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400 MHz - A CHALLENGE FOR THE HYBRID AMPLIFIER

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The trend towards 400 MHz charges the hybrid manufacturer with the responsibility of providing increased performance without jeopardizing the high standards of quality and reliability required for profitable system operation. Thus, a prudent respone lies in the gradual implementation of the new generation of hybrids.

The availability of chips providing gain and match out to 400 MHz constitutes the first step. Advanced circuit techniques and tighter process control are applied. Subsequently, the dynamic range will be increased by phasing-in more sophisticated semiconductors.

This paper previews the upcoming technical changes. It is intended to provide a basis for the evaluation of the impact of hybrid technology on system cost and performance.

1.0 Introduction

Throughout its history, the CATV industry has seen an increasing demand for extended system bandwidth. The latest move raises the upper frequency limit to 400 MHz, thus providing space for 52 channels.

These changes in system parameters make new demands on the hybrid amplifier module. Compared to 300 MHz, module noise figures are on the average 2 dB higher at 400 MHz. Going from 35 to 52 channels, raises the number of worst-channel triple-beats by a factor of 2.63, thus lowering the CTB performance by 4.2 dB. Because of additional deterioration due to high-frequency effects, the degradation at channel H14 with 52 channel loading may be 12 dB worse than 35 channel performance measured at channel W.

Assuming typical amplifier design, these characteristics result in a reduction in trunk reach from 650 dB to 300 dB. A remedy from a system design point-of-view is closer spacing, or, if applicable, more hubs. Both measures are costly. Ideally the performance of the hybrids should be improved to handle the additional work load without deterioration.

In the following the options and possible choices for the hybrid manufacturer are discussed. Trunk station performance is calculated as a function of hybrid improvements.

2.0 Hybrid Improvements

2.1 Noise Figure

The noise figure of a bipolar junction transistor is determined primarily by the parameters: f_t, r_b', and β. Beta is made as high as possible in order to lower the noise and to increase the resistance of base-biasing networks. Practical values of 200 are presently achieved. Major increases are not likely, since other important device characteristics will have to be compromised.

In most general purpose high-frequency transistors, low noise is obtained by reducing r_b' to the lowest possible value. In the case of CATV transistors this technique is not applicable. Resistor noise is generated by all resistors in the base-emitter (= input) loop. The emitter resistance has the same effect as base resistance. Since all presently used CATV amplifier circuits use emitter resistors which are larger than r_b', little benefit arises from reducing base resistance.

The most promising remedy is an increase in f_t. In this area significant progress was made. New manufacturing techniques have resulted in an improvement of 2 dB in hybrid noise figure at 400 MHz. TRW plans to phase-in these new transistor chips during 1980, resulting in 400 MHz hybrid noise of 4.5 dB.

2.2 Output Capability

As evidenced from the illustrations in later paragraphs, an increase in output capability has the most dramatic effects. It is also the most difficult improvement to achieve. In high-performance transistors the distortion characteristics are the result of careful balancing of material and processing parameters. The last few years have brought about advances in material quality, fabrication control and sophistication, and, most significantly, computer-aided-design techniques. This progress puts a 3 dB output increase into the realm of possibility.

Earlier designs have been made which improve the output at the expense of ruggedness. The technique used consists of thinning the epitaxial collector layer and thereby, unfortunately, reducing the protective properties of this region. New designs avoid this shortcoming. The feasibility of reliable high-output devices has been demonstrated on an engineering level. Manufacturing methods are being developed. Incorporation of the 3 dB+ chip in 400 MHz hybrids is anticipated for 1981.

3.0 Trunk Station Analysis

In order to evaluate the behavior of existing and future CATV hybrids in a 400 MHz trunk, a typical station was modelled and subjected to a very detailed computer analysis. The objective was to determine optimum spacing and maximum reach, since these are major cost factors in a CATV system.

3.1 Station Layout

To allow comparison and to take into account industry practice, a previously(1) described layout is used. Refere to Figure #1, Block diagram of Trunk Station.

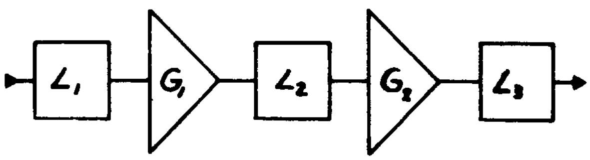

Figure 1. Block Diagram of Trunk Station

The input network, L_1, contains 0.5 dB of flat loss plus an equalizer with a minimum loss of 1 dB @ 400 MHz. For the purpose of analysis, the up-tilt of the equalizer may be changed from zero to full cable-slope compensation. The transfer function is slope-cable equivalent. The first hybrid, G1 is characterized by a flat gain, which may be varied in the analysis. Distortion is specified as 53-channel CTB measured @ H14 (off). Several different curves of noise figure vs. frequency, as measured on actual hybrids, are stored in the computer program, and may be called out as needed. The interstage network, L_2, contains a flat loss of 5.5 dB + 12% of spacing. It further equalizes that part of the station cable slope, which was not taken care of in L_2. Hybrid G2 has the same gain as G1, but may be specified to have different values of NF and CTB. The output circuitry, L_3, exhibits a flat loss of 1.5 dB.

3.2 Modes of Operation

Apart from using different amounts of cable equalization at the station input, two modes of output signal tilt were investigated. In one case a conventional tilt, as used in many systems, was assumed. The program automatically selects a tilt which results in as uniform a CNR as possible. In the other case it was postulated that the output levels were adjusted, (at the head-end) to maintain an exactly equal signal-to-noise ratio for all channels. The noise figure of present day 400 MHz hybrids varies considerably with frequency. An output level tilt which follows the contour of the noise level might, it was speculated, result in improved distortion characteristics. Figure 2 shows the noise output in dBmV for a normal hybrid combination, as a function of input equalization. EQ = 1 means all cable slope is equalized at the input of the station. EQ = 0. means all equalization takes place in L_2.

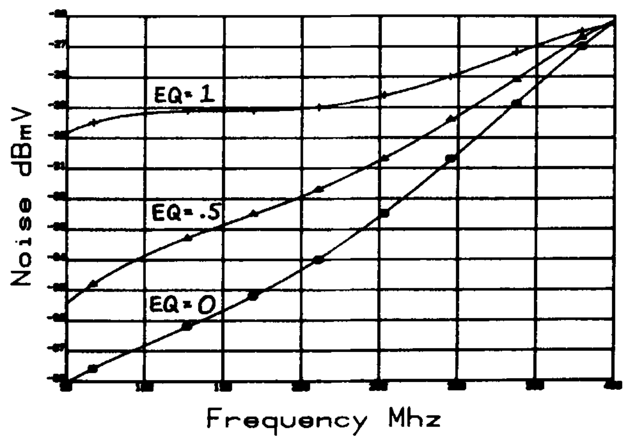

Figure 2. Station Noise, CA4101 and CA4201

Figure # 3 shows station noise using new, low-noise hybrids.

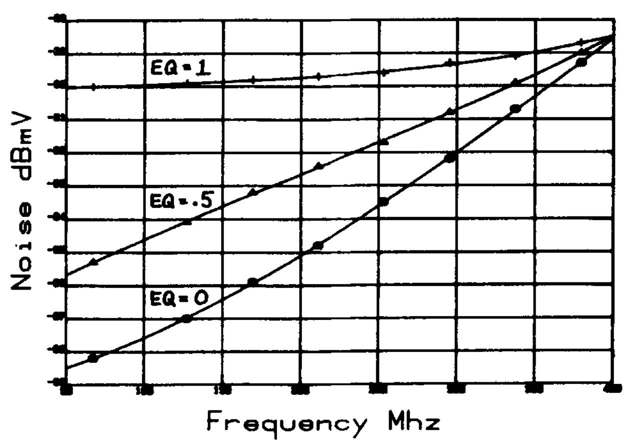

Figure 3. Station Noise, Low-Noise Hybrids

The effect of arbitary output voltage tilts was investigated by the following experiment: 53-channel CTB was measured on eight representative channels. While observing CTB on a particular channel, eight blocks of channels were varied in amplitude, one block at a time. Thus, the CTB sensitivity to amplitude variations throughout the frequency range was determined. After some manipulation, an 8x8 matrix was generated which allowed the computer to predict CTB improvements due to output tilts of various shapes. In the following figures, results obtained from conventional output tilt are identified by TILT-C, while constant CNR tilts are labelled TILT-N.

Figure 3 through 6 show maximum trunk reach for three types of amplifiers as a function of input equalization.

