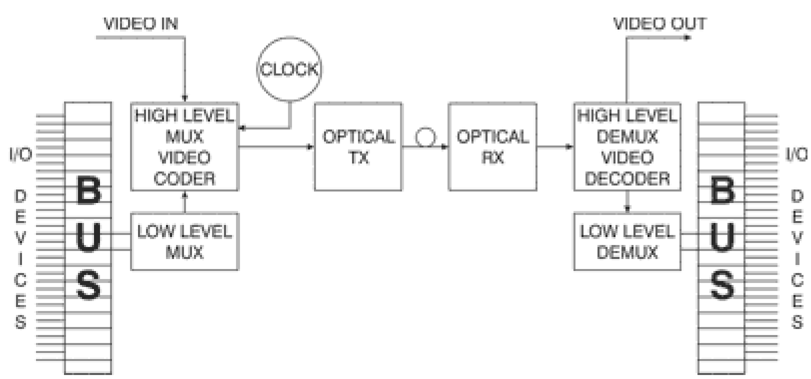
Digital Fiber Optic Multichannel V/A/D Transport Systems

Fiber optics is now the dominant medium for terrestrial transmission of digital signals, and digital fiber optic systems are well established for transporting high quality video, audio, and data signals. Systems must make efficient use of optical fiber by transporting multiple channels of video and audio on a single fiber. A digital system working within a digital domain should be capable of expanding, inserting, routing, and switching signals within a network in such a way that video and audio performance is not affected. Of growing importance is the ability of these networks to accept a variety of signal formats and to interface with public television communication networks. Signal formats for transmission of video might include video encoding at various levels of digitizing accuracy, compressed video, advanced or high definition video, as well as digital high speed data. Understanding aspects of multiplexing, modulation schemes, and digital systems are important to implementing a multichannel transmission system. All video/audio/data transport systems share a number of elements in common that form the basic system building blocks for any v/a/d system. These include: transmitters, receivers, signal regenerators, repeaters, coders, decoders, switches,modulators, amplifiers, A/D and D/A converters, splitters, combiners, signal fanouts, which allow signals to be added and dropped from a network or utilize smaller system components for the signal distribution, A/B switching for redundant circuit protection, network control data interfaces, and synchronizing clock interfaces. Figure 1 illustrates a digital transmission system with a two-level time-division multiplexing (TDM) hierarchy.

Figure 1 — Digital System with a Two-level TDM Hierarchy



At the transmit end, a digital coder converts the incoming analog video signal to PCM digital data. (See Digital Modulation for details.) The coder also contains a time-division multiplexer, called a high level mux, which creates a digital subchannel that is time-division multiplexed with the PCM video data. This high level mux/video coder outputs a digital data stream and a clock signal, used for synchronicity. These signals then enter the optical transmitter for digital line coding, light source modulation, and an interface to the optical transmission fiber. This high level mux receives its input from a second TDM, called the low level mux, which controls a data bus that can interface with a variety of input signals such as digitized audio and digital data signals. At the receive end, an optical receiver converts the signal from optical to electrical and provides line decoding plus clock recovery. The PCM data and recovered clock are then sent to a digital video decoder that converts the digital video back to an analog signal. The video decoder also contains a high level demux, which separates the subchannel and sends it to a low level demux. At the low level demux, the signals are demultiplexed and put back on the data bus where they are decoded to system output.

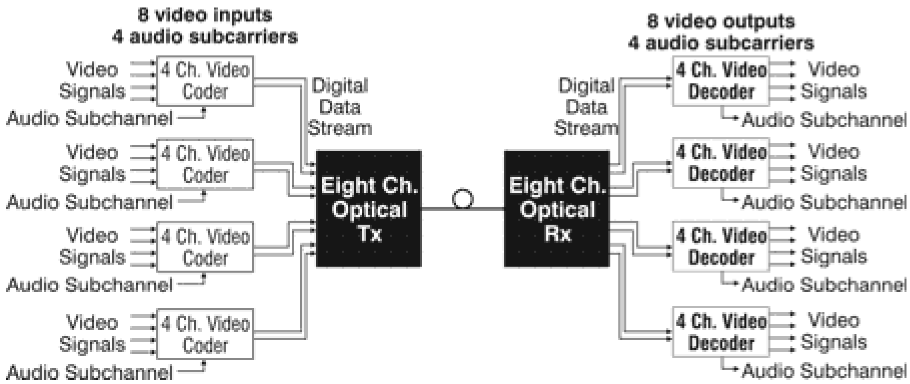
Practical Digital Fiber Optic Multichannel System Considerations

