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Fiber Optics, technology update, applications, planning considerations
Coax cable and hardline (coax with an outer copper or aluminum tube) are traditionally specified for RF transmission applications. While functional, this approach has several shortcomings. Copper coax and hardline are bulky and heavy, they conduct electricity, and they have low bandwidth, which seriously limits the maximum usable distance.
Fiber optic RF transmission eliminates all of these shortcomings. Fiber optic cable weighs less than hardline or coax cable, and since single-mode fiber optic cable has only about 0.25 to 0.5 dB of signal loss per kilometer of fiber, an antenna may be located many kilometers from the receiver or transmitter.
In addition, fiber's dielectric properties prevent lighting from following the fiber optic cable into the building that the antenna serves. Fiber optic transport of satellite signals may be used in a number of applications, including transport from the remote satellite dish farm to a broadcaster's headend, uplink and downlink applications, and DBS services.
Satellite Dish Farm to Headend Network

- Teleport operators use fiber optic transport links to transmit RF signals from a remote satellite dish farm to their headend. Because of the remote location of some dish farms, L-Band transport equipment must be able to withstand wide environmental conditions.
Satellite Dish Farm to Headend Network

- Signal quality is usually assured through some means of gain control, either manual, automatic, or fixed. Many Teleports also incorporate some form of remote monitoring and control using Simple Network Management Protocol (SNMP) tools to remotely monitor such parameters as RF signal level, optical output power (in fiber optic networks), gain settings, device status, and other parameters.
Satellite Dish Farm to Headend Network

- Quite often, a redundant optical and/or RF system and antenna diversity are utilized to protect the satellite distribution system from the effects of weather-fade and sun-fade outages. Figure 1 illustrates an optically redundant system and Figure 2 illustrates an RF redundant signal.
Satellite Dish Farm to Headend Network
Satellite Dish Farm to Headend Network

Remote Dish Farm

Primary RF Signal Path

RF Optical Transmitters (one per satellite)

Secondary RF Signal Path

RF Optical Transmitters (one per satellite)

Primary RF Signal Path

RF Optical Receivers (one per satellite)

Secondary RF Signal Path

RF Optical Receivers (one per satellite)

RF Switch (1 per channel)

RF Out
Uplink and Downlink Applications

Satellite systems are rarely unidirectional. IF uplinks use satellite modems at the headend to transmit IF signals to the remote dish farm, while downlinks transport RF signals from the satellite dish farm to the headend. IF signals typically fall in the 10-200 MHz range. Figure 3 illustrates a typical uplink/downlink application.
- Uplink and Downlink Applications
DBS System

- A typical direct broadcast satellite (DBS) installation uses several satellites. This is necessary because each satellite can only transmit a small number of channels. In order to provide 500 channels, for example, the DBS provider would need additional satellites.
DBS System

- These satellites hold a geosynchronous orbit over the equator and cover the northern hemisphere, from the United States to the northern part of South America. Regardless of the number of satellites needed in a system, the signal path configuration is the same. Figure 4 diagrams this signal path.
DBS System

STACKED LNB
FREQUENCY RANGE
(950 to 2200 MHz)
**DBS System**

- A satellite signal is received by pointing the dish antenna toward a group of specific satellites. Digital broadcast satellite service providers usually include an on-screen interface for aiming the satellite dish. Once the antenna's course is aimed, the signal may be fine-tuned by moving the antenna until the signal meter is receiving at least 60% of the signal strength. This configuration applies to both copper coax set top box (STB) or a fiber optic satellite transport link.
Applications for an L-Band Satellite Transport System

- Antenna remoting and headend relocation commonly appear at radio and television stations, although headend relocation to a CATV installation also applies. Most signals above 2 GHz are converted by the LNB converter at the dish antenna to an L-Band signal, which allows a microwave signal to be transported a considerable distance.
Applications for an L-Band Satellite Transport System

- Sending a 12 GHz signal over copper coax cable would result in extremely high loss; however, if the signal is blockdown converted to 2 GHz (L-Band frequency), the same signal can be transmitted over copper coax up to several hundred feet before the loss degrades the signal.
Applications for an L-Band Satellite Transport System

- Figure 5 illustrates this application. This configuration shows a redundant configuration where back up transmitters and receivers are connected to an A/B switch. In the event of failure on the primary path, the switch will activate the secondary path, keeping the network running at all times.
Applications for an L-Band Satellite Transport System
Baseband Video Transmission

- Baseband video consists of one video picture being sent point-to-point, such as the video output of a VCR to the video input of a monitor. Figure 1 illustrates simple point-to-point transmission.
Baseband Video Transmission
Baseband Video Transmission

- There exist two levels of service for baseband video: broadcast studio and consumer. These types describe, primarily, the quality of the signal. Broadcast studio quality requires a much higher signal fidelity, while consumer quality baseband requires is less demanding.
Baseband Video Transmission

