CONTROL OF REMOTE HUBS IN ADDRESSABLE CATV SYSTEMS

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The application of CATV systems in an urban environment encompassing large geographical areas, large numbers of subscribers and varying clusters of ethnic/demographic groups requires the distribution of signals from local hubs. Operation of these hubs can be controlled from an addressable computer at a remote location using digital communications techniques (protocols).

This paper discusses the control of remote hubs in addressable CATV systems. It examines both continuous and discontinuous communications, emphasizing a distributed intelligence approach.

Both one-way and two-way communications and the use of non-CATV cable signal paths are discussed. Also explored are the interface requirements for the converters, scramblers and data modulators being controlled. In addition, frequency agility techniques are described.

INTRODUCTION

Control systems have been used in many industries for years not only to improve overall operations, but to allow for remote controllability in a more accurate and rapid fashion. Such control systems have helped produce both lower costs and a higher quality product for many companies.

The CATV industry, having the same business requirements and goals in mind, introduced the first CATV Addressable Control systems in 1979. These systems allow cable operators to control subscriber services from a remote computer.

Many extra benefits were realized from the introduction of addressable control systems. Addressable converter/descramblers, unlike programmable converters, can be turned on and off from the computer, contain system specific "site-codes" and receive authorization and operating instructions from the headend computer-controller, making them inoperable in other systems, and helping to reduce converter theft. Technological improvements in converter and signal security and direct links from the addressable controller to computer billing systems have all been implemented with good results and improved efficiency in cable systems.

One area in which addressable control systems are helping to make their greatest technical contributions is pay-per-view. It is no surprise that one of the reasons many pay-per-view events have not been successful financially is their technical inefficiency. Marketing, personnel, order taking and billing costs taken together can make pay-per-view offerings marginally profitable undertakings for many operators, at best. Most systems are ill-equipped to handle peak loads, last-minute program orders and billing problems. And it is the last fifteen minutes before an event that seem to count, a critical time period where, according to some studies, at least two-thirds of a cable operator's revenues can be earned.

In order to overcome the peak load and last-minute ordering problems with pay-per-view, Jerrold has developed practical technical solutions for both one-way and two-way cable systems. This "impulse pay-per-view" technology (IPPV) makes implementation and use of PPV easier and less expensive for cable operators. The IPPV technique allows subscribers to purchase an event and receive immediate authorization to view this programming without communication by the converter to or from the addressable control computer.

The technique uses "distributed intelligence", where each node, or device in the network is capable of making a limited range of decisions based on operating parameters and data loaded into the device from the remotely located computer. Up to this time, this intelligence and memory has been concentrated in the control computer and the subcriber terminals.

Scrambler/Encoder Control

Distributed intelligence technology now impacts the headend components required for addressable systems operation. This equipment includes scrambler/encoders (S/E) and data modulators/demodulators. Engineering and marketing personnel planning to implement PPV will value the system's ability to transmit new operating parameters to scrambler/encoders. A continuous pay-per-view operation might require service code changes every 1-1/2 to 2 hours, in which case the program's service code must also be changed as frequently to permit purchase of distinct events. (Generally, specific channels are reserved for PPV programming and the service code or "tag" transmitted digitally within each pay channel works to distinguish between sequentially offered services on the same channel.) At the same time, the scramble mode can be changed, too. This permits broadcast of previews in the clear, followed by scrambled programming while the same tag is transmitted.

Scrambler/encoders located anywhere in the addressable system -- no matter how far from the hub -- can be controlled from the addressable control computer. Wherever an addressable data stream is transmitted to subscriber terminals, whether to unmanned headends on mountain-tops, or wide-spread distribution hubs, scrambler/encoder information will also be present. This is possible because headend components are addressed over a communications channel that uses the distribution cable. Headend components are assigned their own group of addresses in the system and the computer transmits to them using the same data transmission technique used for converters.

If two-way RF communications is available, headend components can send status information to the computer to assure proper operation. The commands, operating parameters and data transmitted between the control computer and the scrambler are different from the information transmitted between the control computer and converters, since converters receive primarily pay service authorization information.

