ONE-WAY DATA TRANSMISSION FOR CABLE APPLICATIONS

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ABSTRACT

The cable industry has created an extensive satellite connected point to multipoint communications system which is capable of supporting a large number of auxiliary services in addition to the primary video distribution. With the introduction of highly efficient audio subcarrier technology, new and innovative audio services for CATV are developing rapidly. Additionally, the auxiliary capacity is now starting to be exploited for distribution of data. With careful planning and utilization of spectrum efficient, cost effective subcarrier data transmission techniques, the existing cable video distribution system can deliver large amounts of data to provide many unique information services for cable subscribers and business applications.

This paper discusses applications and technical considerations for one-way data transmission using the CATV distribution network.

INTRODUCTION

The cable industry looks to data transmission as a future source of additional revenue. Many of the future applications involve two-way data transmission and a high degree of interactivity with the end user. Although this kind of data transmission is most conventional, there are some present limitations to many cable systems which prevents immediate implementation of this kind of data service.

Several examples of one-way data transmission in use today include the following:

- Improving the efficiency of the day-to-day operations of a cable system by streamlining and centralizing user authorization for premium services and pay-per-view events.
- Providing unique and innovative services to cable systems which help add subscribers and increase revenues.
- Localizing a nationally distributed video channel and allowing insertion of local advertisements.
- Electronic mail for distribution of hard copy system and program change information.

This paper discusses the use of video satellites as a data delivery system to the headend using data subcarriers and the vertical blanking interval and current cable applications using one-way data transmission.

TRUE ONE-WAY DATA TRANSMISSION

True one-way data transmission occurs if after data is transmitted there is no way to request retransmission if data has not been properly received. Data transmitted in this way is usually retransmitted on several occasions to guarantee "legible" transmission. This type of data transmission is best illustrated by teletext transmission.

QUASI ONE-WAY TRANSMISSION

Most one-way transmission of data has a feedback mechanism to indicate if the transmitted data has been properly received. For instance, in authorizing a customer to receive a premium service or a pay-per-view event, the customer indicates if data was not received by calling the CATV office and indicating that he has not received the requested service. Many one-way systems actually have this sort of feedback in one form or another. However, retransmission of a data stream usually requires a large data storage source. Determining if the transmitted data has been received is an important design consideration in elements that rely on one-way data transmission such as addressable set top converters.

CONTINUITY OF DATA SERVICE WITH ONE-WAY SATELLITE TRANSMISSION

BIT ERROR RATES

The satellite distribution network that feeds the cable industry is a very reliable communications network. This has been historically verified by the many radio networks and several data distribution networks currently using subcarriers above video channels to distribute their information. Also, the signal level fades for a satellite system tend to be very moderate and therefore the link parameters are predictable. Generally, an earth station that receives an excellent video signal will provide very good bit error rates (BER) (greater than 10^{-7} BER) using

either subcarriers or the vertical blanking interval to transmit data.

IMPROVING THE BIT ERROR RATE

Forward error correction techniques are commonly used in data communications to improve error rates. However, to accomplish error correction, additional bits are inserted which reduces the actual throughput of the data stream. In a satellite transmission system, sometimes the same results of improved bit error rates can be achieved by increasing the deviation of the subcarrier on the main carrier or the bandwidth of the subcarriers used to transmit the data.

The use of forward error correction is fairly expensive and its use must be balanced against the reduction of transmission costs realized by being able to operate at lower uncorrected bit error rates.

HOW GOOD IS GOOD ENOUGH?

In determining the required performance of a data transmission system, a minimum acceptable bit error rate must be specified. The impact of data errors depends on if the incorrect bit occurred during a control byte or during a character byte. If the incorrect control byte is part of an address for instance, a large amount of data that follows and is intended for a specific location, could be lost. However, control and address bytes generally incorporate error correction bits for these bytes or theyare transmitted multiple times to prevent this. To help put into perspective what a certain BER means, Table 1 shows the time between bit error occurrances for different data rates and various bit error rates.