In addition to the difference in signal fidelity, there is also a difference in the connectors typically used for the transmission of these signals. The broadcast baseband applications typically use a BNC connector and the consumer baseband applications typically use an RCA connector.
Baseband Video Transmission

- The most basic form of a television signal is a baseband video signal, also referred to as a composite video signal. In an AM baseband system, the input signal directly modulates the strength of the transmitter output, in this case light. The baseband signal contains information relative to creating the television picture only.
Baseband Video Transmission

The following information is carried on a baseband signal:

- Scanning: drawing the television picture
- Luminance: the brightness of the picture
- Chrominance: the color of the picture
Baseband Video Transmission

The creation of the baseband signal produces a range of frequency components. The highest frequency in a baseband signal is also its bandwidth. The lowest frequency ranges close to zero Hz or DC. The video output of a television camera or video tape recorder has its highest frequency, therefore, its bandwidth, at either 4.2 or 6 MHz, depending on the type of TV format used.
Baseband Video Transmission

Looking at an actual baseband signal, illustrated in Figure 3, we can see that the camera and the video display are scanned horizontally and vertically. The horizontal lines on the screen are scanned alternately, with the odd numbered lines first and the even numbered lines second, or vice versa. (Figure 3B depicts the initial scan of the odd numbered lines.) This method is known as an interlacing system.
Baseband Video Transmission

The second method is to scan the lines sequentially; this is known as progressive Scanning. The camera and receiver must be synchronized when scanning and reproducing an image. The horizontal and vertical sync pulses regulate the synchronization of the camera and receiver, illustrated in both 3B and 3C, and starts a horizontal trace.
Baseband Video Transmission

As seen in Figure 3A, during the horizontal blanking interval, the beam returns to the left side of the screen and waits for the horizontal sync pulse before tracing another line. The dotted line illustrated the horizontal retrace. When the beam reaches the bottom of the screen, it must return to the top to begin the next field.
Baseband Video Transmission

This is called the vertical retrace, which is signaled by the vertical sync pulse illustrated in Figure 3C. The vertical retrace takes much longer than the horizontal retrace, therefore, a vertical blanking interval ensues to synchronize the two signals. During both the horizontal or vertical blanking intervals no information appears on the screen.
Baseband Video Transmission
Baseband Video Transmission
Digital Video/Audio Network Configurations

- Multi-format Analog and Digital Video/Audio Broadcast Transport Systems described the system requirements of a multi-format analog and digital broadcast transport platform. In fact, many such transport platforms exist, though the types of video signals, the number of audio channels, and the ability to hot swap modules may vary from solution to solution.
Digital Video/Audio Network Configurations

- A state-of-the-art transport platform would allow for a number of video types and enough audio channels to support secondary audio programming (SAP) and surround sound in addition to standard television signals.
Digital Video/Audio Network Configurations

- This section of the presentation discusses the various networks that can be configured in a multi-format analog and digital video/audio network. The elements of this transport platform include the following mix-and-match components:
Digital Video/Audio Network Configurations

- RS-250C video module with six audio inputs/outputs SDI (SMPTE 259M) video module that transports 16 embedded digital audio channels
- DVB-ASI/SMPTE 310M video module with pre-embedded audio
- Hot-swappable power supply module (universal 85-264 Volts AC)
- 1RU chassis with optics (1310 nm or 1550 nm, depending on system requirements)
- Optional CWDM, DWDM, and EDFA configurations
- Optional optical path redundancy via optical A/B switches
Digital Video/Audio Network Configurations

Using these basic components, broadcasters and cable providers can mix-and-match digitized analog video/audio with pure digital video and embedded audio, creating a uniquely flexible system.

Digitized Analog Transmission with Six Audio Inputs/Outputs
Digital Video/Audio Network Configurations

- Most products on the market today that transport both analog and digital video utilize high-resolution uncompressed 12-bit A/D (analog-to-digital) conversion to transport broadcast quality signals. Employing a high signal-to-noise ratio (SNR) provides excellent broadcast quality video that surpasses the RS-250C short-haul video standard.
Digital Video/Audio Network Configurations

- Six channels of digitized audio, with 24-bit resolution, offers CD-quality sound allowing the end user to meet the FCC’s SAP requirements and additional audio channels required for surround sound programming. Figure 1 illustrates a point-to-point network that uses two digitized video/audio modules, each offering one video and six audio channels, for a total of two digitized analog video channels and 12 CD-quality audio channels on a single fiber.
Digital Video/Audio Network Configurations
Digital Video/Audio Network Configurations

- SDI (SMPTE 259M) and DVB-ASI/SMPTE 310M Transmission with Pre-embedded Audio Signals