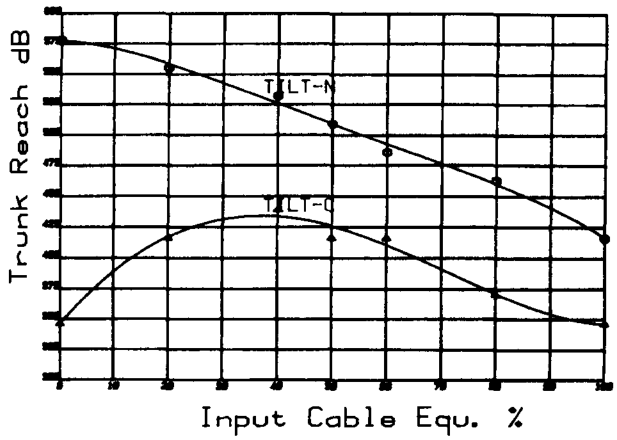

Figure 4. Reach of CA4101 + CA4102

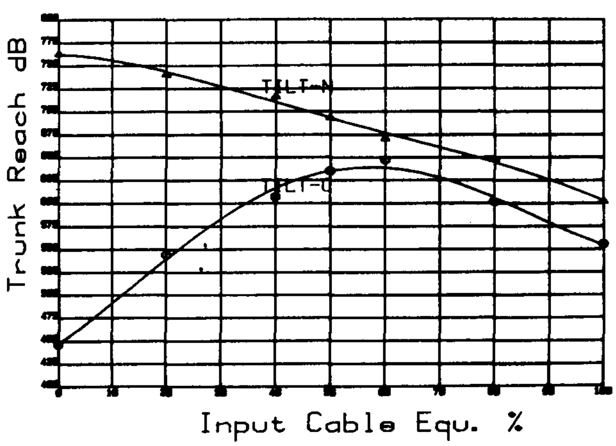

Figure 5. Reach of Low-Noise Hybrids

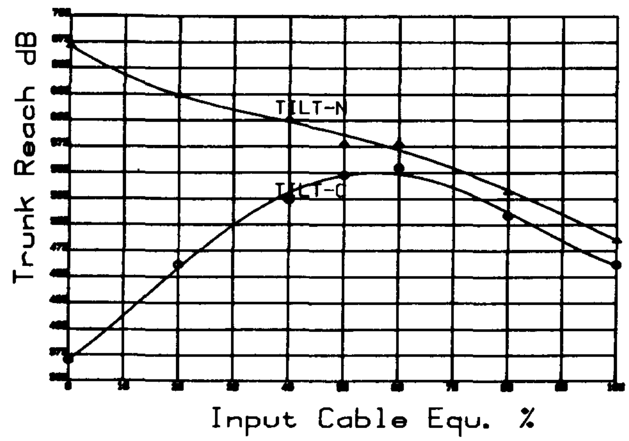

Figure 6. Reach of Low-Noise, Improved Output Hybrids

3.4 Optimum Hybrid Gain

400 MHz hybrids presently on the market are specified for a nominal gain of 17 dB at 50 MHz. The reason for this is that the first step towards 400 MHz consisted of improving existing 300 MHz trunk types with respect to match, gain flatness and second order distortion, so that performance up to 400 MHz could be obtained. As mentioned before, major improvements in semiconductor technology will soon bring up to 5 dB additional dynamic range. At that time the question of optimum hybrid gain may be raised again.

Shown in Figure 7 is reach as a function of hybrid gain for a compliment of future hybrids. Noise figures were 5.4 dB and 6.4 dB, H14 -46 dBmV CTB -56 and -62 dB respectively.

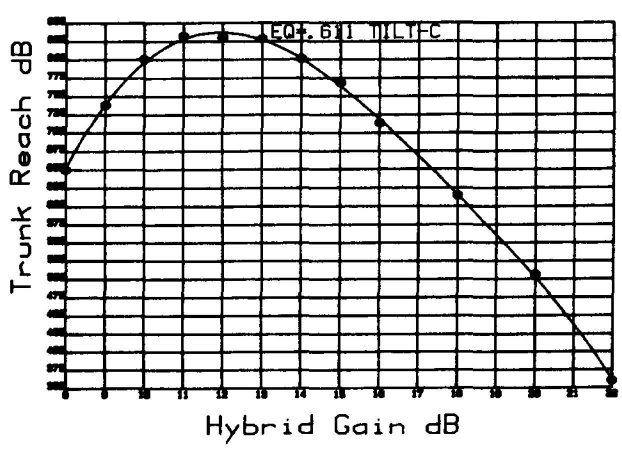

Figure 7. Reach vs. Hybrid Gain

For maximum trunk length, it is seen that 17 dB gain is not optimum. In order to evaluate the cost impact of decreased hybrid gain, the spacing needs to be known. This is shown in Figure 8.

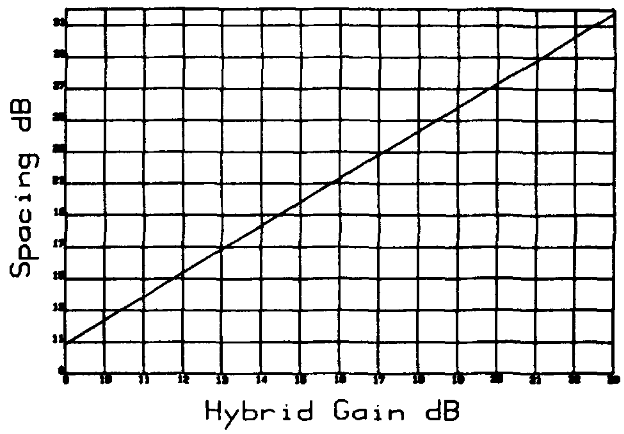

Figure 8. Spacing vs. Hybrid Gain

4.0 System Improvements

The increased work load imposed by 400 MHz operation has led to the use of other techniques to enhance picture quality.

4.1 HRC

The use of harmonically related carriers has long been known to result in improved transmission quality.(2)A computer-aided study predicts a distortion improvement of 6 dB on the worst channel, and more on other channels. (3). The remaining distortion has the appearance of cross-modulation which has led to the speculation that this parameter is of renewed importance. It can be shown, however, that the basic quality parameter is still composite triple-beat. The difference with HRC is that the many components of the "beat-noise" are now on one frequency and have a fixed phase-relationship to each other. HRC seeks to obtain a net zero amplitude by phase-cancellation. The starting point is still a vector resulting from the summation of all triple-beats.

4.2 Frame Synchronization

This technique, which requires complex and costly electronics, causes the sync-pulses of all TV signals to occur at the same time. Thus, maximum intermodulation happens, while no video information is transmitted. The net result is an improvement proportional to the ratio of peak-sync to average signal power.

5.0 Conclusion

The semiconductor industry is responding to 400 MHz according to a plan which will result in trunk characteristics comparable to present 300 MHz performance.

Further improvement may be obtained by head-end sophistication. Presently known schemes apply to TV-signal transmission only. The need to maintain system transparency, the importance of future non-TV services, and the cost of these improvements will be pondered in the time to come.

Reference List

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A 5.1 km REPEATER LESS FIBER OPTIC SYSTEM FOR MULTICHANNEL OPERATIONS

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The present state of the art in fiber optic cable loss is about 4 to 5 dB/km. Operational bandwidths of 300 MHz can be achieved over that distance when using fiber with bandwidths in the 900 MHz to 1 GHz/km range.

In order to provide high quality multichannel signal transmission over extended distances, it is advisable to use FM transmission to overcome the intermodulation products of presently available laser transmitters and improve signal-to-noise performance.

This paper describes a practical 5.1 km fiber optic system using no repeaters. Wide deviation FM video transmission is used to obtain a signal-to-noise ratio of over 52 dB per channel. Up to eight channels can be carried on each fiber.

Because of the increase in the number of channels originated at the Manhattan Cable TV origination facility, a new transportation trunk with higher capacity became a necessity (Figure 1). Thirteen channels to the Head-End and a minimum of four monitor channels back to the origination center were required.

In the process of looking at the alternatives available for this transportation trunk which covers a distance of 5.1 km, the following criteria were considered most important:

1) Quality Transmission
2) Maximum Channel Capacity
3) Minimum Number of Repeaters
4) High Reliability
5) Low Cost

When comparing a coaxial cable trunk to a fiber optic system in the underground duct system of Manhattan, it turns out that the fiber optic system has greater advantages and lower cost.

1) <u>Quality Transmission</u> - Since this trunk is used to carry signals from our originating center to the Head-End for distribution to subscribers, a signal-to-noise (S/N) ratio of at least 52 dB is required. This is comparable to the S/N ratio that is obtained from a satellite receive-only earth station. Also, since

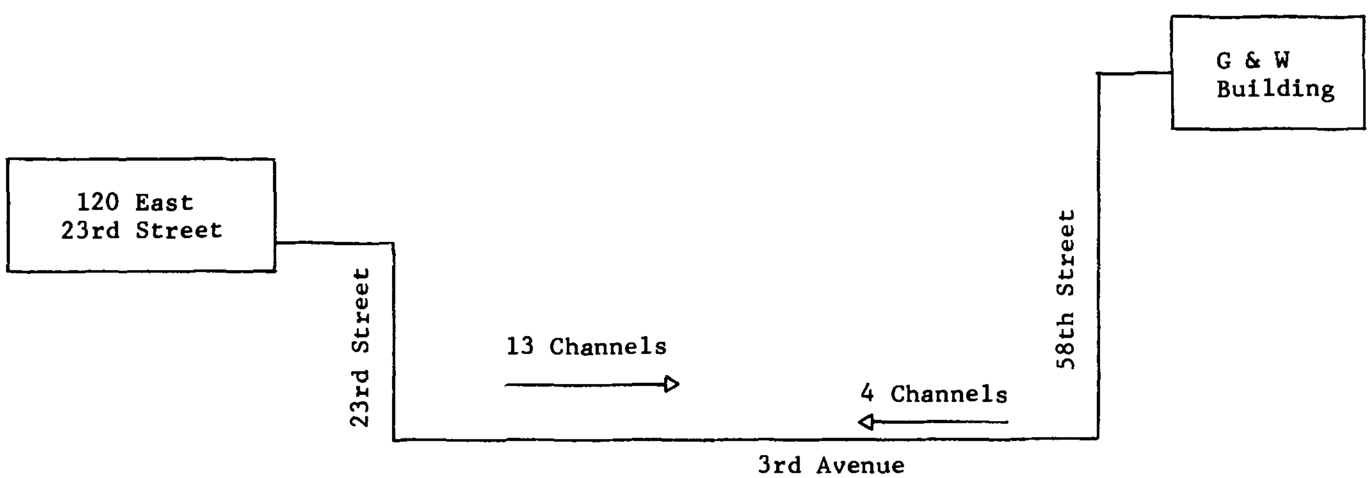


FIGURE 1 5.1 km Fiber Optic Program Trunk the S/N ratio of the video cassette is in the 45 dB range, there only will be about 1.0 dB degradation in performance. This translates to about 0.5 dB difference in degradation at the end of the system. In order to achieve this S/N ratio, an FM Transmission System should be used. Non-linearity of the laser in optical transmitters produce harmonic and intermodulation distortion. In order to determine an acceptable level of interference, tests were run with 6 to 8 FM signals. Results show that the carrier to interference (C/I) ratio must be at least 30 dB for quality signals.

2) Maximum Channel Capacity - Optical fiber is presently available in a wide variety of bandwidths. The specification is usually given as MHz per km. These bandwidths range from 10 MHz per km up to 1 GHz per km. When more than one kilometer of fiber is cascaded, the bandwidth is reduced according to the following formula:

$$f_t = \frac{f_1}{1 + \sqrt{N - 1}}$$

f_t = Total system bandwidth

f_1 = Bandwidth of 1 km of fiber

N = System length

In order to achieve a 300 MHz bandwidth with no repeaters over 5.1 km distance, fibers with approximately 900 MHz to 1 GHz bandwidth must be used:

for f_t = 300 MHz N = 5.1 km

$$f_1 = f_t \left[1 + \sqrt{5.1 - 1}\right]$$

$$f_t = 906 \text{ MHz}$$

Greater bandwidth could be achieved in the system by using one or more repeaters, but this was not in the best interest of system design or cost.