Scrambler/encoders information received includes:

- Service code
- Sync suppression scramble mode
- Baseband scramble mode
- Dynamic switching time
- Encrypting key
- Price of the service
- Purchasability
- Morality rating
- Barker channel
- Date and time to begin this mode

The intelligent scrambler/encoder is capable of storing the above information in an internal memory. It can invoke these parameters at any specified date and time. In fact, the intelligent S/E can store 63 entries such as this list in a queue, and switch from one entry to the next as time elapses. If the data path or the control computer fails at a critical time, the S/E already has the information to function properly.

There are two methods of loading the queue entry into the S/E from the computer. Direct entry is accomplished by entering the information on a computer screen, and then designating the queue position number (0 to 63). If "0" is selected, the parameters are transmitted to the S/E and take effect immediately. Queue positions 1 through 63 are stored in non-volatile memory until the date and time specified.

The second means of programming the S/E is through Channel Scheduling. This is a computer software feature that permits scheduling all known future channel usage. For each new entry into the channel schedule, the computer operator specifies the new operating parameters for the scrambler/encoder that controls each channel. The computer then keeps the 63 queue positions loaded automatically.

Control of the S/E is possible using a standard (EIA-RS232C, ASCII) CRT terminal to load queue entries . A front panel equipped with controls and indicators provides for operation by a headend attendant.

Data Modulator/Demodulator Control

Data modulator/demodulator units can be used to relay data between remote hubs in the addressable system. If the system is implementing IPPV using an RF return path, it is desirable that these devices be under the control of the computer. Early in the development of two-way RF systems, a failure mode was recognized in which one malfunctioning subscriber terminal could block the return path by continuous uncontrolled transmission. Frequency agility -- the ability to move to another frequency -- was designed to identify and isolate converters that transmit when they shouldn't. This technology overcomes the problem of "babbling" converters, by using remote-controlled data demodulators, subscriber terminals, and sophisticated computer software. Software algorithms control the converter's upstream transmission frequency and the headend data demodulator receiving frequency by moving the malfunctioning terminal to an unused frequency, or by moving all terminals except the offending one.

The intelligent data modulator/demodulator is equipped with a control interface that permits control of the operational parameters of the device. Each control interface has a system address, like the subscriber identification number of the converter/descrambler. All communication between the control computer and the interface makes use of that address. The control interface commands the data modulators and demodulators to

- Initialize
- Change frequency
- RF output on/off (modulator)
- Data output on/off (demod)
- Display frequency of operation, lock and data present
- Send module status (2 bytes of status data)

Frequency selection is by digital phase-lock loop frequency synthesis, with default settings on decade switches on the modulator and demodulator boards. Communication between the computer and the control interface is via the standard data stream used for subscriber terminals. A block of addresses is reserved for data modulator/demodulator units. The control computer stores the configuration of all the data paths in the system. For each mod/demod unit, the computer must store information such as the system address, the types of modules, frequency assignments, and cable connections to other system devices. Also stored are the allowable alternative frequencies.

Any hardware reconfiguration must be reflected in the control computer database. In case of loss of communications the device will retain its operating parameters, and local control can be done with a CRT terminal as well. Default conditions are established with decade switches and hard-wired cables.

Data Transmission Protocol

Data from the control computer is bi-phase Manchester-encoded, with special voltage levels (logical 0: 0.00 volts, logical 1: 1.8 volts) that permit driving several thousand feet of standard 75 ohm cable. The data rate is nominally 14K baud, but in actuality is a 3.58 MHz colorburst crystal frequency divided by 256, yielding 13,982.598 Hz.

Data is transmitted in packets containing byte count and checksum. All bytes in the packet conform to the standard EIA word format, but have non-standard ASCII interpretation. Byte translation and packet construction are proprietary, however, it may be said that a packet contains the device address, a command code and data.

