product-line sales directly to end-users as well as to an international network of representatives and resellers. All of our products are backed by an exceptional warranty.

October 19, 2007

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World Headquarters
55 Cabot Court
Hauppauge, New York 11788
USA
Tel: (631) 273-0404
Fax: (631) 273-1638
info@commspecial.com

Asia
Communications Specialties Pte Ltd
100 Beach Road
#22-09 Shaw Tower
Singapore 189702
Tel: +65 6391 8790
Fax: +65 6396 0138
csiasia@commspecial.com

commspecial.com