3) Minimum Number of Repeaters - The ideal design for the 5.1 km system would have no repeaters. As mentioned above, the penalty that is paid when repeaters are not used is a reduction of system bandwidth. However, it was judged that approximately 300 MHz bandwidth would be sufficient for the system requirements.

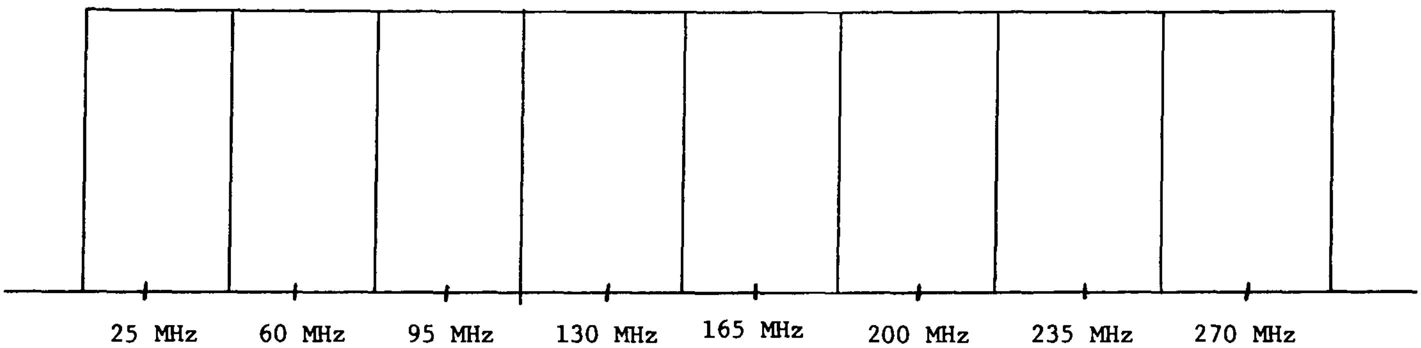
In order to transmit 13 channels, it would be desirable to put 7 or 8 channels on a fiber. Two fibers could be used for transmit and one fiber could be used for receive. This would allow channels to be added easily in the reverse direction, since four slots would be available on that fiber. The forward direction could accommodate one to three additional channels before an additional fiber is needed.

The system loss to obtain the required S/N ratio is about 26 dB. If a connector and splicing loss of 3 dB is allowed, then a fiber loss of 23 dB is required over the 5.1 km. This equates to 4.5 dB/km of cabled fiber loss, a value that is not too difficult to achieve with fiber that is presently available.

Adequate S/N ratio can only be achieved by using wide deviation FM equipment. A deviation of 8 MHz was used to obtain an FM improvement factor of about 26 dB. Channel spacing is 35 MHz and can be accommodated on a 300 MHz system. The channel center frequencies are 25 MHz, 60 MHz, 96 MHz, 130 MHz, 165 MHz, 200 MHz, 235 MHz, and 270 MHz (Figure 2).

4) High Reliability - The trunk is designed to be very reliable. a great deal of protection is designed into the cable to ensure protection from the conduit and manhole environment found under the streets of Manhattan. Among the many possible hazards that which most severely attacks conventional aluminum sheath cable is the continuous presence of moisture in either liquid or vapor form. To combat this condition, five multi-mode graded index glass fibers were stranded around a non-metallic central strength member and secured with core binders. This core was then filled with a water impervious filling compound to prevent the penetration of liquid moisture into the core. Because of this, exposure to moisture is limited and the potential for moisture - induced microcracking in the fiber is minimize.

Mechanical protection for the fiber core is achieved by a three layered construction composed of an inner core jacket of polyethylene, a serving of Kevlar, and a second polyethylene jacket overall. As a result of the heat of extruding the second jacket, the Kevlar strands become imbeded in the second jacket resulting in a reinforced composite section providing the tensil strength and crush resistance



FM Channel Assignments FIGURE 2

required by the core during the installation process.

As additional protection against moisture, a flat aluminum tape, protected on both side with a fused and chemically bound polyethylene film, was formed around the second jacket. A final jacket of polyethylene completed the construction. During the extrusion of the final jacket, the polyethylene film on the aluminum is fused to the jacket creating a moisture resistant metallic sheath overall.

The installation of the cable presented an entirely new set of problems. The biggest of these was the congestion in the manhole and on the cable racks. The fiber optic cable was to be placed along with a bundle of conventional coaxial cable in a common duct. Due to the bulk of the cable bundle, and the congestion and misalignment of ducts, the longest feasible length that could be pulled was about 600 feet. Pulling 600 foot lengths of the optical cable is out of the question be- it would result in 30 splices and the potential for 15 dB of loss due to the extra splices.

To overcome this problem, a welded aluminum conduit with a thermoplastic, anti-corrosion flooding compound and a polyethylene jacket was pulled in as an additional component of the coaxial bundle. When the bundle had all been placed, a pulling line was pneumatically blown thru the conduit section. This line was later used to pull the fiber cable into that conduit. The result of using this approach was that fiber cable length of 1 km could be pulled. This mini-duct conduit also provide capabilities to replace any given length of the optical cable should it ever become necessary. When the entire 5.1 km was pulled, Sealtight tubing, placed over the mini-duct was pulled over the fiber cable and dressed against the cable rack. This Sealtight tubing was mechanically coupled to the mini-duct in each case producing a continuous protection of the optic cable from beginning to end of the run.

The five cable splices required were performed with the fusing technique due to its's inhert low loss (less than 0.5 dB per splice) and its's superior mechanical properties. To facilitate splicing, General Cable developed and obtained approval for a explosion proof welding enclosure which could be used to splice in the manhole despite a possibly gaseous environment.

Overall System Design - The number of channels that can be placed on a fiber is determined by the overall fiber bandwidth, the total fiber loss, the desired signal-to-noise (S/N) ratio, and the amount of intermodulation distortion at a given laser power output (Figure 3).

Given that an improvement factor of 26 dB is available using an 8 MHz deviation FM system, then the carrier-to-noise (C/N) ratio required for a 56 dB S/N ratio is 30 dB. A 56 dB S/N ratio is chosen to allow some margin in the system for aging and additional splices required to repair any breaks.

Using an avalanche photodiode detector, a C/N ratio of 30 dB can be achieved for 8 channels at a receive power level of

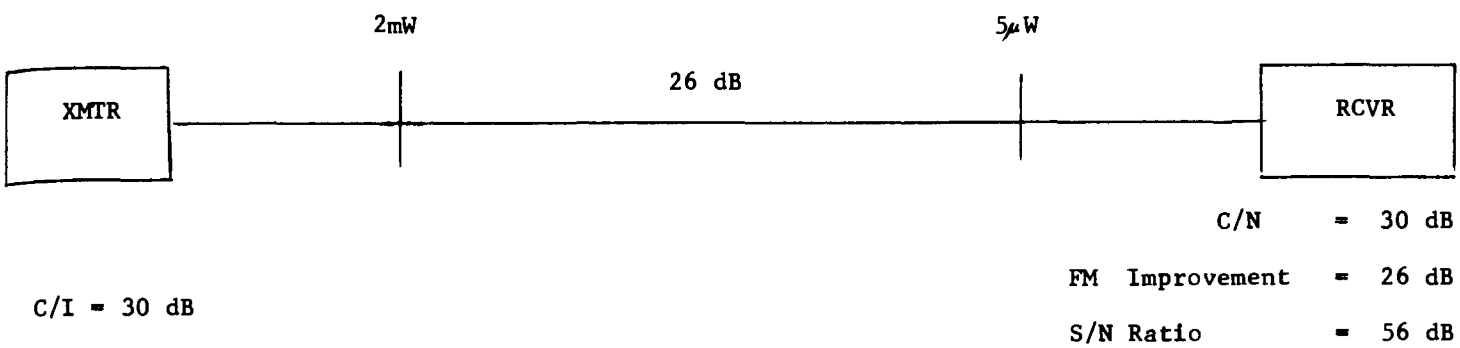


FIGURE 3

5µWatts. The required output power from the fiber pigtail of the laser transmitter must be about 2mW with a system loss of 26 dB.

At the 2mW pigtail output, the laser is operating at a point where the intermods are down at least 30 dB.

5) Low Cost - If a coaxial system is used from Manhattan, installation of expensive sidewalk boxes with a costly street cut between the manhole and box would be required. It turns out that a fiber system without repeaters costs less than a coaxial system under these conditions. In addition, the fiber has more channel capacity than a coaxial cable in this application. Since we could put up to 8 channels per fiber on a 6 fiber cable for a total of 48 channels.

Summary - It is quite possible to install a high-capacity fiber optic trunk having high quality transmission parameters and reasonable cost. Up to eight channels can be accommodated on each fiber and no repeaters are used over the 5.1 km distance. Low loss wide bandwidth fiber and wide deviation FM transmission are combined to provide a system that has pushed forward the state of the art.

ADDRESSABLE SECURITY

AL CLARK

CYBERTECH, INC.

OVERVIEW

The leading edge of operational security technology is found in the military. The methods used 20 years ago included an electronic circuit coupled with the physical act of using a courier to alter the operational characterisitc of the electronic equipment used.

Today we are addressing the issue of security in Cable Television in terms of controlling both the presence of video signal and clarity along with user environmental sampling and transmitting.

In the past and in the present, control of video has been employed by the physical act of using a person to place hardware at the pole and/or in the home. We are now seeing the beginning of the use of electronics to replace the manual function of that operational activitiy and a higher degree of the control function.

In that the Cable Industry is on the verge of becoming a part of a global communication network an overview of other network security requirements is in order.

Those networks are:

1. Satellite
2. Land lines (Phone companies)
3. MDS
4. STV
5. Cable
6. Mushroom return links

Mushroom is a term the Author is using to express the use of a limited distant transmitter used by a person to transmit to a series of geographic dispersed receiving locations. These locations would be the uplink to a Satellite network or go into any other networks. The person or entity could be mobile or stationary.