In general, most analog/digital transport platforms can carry SDI and DVB-ASI video at the same time. The products can transport SMPTE 259M compliant video at a data rate of 270 Mb/s.
Digital Video/Audio Network Configurations

- Using multiple interfaces, products can typically transport two SDI video streams on one fiber. Analog and digital transport platforms can also transmit either 19.4 to 40 Mb/s DVB-ASI or SMPTE 310M compliant digital signals. The units also support the transmission of pre-embedded digital audio channels.
Digital Video/Audio Network Configurations

- Digitized Analog and DVB-ASI
  Figure 3 illustrates a network with the ability to simultaneously transport a combination of analog and digital signals. For example, a studio may need to transport both a broadcast quality analog video and a SMPTE 259M SDI video to a remote location, such as an editing house or a duplication facility.
Digital Video/Audio Network Configurations

[Diagram showing a 1RU Transmitter with Video 1, Audio 6, and Video 4 connections, and a 1RU Receiver with Video 1, Audio 6, and Video 4 connections, with DVB-ASI SMPTE 310M 19-40 Mb/s modules and RS-250C V/A Module connections.]
Analog Fiber Optic CATV System Design

- Analog AM fiber optic systems have begun to replace coax cable for local distribution within a CATV network, while digital systems are being used for headend or hub site elimination and for transmitting various data services. In the past, these analog and digital transmissions systems are operated separately from each other over separate optical fibers.
Analog Fiber Optic CATV System Design

- As these CATV systems grow and expand, the current trend in CATV system design incorporates wavelength-division multiplexing to combine both the analog and digital signals for transmission using the same fiber. This allows system expansion by increasing the number of signals transmitted on fiber currently installed.
Analog Fiber Optic CATV System Design

- As these systems grow, the forward path transmission ceases to be the only required path. Today's CATV system may also require a return path network to handle data from the Internet via cable modems. This article will focus on both two fiber and single fiber two-signal WDM CATV system design.
Analog Fiber Optic CATV System Design

Before 1980, most CATV systems were coax based, but by the early 1980's the CATV industry began using direct modulated 1310 nm VSB/AM links for distribution super trunks. Figure 1 illustrates a typical system architecture including a super trunk. By transporting a high quality replica of the headend signals, this system reduced the number of cascaded amplifiers required.
Analog Fiber Optic CATV System Design
Analog Fiber Optic CATV System Design

- By the early 1990's, CATV providers began using multichannel digital systems to transport large numbers of uncompressed, broadcast-quality, digitized video channels between the headends. Still operating in the 1310 nm wavelength window, in this configuration, a previous separate headend is replaced by very high quality signals that are transported by a multichannel digital system from a "master" headend.
Analog Fiber Optic CATV System Design

- Figure 2 illustrates this configuration. The advent of high performance externally modulated 1550 nm VSB/AM transmitters and erbium-doped fiber amplifiers (EDFAs) changed the architecture of CATV system design once again. These 1550 nm links are used to carry signals between headend sites over long distances, using the EDFA as an in-line amplifier.
Analog Fiber Optic CATV System Design
Analog Fiber Optic CATV System Design

- The high performance 1550 nm systems vary slightly in that a few additional optical components are required. Illustrated in Figure 3, this system also incorporates optical splitters in addition to the EDFA. In this configuration, the transmitter is assumed to have dual outputs, a common feature for these new transmitters.
Analog Fiber Optic CATV System Design

- The first optical output of the 1550 nm transmitter feeds a secondary headend 1310 nm transmitter. The second optical output goes into a 1 x 2 optical splitter. The first output feeds directly into a 1550 nm receiver for distribution from the main headend to a 1310 nm transmitter.
Analog Fiber Optic CATV System Design

- The second output of the optical splitter feeds an EDFA. The signal is amplified optically and forwarded to the optical receiver which supplies a third headend located many miles away in the system.
Analog Fiber Optic CATV System Design
Analog Fiber Optic CATV System Design

The first three architectures use no WDM components and represent completely analog architectures. As CATV systems grow, the need to expand each fiber's transmission capacity grows with it. Wavelength-division multiplexing allows both analog and digital signals to coexist on a single fiber. Figure 4 illustrates a unidirectional WDM AM CATV/Digital transport system.
Analog Fiber Optic CATV System Design
Analog Fiber Optic CATV System Design

- In the configuration shown in Figure 4, the signal from the 1310 nm CATV AM transmitter and the 1550 digital transmitter are wavelength-division multiplexed onto one fiber. At the receive, the signals are demultiplexed and output to the correct receivers.
Analog Fiber Optic CATV System Design

- In order to maintain system quality, the WDM must be a high isolation type that prevents interference between the 1310 nm analog signal and the 1550 nm digital signal. A bidirectional configuration of this analog/digital CATV transport system is illustrated in Figure 5.
Analog Fiber Optic CATV System Design
Thank You!