HIGH SPEED PCM DATA TRANSMISSION ON CATV SYSTEMS

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ABSTRACT:

An opportunity for the CATV industry to participate in the fast growing data transmission area is examined. The established multiplexing hierarchy for high speed PCM data is reviewed, and practical applications on CATV systems are illustrated. Performance results for PCM data streams on coax links are given.

BACKGROUND

a) The Opportunity

The rapid proliferation of data transmission, world-wide, has created two major types of data networks:

- The satellite high speed data networks (e.g. SBS). These networks have ultra high speed transmission capabilities and can span literally thousands of miles.

- The local high speed data networks (e.g. Hyperbus, Ethernet, etc.), confined within a plant or building. These networks are typically baseband time division multiplex systems, using highly sophisticated software to control protocol.

These two types of networks have comparable transmission speeds, and often need to be linked together. In many cases, they may be linked by telephone lines with limited capacities, a costly process which reduces the overall transmission efficiency.

Microwave transmission can be an alternative where channels and paths are available, but in most cases, an existing CATV plant provides a unique opportunity for the transmission of high speed data between the satellite entry point, and the end user.

b) The PCM Transmission Standards:

In the telecommunications industry, PCM coding is commonly used as a method of handling audio and data signals. The most commonly used format is known as a T1 Carrier, created when 300 to 3400Hz bandwidth voice channels are digitized with an 8 bit code at an 8 kHz sampling rate, and 24 such channels are time division multiplexed into a single serial bit stream. This data stream is known as a T1 Carrier, and represents a data rate of 1.544 MB/s.

When defined in terms of interface characteristics the T1 Carrier becomes known as a DS-1 signal.

Further multiplexing produces the following hierarchy.

24 voice channels = one DS-1 channel (1.544 MB/s, T1 rate)

96 voice channels, or 4 DS-1 signals = one DS-2 signal (6.3 MB/s, T2 rate)

672 voice channels, or 7 DS-2 signals = one DS-3 signal (44.736 MB/s, T3 rate)

c) Actual Uses of PCM Coding:

PCM coding is not limited to voice channels. The most obvious spinoff from voice channel coding is the inclusion of serial data streams. In the basic T1 carrier format, any one voice channel represents a 64 kB/s data stream, and can therefore be replaced by pure data at a rate of up to 64 kB/s. In practical applications, rates up to 56 kB/s are used in place of one voice channel.

Several manufacturers offer multiplex equipmer to condense data signals, or mixed data and voice into the T1 format. (Figure 1.)

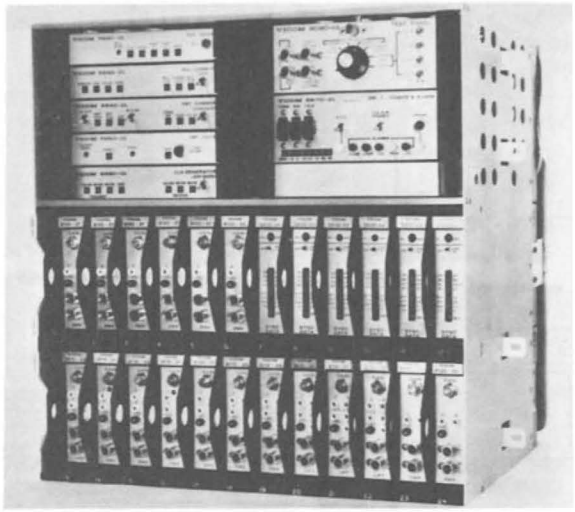

Figure 1. Typical data/voice to T1 rate Multiplexer.

(Photo Courtesy of TRW-Vidar)

Digital coding of video signals has created considerable interest, and current efforts are focusing on bandwidth compression techniques to carry broadcast quality video at T3 rate (44.7 MB/s). One manufacturer is currently offering teleconferencing quality (real time) video transmission at T2 rate (6.3 MB/s) and work is even being done on teleconferencing video at T1 rate.

Digital audio has become the choice format for master recordings, and is currently used on the PBS network as one method of very high quality transmission.

Although there is no industry standard for stereo transmission on PCM data streams, a quick calculation will show that two premium quality audio channels could easily be multiplexed into a T1 carrier.