Business data processing communication has used in some cases a formula that is a De facto standard. This formula takes clear data at the transmit point and scrambles it into garble that is non-readable. At the receive site the formula is reversed and the garble is converted back into clear text. Other means of security at the business or individual level involves software (passwords, etc.) and hardware. As Cable interfaces to these networks the same techniques and standards will be received.

PRESENT TECHNOLOGY

Cable Television is now addressing security at the home level in terms of control of the video signal. The control is performed by a micro-processor in an intelligent tap or an intelligent convertor. Security is based upon using a unique address for each of these devices.

Programming of the micro-processors can be altered by sending software code down the cable system if RAM (random access memory) is used. If PROM (programable read only memory) is used the alteration of the code can be changed by using a person in the field or in the office.

To support the use of these devices by a Cable company requires a very co-ordinated effort at the operational level.

As customer orders are received at the cable office they should be handled one time for requirements. The order should be entered on a computer that can handle billing, operational and control functions or pass electronically the information to another computer or computers for those functions.

The billing system must have the design to support Multi-tiered service. History of the transactions should be stored by each tier for clarity and because of the different types of service cable will be selling in the future, billing should read the history file by each tier and by each transaction to produce an itemized statement for customer acceptance.

The billing system should pass to operations the necessary paper work if a person is needed to install or alter the service. If a person is not required, the billing/or entry process should electronically pass control signals to satisfy all required needs.

FUTURE

The next step in security within the Cable Industry should encompass manufacturing economics and techniques to support software control at a level to defeat economic emulations.

AN AMPLIFIER STATUS MONITORING AND CONTROL SYSTEM

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A trunk amplifier status monitoring and control system is described. Its features include an addressable receiver, a variety of control functions, including reverse feeder switching, and an independent upstream status signal. Addressing is done by means of an FSK'ed signal similar to a sound carrier. The status signal carried information on various aspects of the station status. The status signals are all on a common frequency, occupying minimal bandwidth, and are addressed exclusively, only one replying at a time. The command functions are described in detail, both as currently implemented, and possible future applications. Also described in detail is the status information returned, both as currently implemented and possible alternatives. A simple control unit is described and a more sophisticated means of control is discussed.

INTRODUCTION

With the growing complexity of CATV distribution systems, the need for a way to monitor the system's operation is becoming acute. The traditional status monitor, subscriber complaint, is clearly inadequate for today's systems carrying dozens of channels, premium services, and security data. In addition, the ability to control signal flow, particularly in the reverse system, has emerged as a very desirable feature.

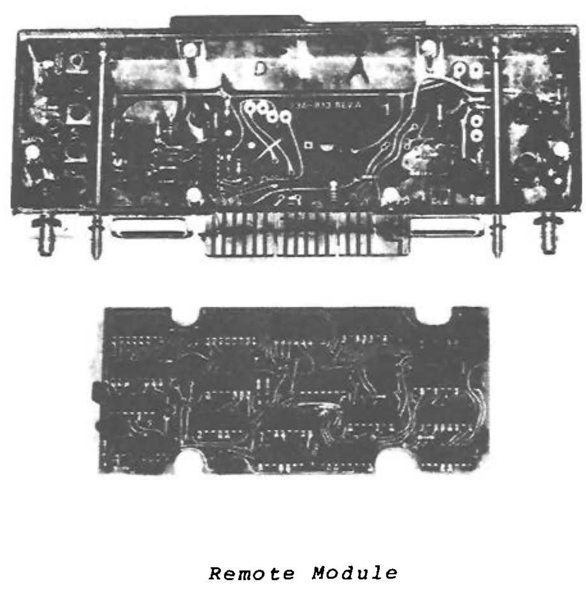
These functions can be accomplished by the system described in this paper. Reliable, low-cost integrated circuitry, both linear and digital, is used in a simple and straightforward system for monitoring and control.

The heart of the system is a transceiver mounted within a trunk amplifier, which receives a downstream control signal, and generates an upstream status signal.

Addressability is an essential feature of this system. Each amplifier that is to be monitored or controlled is assigned a unique digital address. Any command intended for this station, including the command which causes transmission of an upstream status signal, is accomplished by modulating the control carrier with the proper address, and desired command.

CONTROL FUNCTIONS

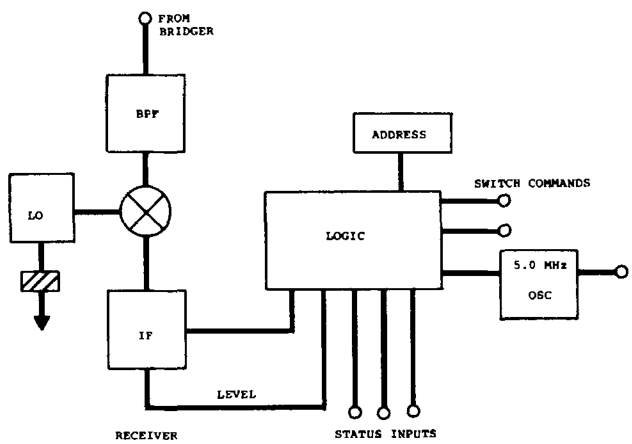
Control is accomplished by means of a frequency shift keyed (FSK) carrier at 53.75 MHz. The digital data is Manchester encoded for easy detection. This signal is in effect a lower adjacent sound carrier to Channel 2 and is run at least 15 dB down from the Ch. 2 video carrier. It is not likely to cause problems on the system or, more importantly, to subscriber sets. (In HRC or other non-standard channel systems, the control carrier is adjusted accordingly). The frequency shift is 30 kHz, which occurs at a 19.2 kHz rate. The transmitted word consists of 16 bits, of which 9 bits are for the address, 5 bits are for 5 independent commands, plus start and stop bits. Words are transmitted asynchronously, each word taking slightly less than 1 millisecond. A nine-bit address allows 512 (2^9) possible addresses, which seems adequate to accommodate the number of trunk amplifiers which might be served from one headend or hub. With this number of addresses and the bit rate above, all stations can be addressed within a half second.



Remote Module

In the amplifier station, the control signal is picked off at the bridger output. A hetrodyne receiver is used, with a crystal controlled local oscillator, converting to a 10.7 MHz IF. Standard automotive specification components are used, which are well suited to the CATV amplifier environment, readily available, low in cost, and of proven reliability.

The detected signal is converted to a digital waveform, and processed by logic circuitry. CMOS integrated circuits are used here, where their low power consumption and wide supply voltage range make this logic family ideal for the application. The logic circuitry checks the received signal for address. If the address matches that which is programmed into the module, then the associated commands are stored by the logic circuitry.



Remote Module

What control functions are desirable or feasible? Certainly the transmission of an upstream status signal should be done on command, and this is done. Since the status signals are transmitted on a common frequency, it is important that no more than one station reply at a time, and this is provided for in the logic.

Reverse feeder switching has come to be considered almost essential in CATV systems making substantial use of two-way transmission. In this system, this is accomplished with a diode switch, which controls insertion of the reverse feeders onto the reverse trunk. The ability to switch individual feeders is attractive, but this is not readily achieved in a conventional bridger station.

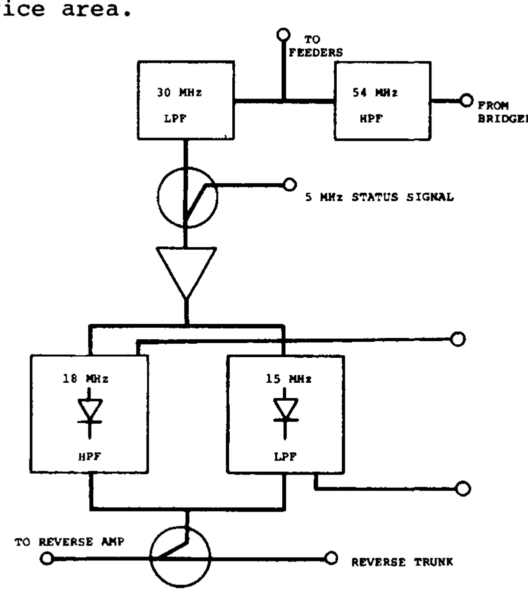
The use of reverse systems for data collection from subscribers is growing rapidly. At the same time, increasing use is being made of reverse video transmission, a rather different type of service. Several considerations may be stated:

1. Addressable type subscriber data terminals are generally believed to be tolerant of the electrical environment typically found on two-way systems without feeder switching, but switching is a valuable troubleshooting tool.

2. Feeder switching is almost essential if video is to be carried on a fully implemented two-way system.

These considerations have motivated the design of a bridger filter in which the 5-30 MHz band is further split into 5-15 MHz, 18-30 MHz sub-bands. These are independently switchable by the control module.

In normal operation, the 5-15 MHz switch is normally closed, allowing speedy response from any subscriber. The 18-30 MHz switch is normally open, and is closed only when video is to be originated in that bridger service area. Thus, the reverse trunk is kept relatively clean in the 18-30 MHz range, for video, and switching overhead is minimized in the 5-15 MHz range, in which data is more tolerant of noise. Alternatively, the 5-15 MHz switch may be normally open and closed only when data is to be collected from that bridger service area.



Bridger Filter

Since the system is digital in nature, any control function which could be digitized could be accommodated.

Under consideration, but not yet implemented, is a facility for switching the reverse trunk path. Other possibilities would include some control of the station's powering, and control of the forward path. Automatic gain control by remote control is a somewhat distant possibility.

MONITORING FUNCTIONS

The upstream status signal consists of a crystal controlled 5.0 MHz carrier, which is frequency shift keyed, with a 3 kHz shift, at a 2 kHz rate. The signal carries Manchester encoded data, including the 9-bit address of the station, 5 status bits, and start and stop bits. This 16-bit word is 8 ms long. In practice, about 20 ms is alloted to read the status word from a station. This allows reading all 512 signals in about 10 seconds.

What aspects of the station's status should be monitored? Again, any parameter which can be reduced to digits can be accommodated by this system.

At the simplest level, the addressable nature of this system provides a path continuity test, both downstream and upstream between the headend and any station. It might not be necessary to return the entire address on the status signal, since parity or some portion of the address might be adequate, but in the interest of keeping the system simple, the entire address is carried.