TABLE 1

TIME BETWEEN ERRORS

DATA RATE BITS/SEC.	TIME BETWEEN ERRORS FOR BER'S OF:		
	10^{-6} (Minutes)	10^{-8} (Hours)	10^{-10} (Days)
300	55.6	92.6	386.00
1200	13.9	23.1	96.5
4800	3.5	5.8	24.1
9600	1.7	2.9	12.1

For low data rates, it is impractical to conduct production tests to measure the higher bit error rates due to the time required to make the measurements. As the table shows, if as few as ten errors are accumulated to validate a bit error rate specification, the bit error rate tests can extend to many hours and days even for the higher data rates.

ERROR RATE VERSUS CARRIER TO NOISE RATIO

Figure 1 shows bit error rate as a function of carrier to noise ratio for a subcarrier FSK system. For data transmitted using the vertical blanking interval (VBI) there are many factors affecting the BER curve including the data level and the type of decoder used. For subcarrier data transmission, the deviation of the subcarrier on the main carrier can be adjusted to allow operation into different size earth stations while nothing can be done to significantly effect bit error rates of data transmitted in the VBI other than forward error correction once an optimum data level has been determined.

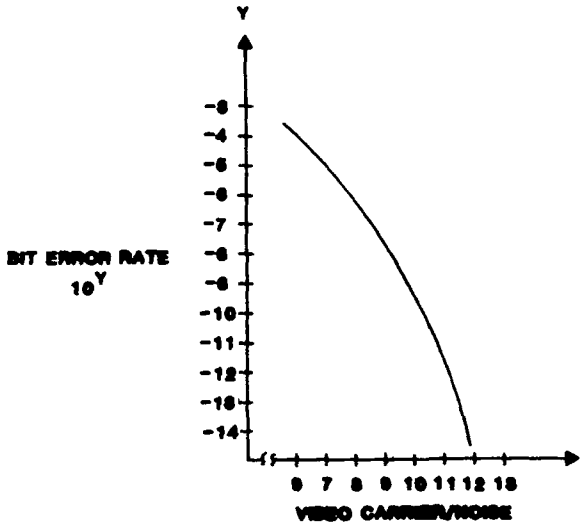

FIGURE 1.
BIT ERROR RATE VS VIDEO CARRIER/NOISE
FSK DATA SUBCARRIER

FACTORS THAT CAUSE BIT ERROR RATE DEGRADATIONS

EARTH STATION DESIGN

It is as important to have the proper amount of margin in an earth station for reception of data as it is for the reception of video or audio services. Many times the weakest link in the data transmission system is an antenna that is too small or a receiver that is not of commercial quality. Key performance parameters for receivers used for subcarrier or VBI data reception include adequate IF bandwidth and linear FM demodulators.

TERRESTRIAL INTERFERENCE

Interference due to terrestrial microwave is another major source of bit error rate degradation. If interference is present, IF traps used to eliminate terrestrial interference to improve video signals can severely degrade data transmission. The only acceptable solution to terrestrial interference is good planning and frequency coordination of the earth station prior to installation.

SUN OUTAGES

Sun outages result in a temporary loss of large amounts of data. It is important to recognize the occurrance of these outages and to avoid

transmission of data to locations experiencing sun outages. Data can be transmitted at night to avoid sun outages. A more elaborate solution to sun outages is to transmit data simultaneously on two satellites and use alarm and switch-over circuitry to select the good channel.

WHAT HAPPENS WHEN ERRORS OCCUR

RANDOM ERRORS

Random errors are a result of thermal noise and generally cause only an occasional character in a data stream to be transmitted incorrectly. Simple error checking such as a parity error check can detect the bad character and not send it on. If the character does go through and it is not part of a control character, the total transmission is usually legible and the overall message of the transmission is not lost.

If the bad character is part of an address code, it is possible that a large amount of data destined for a certain location can be lost. However, most control characters are transmitted with error detection and correction coding or are transmitted multiple times and these errors are usually detected and corrected.