RF Data Transmission Protocol

The above 14 KHz data is FM modulated on a selected carrier frequency, with ± 75 KHz deviation, resulting in occupied bandwith of ± 200 KHz about the carrier. For compatibility with existing cable systems, 106.5 MHz in the FM band is used for the downstream data path. Transmitter output level is nominally -10 dB below channel 6 video level. Other downstream frequencies may be used in the spectrum reserved for FM audio. Selection is based on spectrum availability (avoidance of frequencies in current use) and the requirement to maintain 400 KHz separation between carriers. Upstream data transmission from standard IPPV terminals is on one of eight 300 KHz spaced channels with carriers between 8.3 and 10.4 MHz. This range occupies part of the T7 channel allocation, thus the remainder of T7 is available for other sub-band transmissions.

Multi-Hub Systems

Data communications for the purpose of addressable system control is required when

- control computer is not co-located with distribution hub,

- multiple distribution hubs are required, or
- isolation is required between trunks returning to a single hub.

In all cases, the computer stores the network topology representation of the interconnected devices making up each link, including interface frequencies, default frequencies and allowable alternate frequencies. As data passes through a hub, data translation may be required, in order to use bandwidth efficiently in different links or to regain losses in S/N ratio. The data translation function uses a retimer module to re-synchronize data to clock timing integrity. A translator consists of

- data demodulator
- data retimer
- data modulator
- interconnecting cables

Figure 1 is a simple block diagram of a typical system with multiple hubs, connected with two-way trunk cable, assumed to be sub-split frequency convention. The control computer is shown at the business office, which is on a two-way trunk and feeder from Hub #1. Alternatively it could be located at a hub on the RF headend. In this initial example, scrambler/encoders are located only at the main headend.

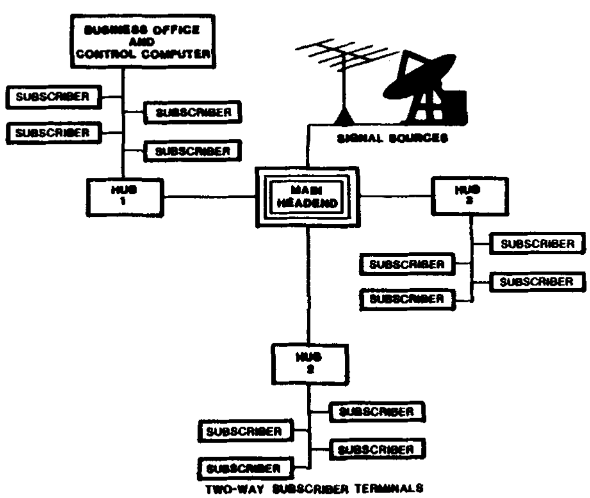

FIGURE 1 TYPICAL MULTIPLE HUB SYSTEM

Figure 2 shows the system configuration with lines between office, hubs and headend representing particular data paths. These channels must be implemented by selecting frequencies on the subsplit cables to/from the hubs. The control computer output data is modulated on a sub-frequency, typically in channel T7, and is sent upstream to Hub #1 where it is translated, and sent on to the main headend. There a demod/remod is used to modulate the downstream data on 106.5 MHz that addressable subscriber terminals are tuned to receive the authorization data stream.