In this system, the level of the control carrier reaching the receiver is converted to a voltage by a tuning meter circuit and this is compared to a preset threshold. The result of this comparison controls one of the status bits; if the signal is lower than that threshold the bit is 0, otherwise it is 1.

The receiver will function over at least a 30 dB range of control carrier. This allows a simple routine for determining system gain to any station; the control carrier is gradually increased to the point of this threshold at that station. This level serves as a reference point for the gain of the system from the headend to that station. A record is made of these reference levels at the time of installation. One would hope that these levels would henceforth be the same, regardless of time, temperature, etc. Since this is unlikely, the system profile that does result each time these measurements are repeated, provides a very useful tool for system maintenance.

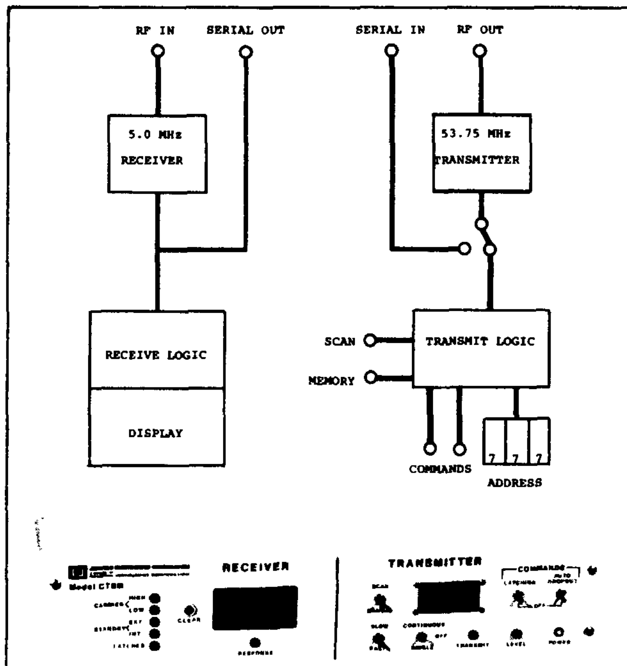
The module can also be provided with two thresholds, spaced typically 6 dB apart. Then, if the control carrier is within this window, no alarm indication is returned, and if the carrier is either lower or higher than this window, the condition is reported. This is especially suited to more elementary level monitoring systems.

One of the most attractive features of this system is its ability to monitor AC standby power supplies. Consider the case in which a standby supply cuts in for some reason other than a brief power outage. Without knowledge that this has occurred, the only benefit afforded by the standby power is a grace period of several hours as the batteries discharge.

To monitor a standby supply, one of the status bit inputs is connected to an accessory port on the housing. This is connected to the standby supply, in which the manufacturer must provide a closure to ground to indicate cut-in. This closure is transmitted upstream on the status signal. Note that this bit could be used to monitor any external parameter that can be presented as a closure to ground.

In stations equipped with a backup DC power pack, one of the status bits is used to monitor its activity. Additional bits have been used to monitor amplifier bypass modules in a failsafe system. Again, any internal parameter which could be converted to a closure to ground could be accommodated by this system.

The suitability of a computer as a control unit for the remote module is obvious, and computers are already in use in some CATV system headends. But, no two CATV systems are alike, and for this reason the control unit which has been designed for this system is a manual unit, which includes a serial computer interface. The unit serves as an RF modem, generating the 53.75 MHz control carrier under computer control, and demodulating the 5 MHz status signal for processing by the computer.



Control Unit

In its manual mode, the address and commands are dialed in, using thumbwheel and toggle switches. "Scan" and "Memory" functions are also provided. In "Scan", all 512 addresses are sent in sequence, and the "Memory" mode allows sending different commands to different addresses. The receiver decodes the upstream status signal, and displays the received address and status on front panel LED's.

CONCLUSION

A versatile status monitoring and control system is made feasible by readily available IC devices. Addressability is a key feature and the digital nature of the system ensures flexibility in the functions controlled and monitored.

AN AUTOMATED PROGRAMMING CONTROL SYSTEM FOR CABLE TV

By
Ann Beck, Manager, Manhattan Cable TV
Frank J. D'Ascenzo, Project Manager, 3M
Joseph L. Stern, President, Stern Telecommunications Corporation

Presented by Mr. Joseph L. Stern

The growth in video sources available, plus the growth in active channels poses a formidable operations problem for the cablecaster. This paper describes an automation system, specifically designed for Programming Control in a Cable TV System. The system provides for off-line preparation of daily program schedules, storage of the schedule on a magnetic disc file, automatic selection of input devices or feeds, automatic control of machines, and development of five printed reports: program schedule, program log, machine-tape status, channel schedules and source-machine status reports.

The system was designed in conjunction with management and operating personnel at Manhattan Cable TV, and is currently under development by 3M.

More and more channels! Whenever we hear of a new proposal for a cable television system, of new equipment for cable television systems, or of new requirements for cable television systems, it always includes more and more channels!

The source of programs on cable TV has now turned the corner. A far larger number of channels are locally originated or controlled than are picked up off-the-air! More flexibility and more precision are required in the programming of a cable television system than ever before, and the complexity increases daily.

This conference has heard it and seen it as well. Forty channels, 50 channels, 58 channels, 100 channels, even 125 channels have been talked about. Each of these channels must be programmed with care, creativity and continuity. What the viewer sees on every channel should be a professionally orchestrated series of programs, interludes, bridges, identifications and commercial arrangements.

In 1978 Manhattan Cable TV retained Stern Telecommunications Corporation to study its transmission facilities and to make recommendations for both near and long term improvements. At that time Manhattan Cable TV was originating or controlling programming on ten different channels from a variety of facilities located at their East 23rd Street facility and at the Gulf and Western Building head end, thirty-seven city blocks north. Program material originated from three-quarter inch cassettes, from half-inch reel-to-reel tape, from remotely located studios, and from a variety of character generators, microwave feeds, AML feeds, and switched antenna feeds at remote locations. At that time these signals were switched by turning modulators located at 23rd street on and off, or by touchtone telephone signalling to the head end. These cumbersome techniques were also being used for the insertion of commercials <u>and</u> will continue to be in use until the facility I'm about to describe is put into operation.

The existing facilities were not designed or installed as a transmission center; they simply evolved from what was assembled to serve as a public access facility. This public access facility was accepting a variety of tape from a variety of sources and it just grew to meet every increasing but unplanned need. It was a tribute, and still is, to the MCTV operations personnel that the facility worked as well as it did. As a matter of fact, it is a tribute to the operations personnel that it works at all.

All the machines are manually operated (see Figure 1) and the operator has to race between machines to load them as well as to start them. Machines are started in sequence and then the operator <u>runs</u> back to his audio-video switching <u>facility</u> and operates a "sålvo" switcher to make the "break". The same operator, after running from the machines, goes to an audio mixer and opens a live mike at the control console and personally makes the disclaimers required on individual channels. One of the most important attributes of an operator for this facility is physical agility, and a very good memory.

It was obvious that with ten channels being sort of programmed and more programmed channels being planned, there was need for a major change in philosophy as well as a major change in equipment. (See Figure 2)

A study of the transmission facilities' requirements of MCTV showed needs comparable to those of a telephone company video-technical operations center. And the type of switching equipment that might be installed if all CBS, NBC and ABC network control facilities were located in the same room. The variety of signals being generated or switched exceeded that normally controlled by any single commercial broadcast station. In 1978 between 85 and 100 transmission switching functions were being executed on any of six channels in an average 12-hour day (as illustrated in Figure 3) The number of switching functions have already doubled from those which were considered in the initial study. Even as the facility was being designed, new satellite feeds were being considered, and at the last reading, plans provided for 1000 hours of programming weekly, exclusive of alpha-numeric channels.

Within the 1000 hours of programming there's a requirement of channel identification, programming promotion, public service announcements, interludes or bridges, and commercials. In some cases we find that as many as 25 separate switches would take place in 2½ minutes of break time. If you consider that the facility is planning to program 10 channels and has a break every ½ hour, we find something in the neighborhood of 250 switches possibly taking place every 30 minutes. Each of these switches can involve the start and/or of a videotape machine, an audio cartridge machine, a slide scanner, an audio feed from an FM receiver, a switch to a live pickup, a feed from a character generator, audio/video switching and head end switching.

To do all this and present a professional image, some form of automated system is obviously indicated.

The major goals of a redesign was to provide for simplicity of operation, a high degree of consistency or continuity, a level of quality which was cost effective and the ability of the facility to expand in an anti-obsolescent manner, providing both for flexibility and for future growth.

It was decided to study a number of approaches including:

1) manual operation of all facilities, utilizing remote control for all major machines
2) installation of video cassette changers for some channels and manual operation on others
3) automatic operation of selected channels on a time and/or cue tone basis with manual operation for others
4) complete micro-processor computer control of programming and of machines.

In addition to these operating approaches being studied, there were a number of other facilities which were not involved in a study but were simply involved in a decision-making process. They included:

1) provision of time-base correction on all program channels
2) provision of a centralized multi-channel output character generating system
3) provision of full preview facilities for all outside sources as well as inside sources
4) provision of production program control rooms
5) provision of automated remote control audio-cartridge facilities, and
6) doubling of editing facilities.

The study showed that there was significant benefits to be achieved through the use of a micro-processor control system. The amount of programming and the flexibility required made it impossible to work on a time and/or cue tone basis. The constant additions of programming sources made it impossible to work on a manual basis. As an end result of the study, we began searching for suppliers of the type of equipment we required.

We were looking for a system which could be programmed and could also be interrupted. We were looking for a system which would give the operators reports and also print a log. We were looking at a system which could be interfaced with human beings very easily.

Reviewing potential suppliers of equipment, we elected to utilize a system jointly developed with the Mincom Division of 3M. A contract was signed for the provision of a complete program automation system consisting of a number of hardware elements arranged in two major subsystems:

1) An on-line Automation System, and
2) An off-line Disc Preparation System.

The on-line Automation System is the day-to-day, active operating system, and provides control of both video switching and machine functions in accordance with the daily Program Schedule.