A desirable feature in multichannel digital networks is the capacity to add video channels, or "contribution circuits," that are digitally transmitted from a remote site to a network node. The contribution circuit must be bidirectional for transmission from the network node back to the remote site; a system clock must be at the remote site as well. In a TDM structure all inputs are time-division multiplexed in a fully synchronous digital system without interaction or crosstalk allowing signals to be added or dropped without affecting the rest of the system. Diplexed, reverse direction data channels provide a cost effective and convenient method to enable synchronous multiplexing of remote unidirectional signals into a digital network. This also provides a low-cost method for adding bidirectional, low speed data channels to single direction, high speed video links. Synchronous transmission is not possible without a bidirectional contribution circuit. To achieve this, one needs a duplex transmission link operating on one fiber at the same optical wavelength in both directions. This is achieved by diplexing the forward and reverse optical signals using optical couplers; however, this causes signal interference which degrades signal-to-noise ratio. Optical couplers can minimize this degradation, as can shaping the power spectrums of the forward stream and reverse data streams. Provided the frequency is synchronous with the signal clock, the digital ports for a synchronous TDM should have the ability to interface with a variety of input signal formats such as digital coding and/or framing patterns. This allows signals to be multiplexed and transported over the same optical channel. These universal ports can be achieved by scrambling or coding the incoming data on each TDM port. The system should only require that the incoming data be frequency synchronous but not necessarily phase coherent with the rest of the system. This facilitates the use of video codecs of different sample accuracies or coding formats, transporting digitized non-video signals, and adding signals such as digitized SDTV/HDTV or digitally compressed MPEG-2 signals all in the same system. Practical CATV or RF-based networks should interface to existing CATV signal formats and co-exist as easily as possible with the RF portions of the signal distribution plant. This requires that the digital video coders and decoders in the system be capable of accepting variations to the "standard" video signal. Because the final signal format for CATV networks is VSB/AM, a valuable feature for any digital transport system would include the ability to output a VSB/AM signal, rather thanbaseband video, to the RF portions of the distribution plant.

System Examples

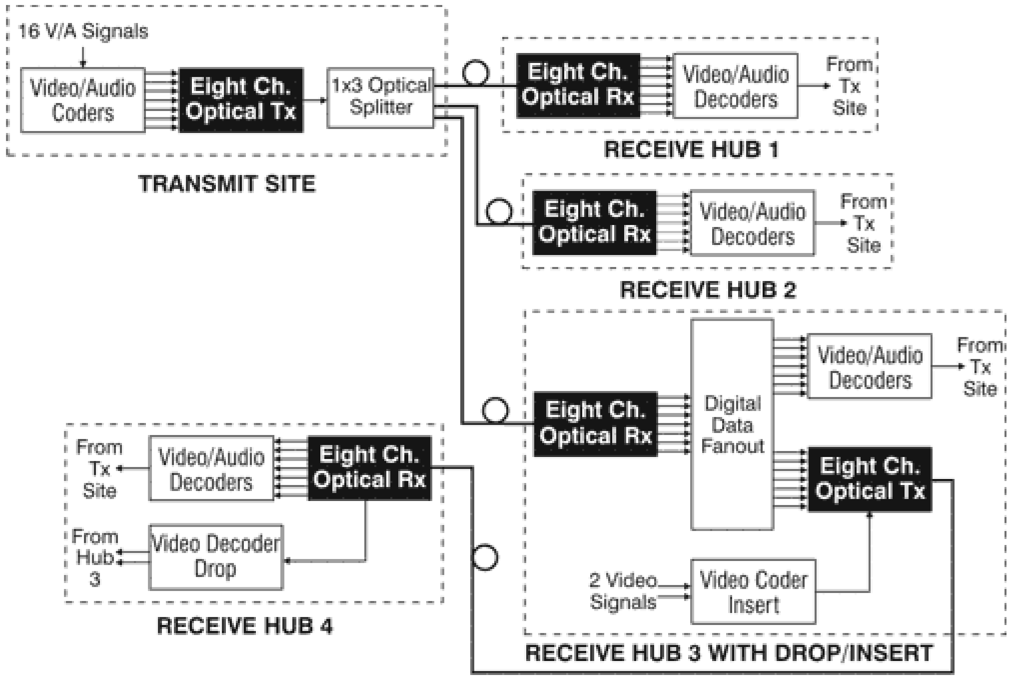
The simplest multichannel video transport system is the point-to-point link. The example in Figure 2 illustrates an eight channel digital video system.