BURST ERRORS

Burst errors occur when many data bytes are lost all at once. This situation might occur during a heavy snow storm. The only feasible way of handling this situation is to detect the loss of data and request a retransmission of the data.

Generally the consequences of data errors are not catastrophic because the equipment using the data generally employ extensive error checking circuitry that prevents bad data from proceeding further downstream.

SOME WAYS OF TRANSMITTING ONE-WAY DATA OVER THE SATELLITE TO THE HEADEND

The following paragraphs discuss ways of transmitting data over the satellite using existing video channels and using either subcarriers or the vertical blanking interval to transmit data.

AUDIO CHANNEL WITH PHONE MODEMS

State of the art subcarrier technology such as the Wegener 1600 System allows placing high quality 3.4 kHz voice channels on 30 to 45 kHz spacing in the baseband above video. With these channels, a conventional phone line modem can be used to send the data over the satellite. The audio characteristics of this 3.4 kHz satellite channel are far superior to a conventional phone line, and should provide extremely transparent data transmission. Phone line modems, however, are quite expensive for higher data rates since they must transmit data reliably through somewhat unpredictable and varying quality transmission channels. Also, most phone line modems have full duplex capabilities and other features which are not necessary in one-way data transmission. Table 2 shows the range of the prices for some phone line modems. Following are trade-offs of using this system.

Advantages

- System can be connected directly to local phone lines at the cable headend for further distribution of the data.
- High degree of noise immunity inherent in this system.

Disadvantages

- Not a spectrum efficient approach for lower data rates.
- Very expensive at higher data rates.

TABLE 2

PHONE LINE MODEM PRICE RANGES

DATA RATE (BITS/SEC.)	APPROXIMATE PRICE RANGES ($)
300	130 - 400
1200	250 - 1000
4800	1500 - 4000
9600	3000 - 7000

AUDIO FSK

Expanding slightly on the phone line modem concept of using audio FSK carriers, this technique also uses audio channels but of higher bandwidth and quality to transmit higher data rates using simple FSK modulation schemes. This eliminates the expensive part of a high data rate phone line modem since this modem must get those data rates through a 3 kHz voice channel. In the satellite application, the higher data rates can be transmitted over higher frequency audio channels which are readily available. Using this technique, a 9600 Baud data demodulator designed for satellite applications costs about one tenth what a 9600 Baud phone line modem costs. Following are some trade-offs of this system.

Advantages

- Has a high degree of noise immunity.
- Very cost effective.

Disadvantages

- Not optimally spectrum efficient.

SUBCARRIER FSK

This technique directly modulates the subcarriers and provides a much higher spectrum efficiency than the audio FSK technique. Other modulation schemes besides FSK could be used.

Advantages

- Is much more spectrum efficient, (1 bit/Hz).
- Cost effective.
- Capable of high data rates.
- Large data throughput available using the spectrum above video.

Disadvantages

- Lower data rates require use of demultiplexers which adds expense.

VERTICAL BLANKING INTERVAL TRANSMISSION

This technique either uses convention teletext protocols or uses the vertical blanking interval lines simply as a data transmission path for standard RS232C asynchronous data channels. For RS232C transmission, incomming data is stored and then burst out on a video line in groups of thirty or more bytes at a time. Figure 2 shows the Wegener Series 2100 VIDATA® used for VBI transmission of data. Following are some trade-offs of this technique.

Advantages

- The data stays with the video signal.
- This is a cost effective home-data delivery system for text (KEYFAX for instance) with the availability of low cost home decoders.

Disadvantages

- This technique relies heavily on a good video transmission link.
- The optimum data levels for satellite and cable transmission are different.
- There is a limited data throughput (maximum of about 9600 Baud per line per field).