The Program Schedule is stored in a floppy diskette and is loaded into the Disc Transport (Figure 4). An associated Zenith micro-computer interfaces the Disc Transport with a 3M, Model 6500 Micro-Controller (Figure 5). The micro-computer contains the on-line program instructions, or software, which enable it to control the system. It reads the Program Schedule information from the diskette on a time sequence basis, and transfers control commands to the Model 6500 Micro-Controller.

The Model 6500 Micro-Controller performs the actual video switching and machine control tasks. Video switching commands are sent to a 3M, Model 40X Routing Switcher (Figure 6). The routing switcher will accommodate up to 40 different video and 80 audio inputs from various sources. These can be inputs from video cassette player/recorders, film chains, audio cart machines, off-line feeds, or locally generated TV signals. The 40 different inputs can be selectively switched (or routed) to any one of 20 different outputs, or designated channels.

In addition to video switching control, the 6500 Micro-Controller feeds a machine control interface unit (Figure 7). The machine control interface unit provides interconnection between the Model 6500 Micro-Controller and any variety of "machines", such as video tape recorders, audio carts, film chains, and so forth.

In this MCTV system, the machine control interface unit contains special circuits for sensing the control track pulses, the system can accurately search for different program material and commercials recorded on one tape; pre-roll a tape to a specific program; or rewind a tape to a previous segment. The result, essentially, is random-access to the contents of a video tape, under full system control.

Additional system elements include a Printer (Figure 8) for automatic log preparation, and a video terminal (Figure 9) for checking the status of the system and for making manual entries -- such as correction or schedule changes -- as required.

The following block diagram (Figure 10), shows the various system elements as they are interconnected in the system:

1) The diskette with stored Program Schedule information;

2) Disk transport;

3) Computer and Model 6500 Micro-Controller;

4) The Model 40X Routing Switcher;

5) Machine Control Interface and the machine under control;

6) Logging Printer;

7) Video terminal, and, not yet mentioned;

8) An external master clock for synchronizing the system.

The second sub-system mentioned earlier was the Disc-Preparation System (Figure 11). This is called an "off-Line" system, since it does not directly control the switches or machines. The Disc-Preparation System allows composition of the program schedule away from the operating system. The primary product of the system is a diskette containing the Program Schedule arranged in a time-sequence fashion.

Let us now take a look at how the work will flow (Figure 12); how we make an advance preparation for this complex operation at MCTV.

Program coordinators prepare traffic cards from the Program Producer's inputs. These cards include program titles, producer identification and planned channel and broadcast date and time. These traffic cards are routed to the Tape Library where a multi-part traffic scheduling form is completed including such information as channel assignment, Program ID, Tape ID, date and time of play, and indication if duping or editing is required.

The traffic forms are sent to the equipment room with the tapes. Here the tapes are timed, having their control track counted. All timing is then recorded on the traffic form.

The form and tape are then returned to the Tape Library and one part of the form stays with the tape and all other parts go to the coordinator. (See Figure 13)

The coordinator now prepares a work sheet from the schedule traffic form. This work sheet includes fillers, commercials, channel ID's and PSA's.

Next, there is a daily conference including the Programming and Promotion Departments which includes:

a) Placement of all spots on all channels are discussed.

b) Requests for production of program highlights.

c) Reports from Promotion on new spots.

d) Audio announcements and request for fillers.

e) Last minute scheduling changes.

f) Crawls written for 6 channels: A, D, I, K, L, K, 12.

g) Review of Transmission Reports.

At the end of the conference, work sheets are distributed, spots or interludes are then edited, and this includes audio cartridges, commercials, program highlights and promotion. These can be produced on individual tapes or made up on "spot reels".

Next, the Transmission Supervisor receives the adjusted work sheets and completes the channel-by-channel work sheets indicating the tape deck assignments. He completes the information in the control column (manual, time, cue track, open, stop and rewind, etc.) The complete schedule then goes to the Scheduling Department where it is entered into the computer terminal and a disc prepared for a future programming day. The program schedule is entered at the video terminal channel-by-channel, in either a time sequence or random fashion. After the information is entered, the computer automatically sorts the data and prepares a time-sequence schedule. If scheduling errors are found, the computer will note these and present an "error listing" to the operator. The system software will automatically check the data entered for:

1) Open segments
2) Overlapping times, and
3) Duplication of programming

In addition, warnings are provided when

4) Manual control of the system is required.

The final result is a correctly prepared list of a day's programming stored on a floppy diskette which forms the input for the on-line automation system.

In addition to the program schedule diskette, the off-line system also provides four different printed reports. These reports are generated from the data entered into the computer by the operator during preparation of the program schedule. The four reports are:

1) Program schedule
2) Machine-tape status report
3) Channel-by-Channel Schedule report
4) Source-machine status report

A fifth printed report, the Program Log, is generated as a by-product of the on-line automation system.

These reports constitute an important set of information for the operating staff. They allow the staff to:

1) Plan and make scheduling changes to the daily program in advance.

2) Assign or re-assign machines as required.

3) Review the entire schedule at one time.

4) Review each individual channel schedule.

5) Monitor present and future machine assignments and machine availability.

6) They free the staff from the requirement of manually recording the program log.

To better understand the capability of the Automation System, let's review the printed reports. All reports are based on the same general format (Figure 14). All reports require a report title and a time display. There are ten (10) different columns across the report, and a total of 80 character spaces available. The column headings shown are:

Start - Indicates the start time of an event

DST - Channel destination of the event video output

Program - Description of the program material

Tape - Identification of the tape to be played

Source - Identification of source video and source audio

Duration - Length of the event

C-Track - The VTR control track number at which the material is located

SM - Stop mode of the source VTR or audio cart

TL - Tape loaded, for equipment from operator entry

C - Type of control - manual or timed.

Here is an example of the printed Program Schedule (Figure 15). The events shown are scheduled to occur between 7:00 p.m. and 7:29:30 p.m. Reading across line 1:

at 7 p.m., on Channel 10, audio interlude number 1, from tape #TJ01, will be played with video from source 13 and audio from source C3, for a duration of 15 seconds. The control column at the right indicates "T" for Timed control.

At 7:00:15 p.m., on the same Channel 10, the program "Music Is", video tape #6539, will play on source VTR 14 (both video and audio), for 28 minutes. The program starts at Control Track #001234. The instruction SRE means that at the end of the program the tape machine should stop (S), rewind (R), and eject (E) the tape.

Note that at 7:27:45 p.m. two events are occurring: one on channel C and another on channel D. The system will scan and implement the channel C event first, followed by the event for channel D. The time delay between the two "simultaneous" events is only a matter of one or two seconds maximum. Also note the commercial events at 7:13:30; 7:14:00; 7:14:30; 7:28:30; and 7:29:00 p.m. These events are always using video tape units 1111, 2222 and 3333. The commercials, in this instance, are recorded serially on these recorders and accessed in sequence via the control track number entered into the Program Schedule.

The Machine-Tape Status report (Figure 16) is for the convenience of the equipment room operator, to aid in loading tapes onto the proper machines. It's a slightly shorter report, containing only six columns rather than ten. From the event start time of 7:44:00 p.m., for example, the operator knows that he must have tape #2222 loaded into tape machine 26 before 7:44:00 p.m. or the event will not play. While keeping the machines loaded with the proper tapes is a manual task, the automation system helps by providing tape and machine loading information, and automatically controlling machine functions, simplifying the job as much as possible.

The Channel-by-Channel Schedule (Figure 17), is a display of events scheduled on a single channel for either the entire day, or from the requested time forward. The report allows an operator the ability to look at each channel's schedule for programming detail.

The Source-Machine Status report (Figure 18) presents a listing of sources -- machines, incoming feeds, local feeds, etc. -- arranged according to their destination. Presented this way, it makes it easy to see and verify the scheduled activity per source.

The final report, the Program Log (Figure 19), is a listing of events as they actually occurred. If an event did not take place at a scheduled time, the log will indicate the actual time it did occur. One thing the system cannot do, however, is verify if the tape actually loaded was correct. This error would have to be caught by the operator and so noted.

All this automation, logging, report printing and error correction is possible due to the use of computers, micro-processors and software. Indeed, the system software - or programming - is truly the crucial part of the system. The system described utilizes a PL/65 "high level" computer language for the 3M, Model 6500 micro-controller, and Basic/Fortran for the disk system. Standard data elements are designed for use throughout the system whether generating reports, controlling the switcher, processing disc information, or displaying system status. Because of these standard data elements the system can operate without the disc system using available memory in the 6500 micro-controller, or with the disc system which provides a larger schedule capacity. The software system consists of the programming building blocks as shown in Figure 20.

To start a day's Program Schedule, the Transmission Room operator places the proper Program Schedule diskette into the Automation System Disc Transport and types "START" at the terminal (Figure 21). The system then proceeds to operate on the Program Schedule diskette information, and provides the required automated switching and remote machine control.

Video terminals are located in both the Transmission Room and the Equipment Room. The Equipment Room operator is responsible for manually loading the proper tapes on the proper machines. When loaded, the Equipment Room operator types in the tape number at the Equipment Room terminal followed by the word "loaded". This data is forwarded to the computer, which inserts it into the schedule for proper logging. If a machine is out of service, the Equipment Room operator manually re-assigns machines using the terminal. The Equipment Room terminal is restricted to making tape-loaded comments and machine re-assignments.

The Transmission Room operator has more complete control over the system, and can initiate Program Schedule changes in addition to machine re-assignments, and can also take manual control over a timed event if required. The Program Log is printed out in the Transmission Room, at the printer terminal.

The facility is under construction. The equipment checkout starts this week. Full air conditioning will be ready in two more weeks. We are planning to cut over to partial automation the first week of July and we are planning to have the complete system, as has been described here, in operation this Fall.

CABLE ALARM SYSTEM ECONOMICS

Clifford B. Schrock
CableBus Systems Corp.
Beaverton, Oregon

ABSTRACT

How many subscribers does a cable operator need in order to profit from alarms? What should he charge? How much will he make? The author uses a computer to examine an economic model of a cable system alarm operation. He presents analyses for potential alarm operations on cable systems in four cities.

INTRODUCTION

There are many ways cable operators can make money with alarms. There are also a few ways they can find themselves in Chapter eleven.