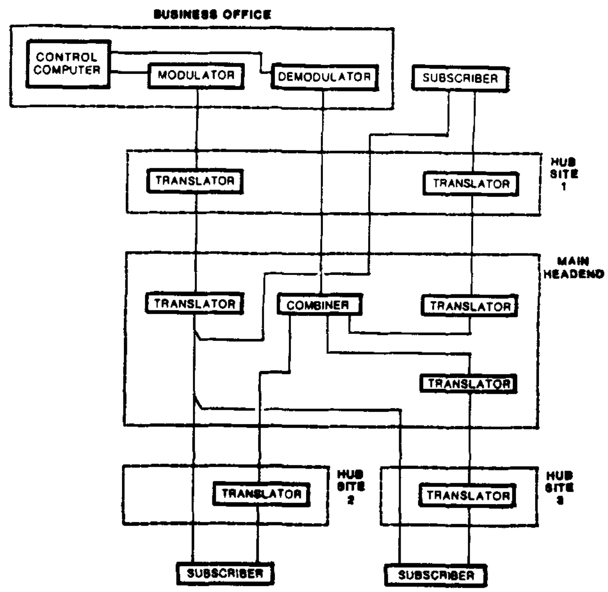

FIGURE 2 SYSTEM CONFIGURATION

This is illustrated going out from the Headend to each of the three hubs, and then to subscriber terminals. Purchase data requested from IPPV terminals is received at 8.3 to 10.4 MHz by each hub and translated as needed to conserve trunk bandwidth, to avoid jammed frequency channels and to insure clock sync. These signals are combined in a Data Combiner prior to modulating the return data carrier, which is then demodulated at the control computer. Upstream, or return data is not continuous. It is intermittently transmitted by one subscriber terminal after another in a time-controlled sequence under the direction of the control computer. Only one terminal may transmit at a time. The data combiner has been designed to operate with up to 16 input lines with discontinuous (or transient) data. Data combiners and data splitters may be cascaded to accomodate the necessary number of devices.

Figure 3 shows a detailed representation of the main headend site. The addressable data stream enters the headend from Hub #1 at the low side of the diplex filter, to a demod/retimer through a data splitter to become the control input signals for a number of scrambler/encoders and control interfaces. Also supplied with data is the system's 106.5 MHz modulator. Data return paths from low side of all three RF trunks uses demod/retimers to generate baseband data signals, which are combined with feedback signals from S/E's and control interfaces, re-modulated on a downstream frequency and communicated to Hub #1 and then to the demodulator at the control computer.

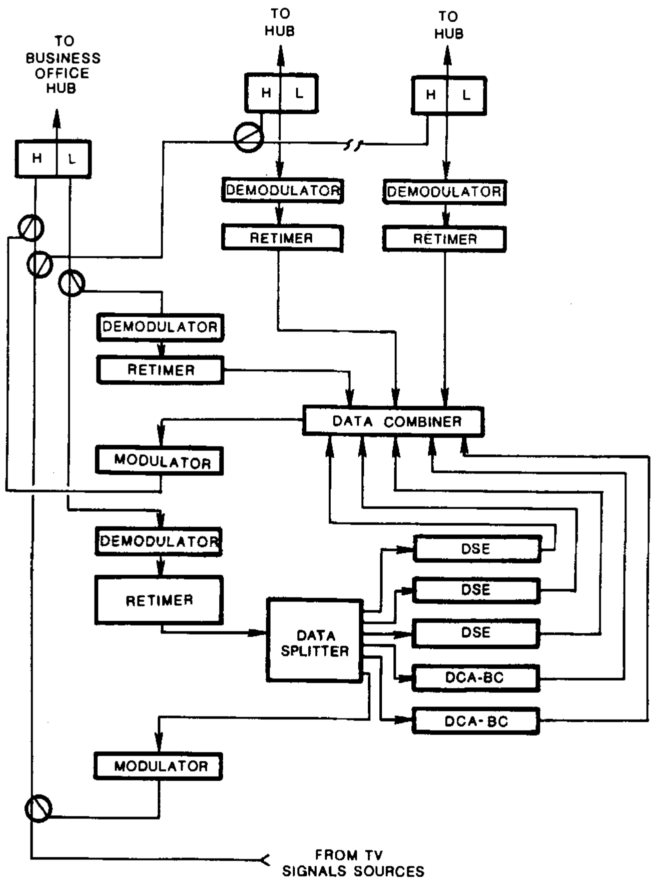

FIGURE 3 MAIN HEADEND SITE CONFIGURATION

Figure 4 represents Hub #1, showing two upstream data paths, one for the computer data stream to the entire system, the other for return data coming from all IPPV terminals on this hub. Note that demodulated data is used as input to the control interface at this hub site.