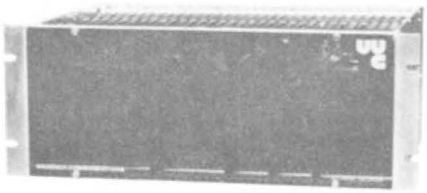

FIGURE 2
Series 2100 Asynchronous Data Transmission System

SOME CURRENT APPLICATIONS OF ONE-WAY DATA TRANSMISSION

TELE-COMMUNICATIONS, INC. - (TCI) - SATELLITE ADDRESSABLE SYSTEM

This system announced by TCI in April of 1983 allows TCI to authorize premium services and pay-per-view events for customers in their systems located throughout the United States from a central computer located near Denver. A subscriber calls the computer center and requests either to add or delete a premium service or to receive a pay-per-view event. The authorization to the set top converters is then sent first over an SCPC channel to the Group W uplink in Stamford, Connecticut where it is placed on a data subcarrier in the Satellite News Channel (SNC) baseband using equipment manufactured by Wegener Communications. This data channel is sent to all headends, demodulated by a Wegener subcarrier data demodulator, processed by equipment manufactured by Jerrold, and sent to the subscriber using a data carrier at 106.5 MHz using an FM modulator also manufactured by Wegener Communications.

ELECTRONIC PROGRAM GUIDE

This service offered by United Video provides cable systems with localized CATV program guides which are assembled by a computer center located in Tulsa, Oklahoma. Programming information on premium channels and network stations are automatically updated on a daily basis and the individual system receiving the service can call in local schedule updates to the computer center in Tulsa. This information is then formatted and sent out on a 2400 Baud data channel over a phone line to the United Video uplink near Chicago, Illinois. The data is then placed on a 2400 Baud data subcarrier using equipment manufactured by Wegener Communications where it is then made available to all systems receiving the service. Imbedded in the data is an address code which indicates who is authorized to receive the data at the headend. The data is demodulated by a subcarrier data demodulator manufactured by Wegener Communications and when a transmitted address code is matched with the local code, is loaded into a character generator which has sufficient memory to store several days of programming information. This information is then sequentially put on the screen under control of the character generator.

CABLE NEWS NETWORK (CNN) PRINTER CHANNEL

Although at the time of this paper, this service was not specifically used for CATV applications, this technique may be used in the future for affiliate updating and news distribution. The system that CNN is using provides program queing and timing information to radio and television affiliates receiving CNN Headline News.

The information for this service originates from a computer located in the Turner Programming Services facilities in Atlanta. Data is transferred from the computer to one or more of the eight 300 Baud data channels at RS232C levels. The individual channels are then multiplexed into one 3000 Baud data stream which is then modulated on a data subcarrier using a system developed and manufactured by Wegener Communications. At the receive locations, the data is demodulated and demultiplexed and affiliates can select any four of eight data channels to drive one or more printers. The entire receive package is manufactured by Wegener Communications and provides a highly reliable and flexible way of distributing hard copy information to all affiliates.

CABLETEXT

Since 1980, Southern Satellite has distributed news and other information services to cable headends using the vertical blanking interval as the data transmission medium. The information from the news services passes through a computer where the data is formatted for distribution over the satellite. This information is placed in the vertical blanking interval by insertion equipment manufactured by Wegener Communications. The data is transmitted in burst format to all cable systems where it is converted to an RS232C data stream by decoders placed at the headend.

THE WEATHER CHANNEL

Another example of one-way transmission using the vertical blanking interval is the Weather Channel. Data that provides local forecast information is transmitted from a computer to insertion equipment manufactured by Wegener Communications where it is placed in the vertical blanking interval of the Weather Channel video signal. This data goes to affiliates and provides the current weather forcast for that area. The information is downloaded into a character generator, (located at each headend) that has sufficient memory to store the current forecast. Local weather sensors are provided that input local conditions to the character generator for display on the TV screen. In addition, a keyboard is provided to the CATV operator to allow him to insert local commercials. All of the downloaded data which provides the localized information is inserted in the real time video on command of data signals generated at the Weather Channel control center in Atlanta, Georgia.

THE FUTURE

The above shows some very innovative ways that one-way data transmission is currently being used in CATV applications. The future will bring additional applications that can both improve the efficiency of the operations of a CATV system and also generate new revenue from specialized data services. The development of highly efficient and cost effective subcarrier data equipment is making many data services economically feasible for cable systems today.