At CableBus, we decided to design an economic model of cable alarm systems so we could use a computer to see where the rewards and pitfalls of cable alarms lay. In general, we found that:

1. The larger the system, the better.
2. Two-way rebuild can be a big hidden burden.
3. Joint ventures with established alarm companies can be attractive in some cases.
4. Adding two-way services beyond alarms increases profits.

COMPUTERS

We used two computers in developing the model. We started out using one of the fast, powerful DEC machines that we otherwise use for developing applications programs for alarms and other services. Then, for the NCTA Dallas show, we transferred the model to a desktop Hewlett-Packard machine so that we can run system models for show goers at our booth or around the convention.

THE ECONOMIC MODEL

The model is very conservative. Whenever there was a choice, we picked the numbers that would show the lower returns. We wanted a sound financial decision-making tool, not a marketing gimmick. This is a list of the factors the model takes into account:

- Monthly Fee
- Homes Passed
- Penetration
- 2-Way Upgrade
- Headend Cost
- Headend Service Contract
- Home Terminal Cost
- Home Terminal Installation
- Liability Insurance
- Customer Service
- Billing and Collection
- Alarm Monitoring

Figure 1 (Assumptions) gives details. There are some points for further explanation:

1. Our standard CableBus Headend package includes a DEC LSI-11 computer package that costs $42,000. At this show, we expect to introduce a low-cost $7,900 poller for systems with fewer than 500 alarm customers. This is why we put in a price break at that figure.

2. Monitoring alarms costs a lot of money. If it costs you $12 per hour including burden to have someone constantly monitoring alarms, then it costs you $8640 for a 30-day month of 24-hour days. To have an established alarm company monitor for you will cost $8-10 per customer per month. That's what we've found in Portland and that's why we have the model cable company take over its own monitoring after it has 900 alarm customers.

3. The system maintenance burden of $2.50 per customer per month includes a once-a-year checkout of each alarm customer's home alarm

FIXED COSTS

First Month:

HEADEND INSTALLATION

Alarm Customers	0-500	500-2500	2500-5000	5000-7500	7500-10,000
Headend Modem(s)	$950	950	1900	2850	3800
Poller(<500 cust)	7900	-	-	-	-
Computer System	-	42,000	42,000	42,000	42,000
Totals	$8850	42,950	43,900	44,850	45,800

UPGRADE TO 2-WAY (IF REQUIRED)

$700 for each 100 homes passed.

LIABILITY INSURANCE

$1500 initial payment (becomes a variable cost)

Monthly:

POLLER/COMPUTER MAINTENANCE CONTRACT AND MONITORING

Alarm Customers	0-500	500-900	900-10,000
Maint. Contract	$40	150	150
Monitoring	[1]	[1]	8640 [2]

[1] This is a variable cost.

[2] 24-Hour/Day monitoring @ 12.00/Hour

Figure 1. Assumptions used in the computer economic model.

VARIABLE COSTS

Monthly:

PER ALARM CUSTOMER INSTALLED LAST MONTH

Alarm Customers	1-99	100-500	500-1000	1000-plus
CableBus Home Term.	$285	259	222.25	186.44
Installation	30	30	30	30
Sub-totals	$315	289	252.25	216.44

PER ALARM CUSTOMER ON SYSTEM

Monitoring Fee (Paid to Alarm Co.)	[3]	$10	10	[4]
System Maintenance	2.50	2.50	2.50	2.50
Billing/Collection	.20	.20	.20	.20
Liability Insurance	[5]	[5]	[5]	[5]

[3] Fewer than 100 alarm customers should be set up so that alarms are reported directly to a police dispatcher.

[4] More than 900 alarm customers can more profitably be monitored in-house by the cable company at a fixed cost of $8640 per month.

[5] 1.5 percent of last month's gross income.

BUILD RATES:

INSTALLATIONS COMPLETED PER MONTH

Alarm Customers		10-100	1000-2000	2000+
Month	1	0	0	0
	2	10	20	20
	3	20	40	40
	4	30	60	60
	5	40	80	80
	6	50	100	100
	7	50	100	200
	.	50	100	200
	.	50	100	200
	.	50	100	200
	etc.			

UP TO MAXIMUM PENETRATION

4. Selling alarm systems is considered to be a separate business which the cable company can treat as a profit-making venture or as a loss leader. According to reports in Paul Kagan's cable security newsletter, in new franchise applications, the MSO's are doing both. They have one or two tiers of service involving pushbuttons and smoke detectors that are loss leaders plus a third tier involving perimeter security that is a money maker.

BASIS FOR EVALUATION

The computer model produces monthly cashflow figures for two cases: pay-as-you-go and a bank loan. The bank loan incorporates an interest rate entered along with the other data. It assumes a line of credit is available and that money is not borrowed before it is required. The entire loan is paid back 5 years after the project start date. To evaluate the investment, financial people usually consider the pay-as-you-go cashflows. There are four figures of interest:

1. PAYBACK--How long before the investment starts making money. We sum the positive and negative cashflows and when the result turns positive, you have payback. An investment that starts making money after 24 months is much better than one that's still in the red at that time.

2. IRR (Internal Rate of Return)--Some refer to this as a discounted cashflow analysis. A few MBA's may be horrified at this layman's definition: IRR is the percent interest that a bank would have to pay you to match the investment represented by the cashflows.

3. NPV (Net Present Value)--This involves the same kind of discounting on cashflows as IRR, but it gives you a dollar value, rather than a percentage. Here's another layman's definition to dismay the MBA's: NPV asks you to select a percent return you can expect on your investment. It then tells you how much more (or less) money you'd be making given the cashflows you're talking about compared to that percent return you selected. To keep our analysis conservative, we always assumed you could get 20 percent from some other investment and then compared your cable alarm system to that.

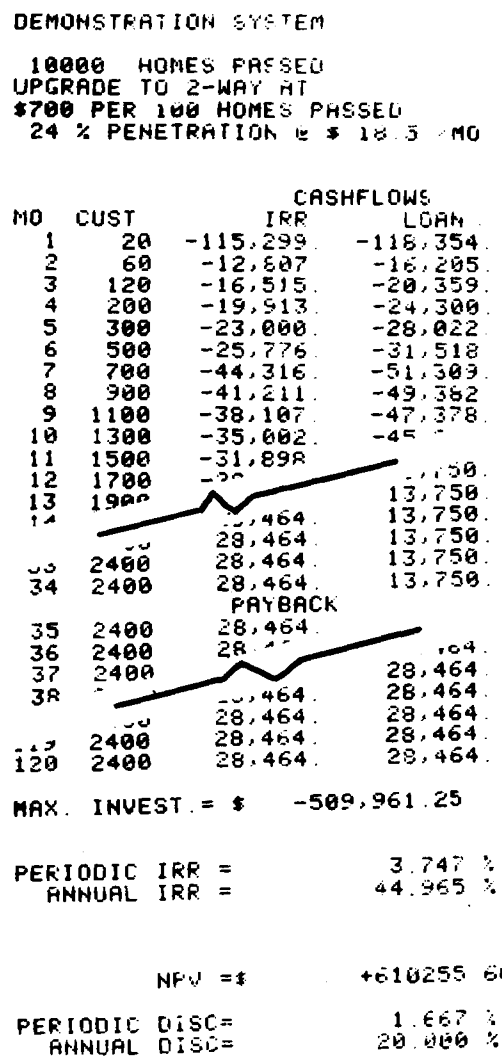
4. MAXIMUM INVESTMENT--Some people like the straightforward approach. "How much is it going to cost?" This figure is simply the sum of all the negative cashflows.

Part of today's realities is the interest that you have to pay for the bank's money. That's why we included the cashflows for a bank loan. If the IRR calculated over ten years is close to the bank's loan rate, you may find that you have negative cashflows

RESULTS

On the H-P computer, the economic model produces a printout such as the one in Figure 2. Here's what that print-out tells us:

- 10,000 homes passed
- Upgrade to 2-way
- $18.50 monthly monitoring fee
- 24 percent penetration
- Payback in 35 months
- 44.9 percent IRR
- $610,255 Net Present Value compared to a 20 percent investment
- $509,962 total investment


DEMONSTRATION SYSTEM

10000 HOMES PASSED
UPGRADE TO 2-WAY AT
$700 PER 100 HOMES PASSED
24 % PENETRATION @ $ 18.5 /MO

MO	CUST	CASHFLOWS IRR	LOAN
1	20	-115,299.	-118,354.
2	60	-12,607	-16,205.
3	120	-16,515.	-20,359.
4	200	-19,913.	-24,300.
5	300	-23,000.	-28,022.
6	500	-25,776.	-31,518.
7	700	-44,316.	-51,309.
8	900	-41,211.	-49,362.
9	1100	-38,107.	-47,378.
10	1300	-35,002.	[illegible]
11	1500	-31,898	[illegible]
12	1700	[illegible]	[illegible],750.
13	[illegible]	[illegible]	13,750.
[illegible]	[illegible]	[illegible],464.	13,750.
[illegible]	[illegible]	28,464.	13,750.
[illegible]	2400	28,464.	13,750.
34	2400	28,464.	13,750.
		PAYBACK	
35	2400	28,464.	[illegible]
36	2400	[illegible]	[illegible]
37	2400	[illegible]	28,464.
38	[illegible]	[illegible],464.	28,464.
[illegible]	[illegible]	28,464.	28,464.
[illegible]	2400	28,464.	28,464.
120	2400	28,464.	28,464.

MAX. INVEST. = $ -509,961.25

PERIODIC IRR = 3.747 %
ANNUAL IRR = 44.965 %

NPV =$ +610255 60

PERIODIC DISC= 1.667 %
ANNUAL DISC= 20.000 %

Figure 2. Sample printout from the model.