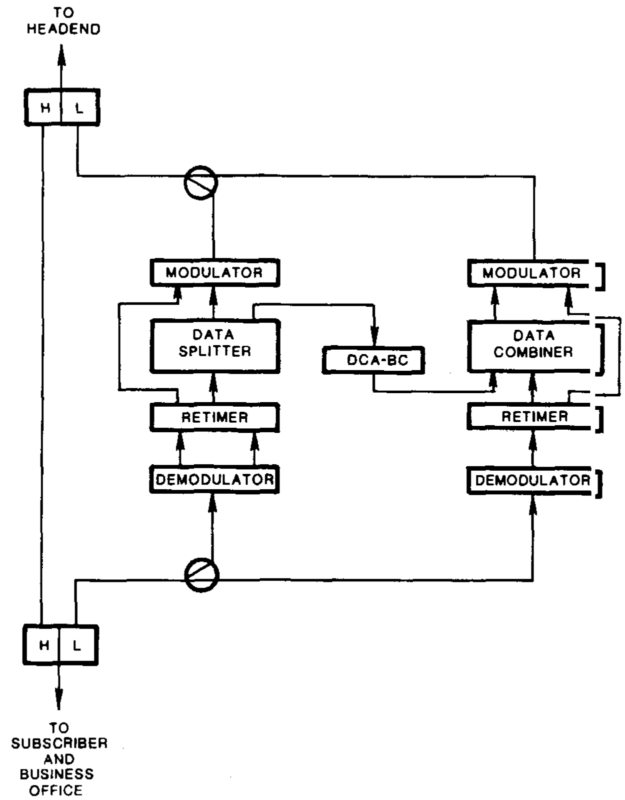

FIGURE 4 HUB SITE 1 CONFIGURATION

Figure 5 shows a typical hub site that does not need to relay control computer data signals.

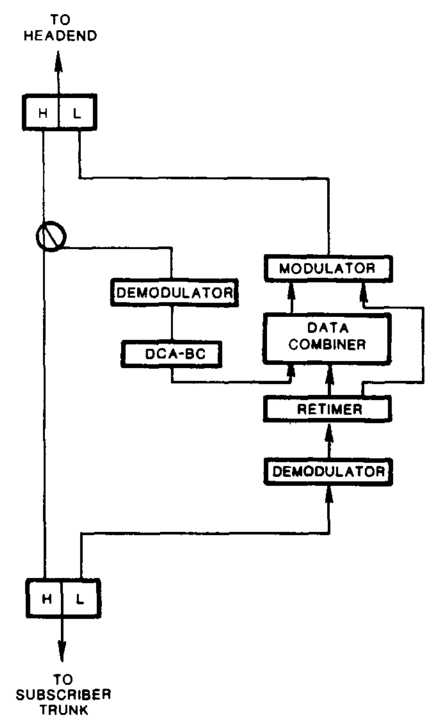

FIGURE 5 HUB SITE 2 OR 3 CONFIGURATION

Figure 6 shows a similar hub that has its own complement of scrambler/encoders which are controlled from the computer. This configuration can be controlled to switch operating parameters at the same time as S/E's at any or all other headends and hubs. This simultaneous switching minimizes personnel cost and enables system-wide IPPV offerings.