IMPLEMENTING PCM DATA TRANSMISSION ON CATV SYSTEMS

a) Data Stream Density and Bandwidth Requirements:

Manufacturers of PCM multiplexers offer various configurations, such as 2 port, 4 port, 8 port, and 12 port multiplexers where each port handles one T1 line. All use multiple level (and/or phase) coding methods to reduce the occupied bandwidth of the PCM baseband signal.

Our work at Catel has focused on the use of 4, 8, and 12 port multiplexers in conjunction with broadband FM modems. (Figure 2)

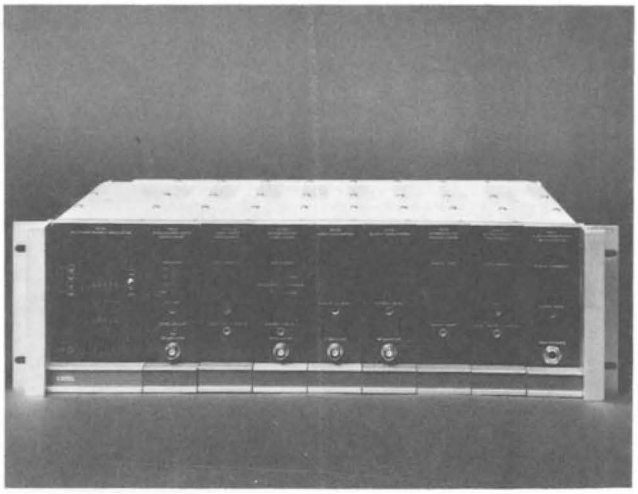

Figure 2. Typical Broadband FM Modem

The coding efficiencies of the multiplexers are offset by the relative inefficiency of FM transmission. Past attempts at the use of VSB-AM transmission to reduce bandwidth have given disappointing results. The FM/PCM combination is a good compromise which allows highly reliable transmission with "off-the-shelf" components, while retaining an overall transmission efficiency which ranges from 0.5 to 1.2 bit/hertz. Figures 3, 4, and 5.)

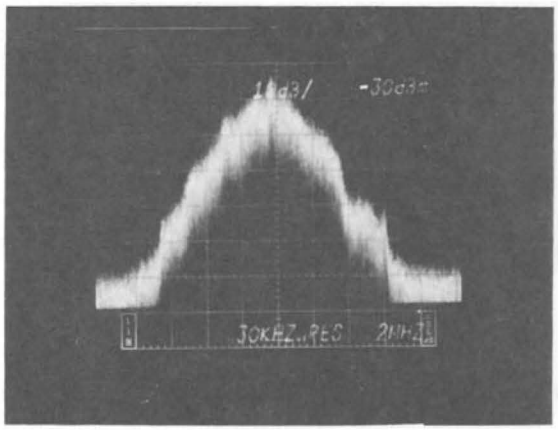

Figure 3. 4 Port Multiplexer, FM Modulated Spectrum.

(96 Voice/Data Channels, 6.3 MB/s)

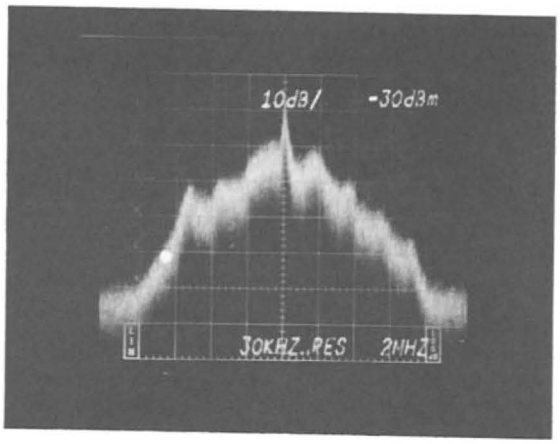

Figure 4.

8 Port Multiplexer, FM Modulated Spectrum.

(192 Voice/Data Channels, 12.6 MB/s)

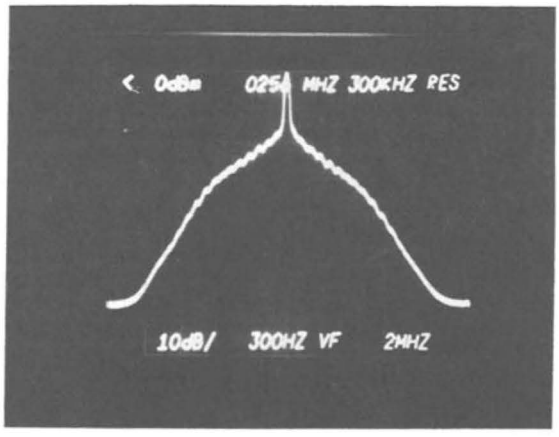

Figure 5.