Figure 2 — Point-to-point Video Transport System



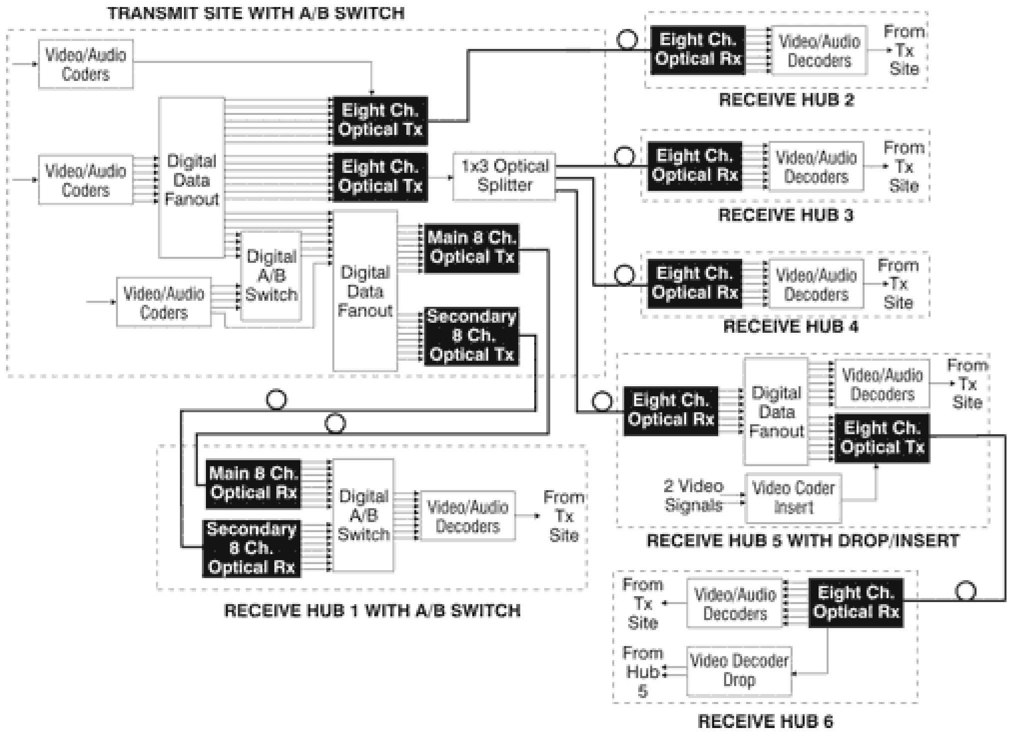
It is useful to think of a partition in the system between its signal codecs and the optical transmitter and receiver. In this example, the system uses an eight channel optical link. It is important to decide how these digital channels are utilized. Figure 2 shows all eight inputs and outputs on the transmission terminals in use, leaving no room for future expansion. More system capacity could be achieved with additional optical terminals or optical terminals that offer a higher channel count. Many multichannel video transport systems require linking one transmit site to several receive sites in a point-to-multipoint configuration. Figure 3 illustrates an example of this type of system. In this figure, there are three end-of-the-line receive sites and one intermediate receive site where a digital drop/add function has been incorporated. At the intermediate hub, all channels from the headend are dropped for local use and are retransmitted to the next site. Two channels are also added to the intermediate hub for transmission to the next hub.

Figure 3 — Point-to-multipoint Configuration



As video transport systems evolve into multi-service communications networks, with stringent up-time requirements, system redundancy becomes a must to provide remote monitoring of the system. A redundant path with automatic switching, added to the system, allows full monitoring and control at each site, with communication back to the headend. The redundant elements required include digital signal fanouts as well as digital A/B switches. Failure on the primary fiber will cause the system to automatically switch to the secondary fiber keeping network performance unaffected. Figure 4 illustrates this enhanced system feature.

Figure 4 — Digital Video Transport System with System Redundancy



Digital systems can be used to build fiber optic video transport networks from a set of basic common components that can provide configurations that range from simple point-to-point links to complex point-to-multipoint systems with enhancements for system redundancy. As the system grows, this building block approach allows for system expansion using existing parts. Signal performance remains uniform while any number of channels and services can be transported independent of the distance of the link or the number of links. This offers a level of "future-proofing" that allows the installed system to keep up with the customer's needs.

Source: http://www.fiber-optics.info/articles/digital_fiber_optic_multichannel_v_a_d_transport_systems