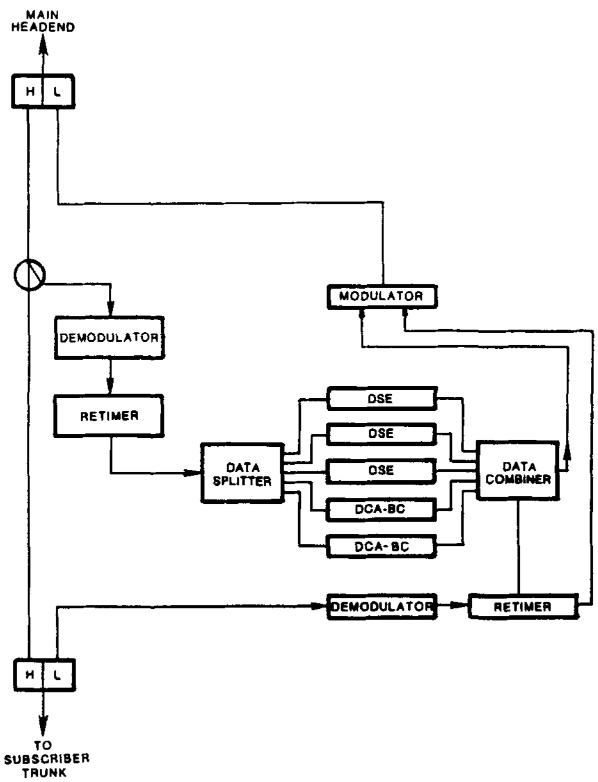

FIGURE 6 HUB SITE WITH REMOTE CONTROL SCRAMBLER/ENCODER

There are systems that must transmit the addressable control data stream by telephone line. Equipment required includes a pair of telephone modems, and a pair of data adapters to convert the synchronous data stream to the asynchronous EIA-RS232C convention (we have packaged the data adapters with 14.4K baud modems), permitting transmission on a leased telephone line. The delay experienced by telephone link mod/demod processing is not detectable in downstream data, but upstream response data arrives later than its RF-linked equivalent. To insure that data returning over telephone line does not collide with data returning over an RF path, we require all non-telco return paths be delayed equally, using a Transmission Link Equalizer (TLE). This unit will handle up to four data paths that require added delay. Figures 7A and 7B show the control computer site and an independent hub with leased telephone line data path.

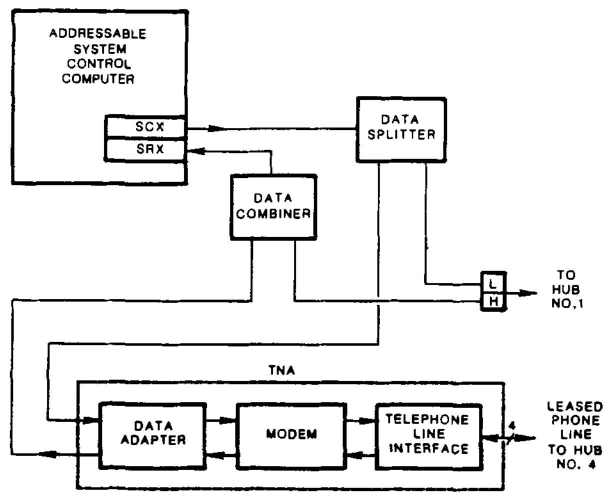

FIGURE 7A NEW CONTROL COMPUTER SITE CONFIGURATION WITH TELEPHONE LINE DATA PATH

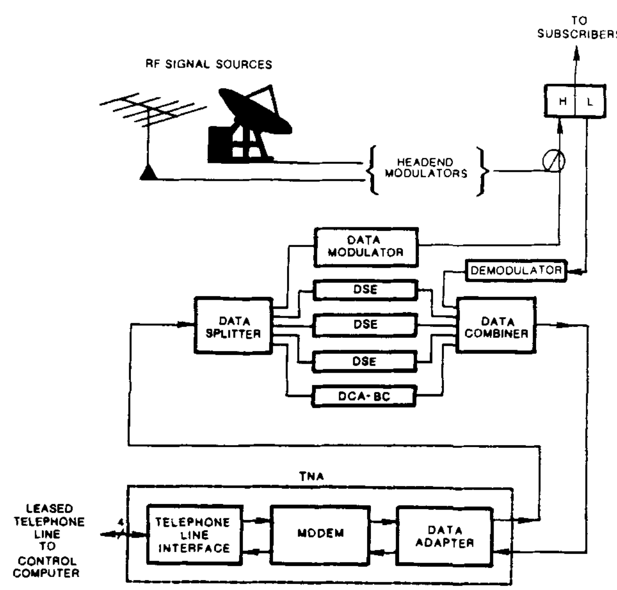

FIGURE 7B INDEPENDENT HUB WITH LEASED TELEPHONE LINE DATA PATH

An alternative implementation of IPPV with one way plant utilizes return data transmission over telephone lines from subscriber terminals. The advantages over two-way RF distribution plant are the time and cost required to install it. If there are remote S/E's, they may be controlled in one-way mode, however, there is no certainty that commands are being executed at the device without feedback.

Conclusion

The systems described here demonstrate the new ability for the remote control of scrambler/encoders and data modulator/demodulators from a central addressable system control computer. This promotes cost effective and timely implementation of pay-per-view, and impulse pay-per-view in systems with multiple hubs and remote headends.

REFERENCES

1. "System Design Criteria of Addressable Terminals Optimized for the CATV Operator", T. E. O'Brien, Jr., NCTA Technical Proceedings, 1980.