12 Port Multiplexer, FM Modulated Spectrum.

(288 Voice/Data Channels, 19.2 MB/s)

b) Interfacing PCM and RF Equipment:

PCM multiplexers are available with 75 Ohm BNC Transmit/Receive Ports. The data amplitude at these ports is 1 Volt P.P., which makes interfacing quite straightforward. RF interfacing follows standard CATV procedures, and the complete interconnect is illustrated on Figure 6.

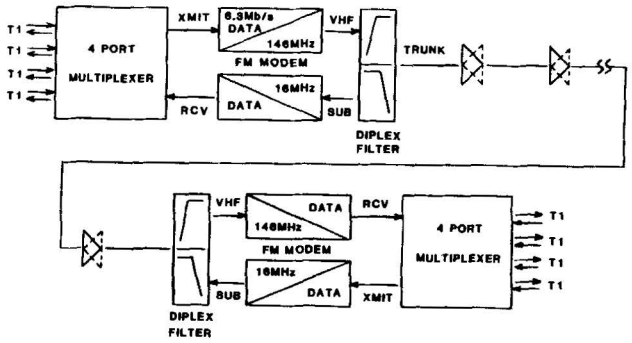

Figure 6. PCM Multiplexer to CATV System Interface.

c) Performance Results:

The performance data presented here was obtained with an amplifier cascade of 8 line extenders, equipped with diplex filters.

Tracking input/output attenuators were used to create a variable carrier to noise ratio in the 25 to 35 dB range, which is considered to be a realistic range of "actual life" performance. Carrier to noise was measured on a Tektronix 7L13 spectrum analyzer following the manufacturer's recommended methods.

A qualitative evaluation of transmission performance was made by observing the eye pattern of data, which is created when all possible combinations of ones and zeros of the data are displayed on an oscilloscope locked to transmit clock. Results for 4, 8, and 12 port data streams are presented in Figures 7, 8, and 9 respectively.

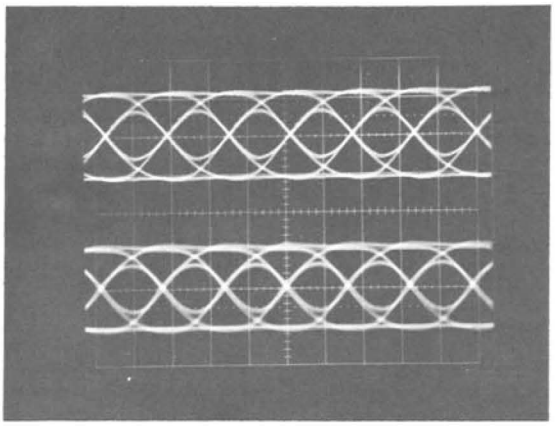

Figure 7. 4 Port Multiplexer Eye Pattern (6.3 MB/s Data)

Upper Trace: Transmitted
Lower Trace: Received

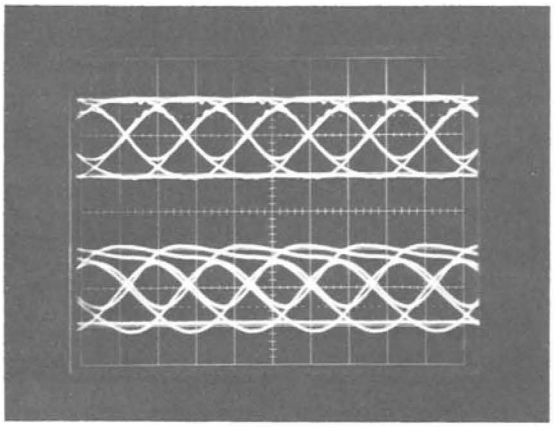

Figure 8. 8 Port Multiplexer Eye Pattern (12.6 MB/s Data)

Upper Trace: Transmitted
Lower Trace: Received

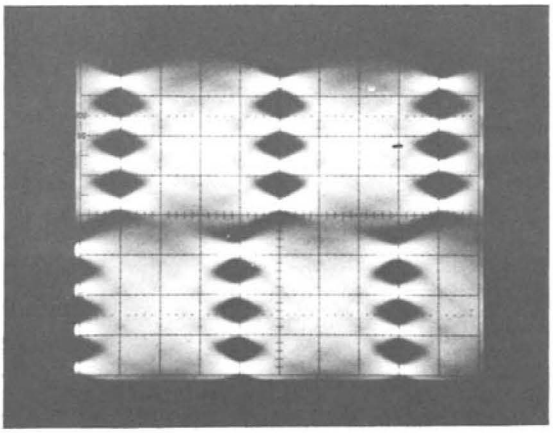

Figure 9. 12 Port Multiplexer Eye Pattern (19.7 MB/s)

Upper Trace: Transmitted
Lower Trace: Received

A quantitative evaluation was made by performing a bit error rate test.

In figure 10, bit error rate was plotted as a function of carrier to noise ratio for a 4 port multiplexer.

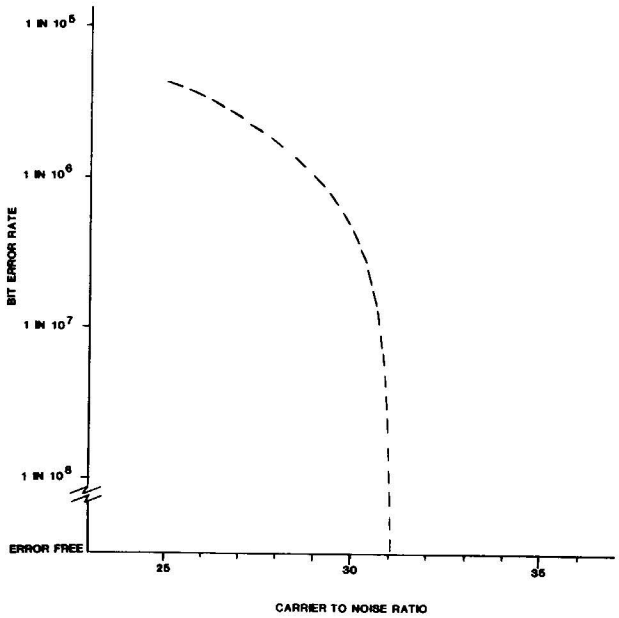

FIG. 10
BIT ERROR RATE VERSUS CARRIER TO NOISE RATIO.

The effect of intermod products was simulated by sweeping an interfering tone through the modulated PCM data spectrum. The level of the interfering carrier was varied to produce a fixed error rate of 1 in 10^6 bits, considered to be the minimum acceptable for quality PCM transmission. Figure 11 illustrates the experimental curve derived, as well as a practical protection curve.

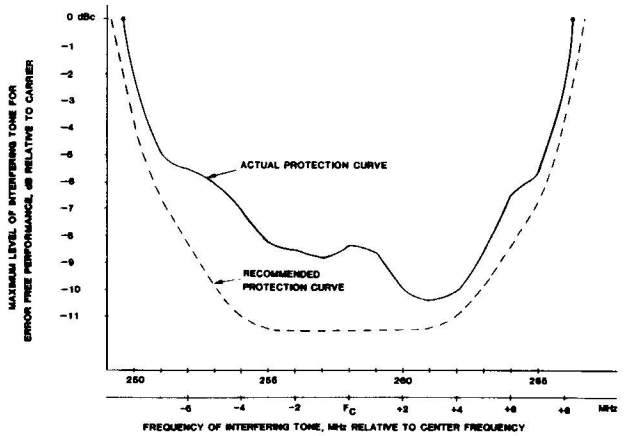

FIG. 11
PROTECTION CURVE FOR ERROR FREE PCM OPERATION IN THE PRESENCE OF INTERFERING TONES.

CONCLUSION

The T1 PCM carrier and associated multiplexers offer a versatile and accepted format for data, voice, and even video transmission.

Interfacing T carriers to CATV systems is a straightforward procedure, and the performance results are excellent.

The inherent bandwidth capabilities of a coax network give the CATV operator a unique opportunity to transport T carrier signals, and participate in the current communication explosion.

GENERAL REFERENCES

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