SYSTEM: Lake Oswego, Oregon 1865 Homes

PERCENT PENETRATION	INCLUDE 2-WAY UPGRADE?	PAYBACK (MOS.)	IRR (%)	NPV @ 20% ($)	MAX. INVEST ($)	LOAN CASHFLOW (+ OR -)
10	YES	66	14.5	-	72,843	-
10	NO	56	20.1	191	59,543	-
26	YES	57	20.8	4,117	141,514	-
26	NO	53	23.8	17,417	128,214	-
30	YES	62	17.7	-	173,960	-
30	NO	58	19.9	-	160,660	-

SYSTEM: Palos Verdes/Rolling Hills, Cal. 8900 Homes

PERCENT PENETRATION	INCLUDE 2-WAY UPGRADE?	PAYBACK (MOS.)	IRR (%)	NPV @ 20% ($)	MAX. INVEST ($)	LOAN CASHFLOW (+ OR -)
05	YES	74	12.1	-	183,430	-
05	NO	53	23.6	15,291	120,429	-
10	YES	67	15.9	-	269,359	-
10	NO	57	22.9	22,926	206,359	-
15	YES	43	32.1	189,777	358,611	+
15	NO	39	38.9	252,777	295,611	+

SYSTEM: Corvallis, Oregon 20,210 Homes

PERCENT PENETRATION	INCLUDE 2-WAY UPGRADE?	PAYBACK (MOS.)	IRR (%)	NPV @ 20% ($)	MAX. INVEST ($)	LOAN CASHFLOW (+ OR -)
05	YES	63	16.4	-	407,630	-
05	NO	46	28.6	89,285	265,530	+
10	YES	42	36.8	421,133	460,539	+
10	NO	36	49.7	563,233	318,439	+
15	YES	41	44.0	799,126	461,489	+
15	NO	38	56.3	941,225	319,389	+

SYSTEM: Portland, Oregon 385,000 Homes

PERCENT PENETRATION	INCLUDE 2-WAY UPGRADE?	PAYBACK (MOS.)	IRR (%)	NPV @ 20% ($)	MAX. INVEST ($)	LOAN CASHFLOW (+ OR -)
1.5	YES	65	16.6	-	3,141,150	+
1.5	NO	35	70.9	2,196,445	445,499	+
3	YES	63	24.3	857,805	3,143,050	+
3	NO	36	74.0	3,553,505	447,350	+
6	YES	63	26.2	1,402,323	3,147,800	+
6	NO	36	73.9	4,098,023	452,100	+

Figure 3. Summary of results from models of alarm systems in 4 cities.

REAL SYSTEMS

We applied the model to a range of cable alarm systems. For this paper we decided to analyze four real-life cable systems, representing a range of sizes. We picked three in Oregon and a fourth in California. The data on system size is from CABLEFILE/80, except for the hypothetical Portland system. We used the 1970 census figures for that. The same monthly fee, $19.95, was used in all cases. Figure 3 summarizes the results we obtained. Let's analyze those results.

Lake Oswego is a small system in a wealthy community. We used high penetration figures. in a 2000 home system, 20 sales represents one percent, and wealthy people are more apt to buy security.

It looks like 26 percent penetration makes you more money than does 30 percent. That's because the model has a break point at 500 customers. Beyond that, the model has you buying the full-scale computer system. But the real life people at CableBus are more flexible than the computer. If it's a matter of a couple of hundred alarm customers beyond 500, we'll work with you to keep you in the low-cost price range.

Palos Verdes is another wealthy community, but the system there is much bigger, so we held penetrations down. The results show a better than 30 percent rate of return with a 15 percent penetration. That includes charging the entire cost of two-way upgrade to the alarm system.

Corvallis, a university town with a light industrial base, shows better than 35 percent rate of return with only 10 percent penetration.

And Portland, a major metropolis, returns better than 20 percent with just 3 percent penetration.

VARIATIONS

There are some intriguing possibilities beyond the computer model. One is the prospect of joint ventures between cable operators and established alarm companies. In talking to alarm companies, we've noticed that the smaller, more agressive companies are more interested in discussing joint ventures than are their larger competitors. If you get involved in a joint venture, you'll want to deal with someone who's not afraid of new ideas because the mass marketing required for cable alarms is a long way from the custom one-at-a-time approach the alarm companies are used to.

We've seen two joint venture possibilities. In one, the alarm operator owns the system and leases the cable. He pays the cable operator 3 to 4 dollars per month per alarm customer. It's a nice arrangement if the cable operator just doesn't want to be bothered with the alarm business.

In the other possibility, the cable operator owns the system and pays the alarm monitoring company for monitoring. The more progressive alarm companies we've talked to say they want 8 to 10 dollars per customer per month for monitoring, but that they might negotiate that figure down if there were large blocks of customers that required fire alarm monitoring only. The alarm companies say that the false alarm rate is much lower with fire alarms than it is with burglar alarms.

Another appealing possibility is adding more two-way services on top of alarms. With the computer already in place at the headend and the most expensive part of the home terminals already installed, it's relatively economical to add utility meter reading or power load shedding to the system.

CONCLUSIONS

Large metropolitan cable operators can almost certainly profit from alarms. Operators of smaller systems must look more carefully before they decide. There are potential economies in joint ventures with alarm companies and in selection of equipment. But there are cases where alarms will lose money, and no operator should enter the business without carefully examining his unique position.

CABLE AUDIO SERVICES --- THE (HI-FI) SKY'S THE LIMIT

Ned Mountain

UA-Columbia Cablevision, Inc
San Angelo, Texas

The time has come to re-examine the potential and impact of audio services within the cable television industry. This paper comments on several marketing and technical aspects of implementing quality service. A unique blend of technology, public demand for diversification, and new program services is rapidly coming together that will allow creative operators to develop an exciting audio product for their subscribers.

INTRODUCTION

Cable television is a dynamic, expanding business with unlimited potential. Much current thinking is directed toward taking the "television" out of the term and looking at the ultimate blue sky potential of the "cable". At this point in the growth of our industry, it is a good idea to examine all potential sources of revenue that our broadband networks will generate in the future. It is being demonstrated daily that the public's thirst for entertainment alternatives in the home is vast and underestimated. It is my contention that the demand applies to audio as well as video.

VIDEO AND AUDIO DEVELOPMENT

For the sake of comparison, let's look separately at the development of two types of electronic home entertainment services; video and audio. Electronic video services started with commercial television in the early 1940's. Obviously, the needs of the public could not be met with just one video channel; thus evolved the networks, independents and public broadcasters. Cable television came along early in the life of broadcast video first as a means to extend the broadcast range to new geographic locations and in recent times, as we all know, to expand the programming varieties to beyond those which could be broadcast in a particular area due to spectrum shortages. An additional source of video entertainment service is rapidly emerging in the form of home video recording and playback equipment. The concensus seems to be that all 3 forms of video sources will continue to exist, compete, and to various extents compliment each other.

The development of aural entertainment service can be looked at in a similar analogy. The same 3 forms of consumption exist; broadcast, cable, and home audio recording/playback, but they evolved in slightly different order. First to be developed was the phonograph in 1877. Next, commercial radio broadcasting began in 1920. These two forms of audio entertainment make up the bulk of today's available sources. Both industries continue to grow, flourish and compliment each other. The third item to be considered is audio services via cable. It is my opinion that the area is being left behind in our industries "blue sky" thinking.

TECHNICAL CONSIDERATIONS

It is possible to add a multi-channel FM audio service in just about any well designed CATV system provided that good engineering practices are used. The spectrum from 88 to 108 MHz is generally available for FM services with the FCC subdividing this 20 MHz of spectrum into 100 channels each of which is 200 Khz wide. Over the air channel assignments are never made on adjacent channels in the same area and the same should be the rule when planning the cable FM spectrum. If a minimum adjacent channel spacing of 400 Khz is used, a maximum of 50 cable FM channel slots will be available. Local FM broadcast signals should be translated to a new frequency preferably 400 Khz removed from the assigned off-air frequency. This is done to avoid multi-path problems and results in a clean feed of local FM stations at predictable levels. A word of caution: Be sure to use only FCC channel assignments for cable FM as many of the new digital tuners will tune <u>only</u> these frequencies. It should be obvious that any serious FM service will require the use of FM head-end processing so that level uniformity and control can be maintained by the cable operator.

Speaking of levels, FM carriers can be run at a much lower level on the system, typically 15db below video carrier. The main reason is that the only portion of the signal that is overly sensitive to high carrier to noise ratio is the stereo sub-carrier. Since this sub-carrier occupies only 30 Khz of spectrum, the system noise present in this slot is at least 20db lower than that present in the 4 MHz video spectrum. The net effect is that -15db levels will generally produce stereo signal to noise ratios of 50db or greater.

The effect of adding even 50 FM carriers to a system carrying 35 TV channels is insignificant. The net increase in amplifier level would be less than .2db. Since all FM carriers are at least 15 db down from video, resultant distortion products will be insignificant and random. Essentially a well designed CATV distribution will be transparent to the FM signals and video operation will not be affected.

Since FCC rules do not exist for cable FM, it is in the operator's best interests to define his own performance standards. The objective should be to provide the subscribers with stereo signals free of whistles, beats and other noises. For off-air sources, the commercially available heterodyne processors will provide excellent quality. FM signals imported via microwave sub-carriers (be it terrestrial or satellite), however, deserve special attention. A general rule of thumb would be that if the microwave system is single hop or multi-hop with no demod - mod process at intermediate points, than standard heterodyne processing with 75 Khz deviation will probably provide excellent results. If the signal must go through more than one demod - mod process, then methods other than standard heterodyne processing may be required for satisfactory stereo operation free of beats and noise. This is due to inherent nonlinearities in the FM detection which causes a beating of horizontal sync multiples with the 38 Khz stereo sub-carrier frequency. This shows up as distinct annoying audible notes in the stereo audio. The beat frequencies are derived as follows:

3 (15734) - 38000 = 9202 HZ Audible Beat

38000 - 2 (15734) = 6532 HZ Audible Beat

Satellite delivered FM stereo is relatively new and more work remains to be done to maximize quality while minimizing bandwidth. Methods do exist to transmit excellent quality FM stereo via satellite while keeping the hardware cost to the cable operator reasonable. The Leaming system of enhanced multiplex transmission was chosen by United Video for transmitting the signal of WFMT-FM, generally regarded as one of the highest technical quality FM stations in the country. Actual proof of performance data verifies that this method is probably the best available with today's state of the art.[1]

To summarize the technical considerations, do not leave them to chance! Individually process the FM sources and pay close attention to transmission methods for imported sources. Quality must be of paramount importance when considering audio service.

THE (HI-FI) SKY'S THE LIMIT

Nobody needs to tell us about the television programming variety available to today's cable operator. Local off-air, imported off-air (with restrictions), satellite non-broadcast, and local origination sources are combined in a programming "blend" tailored for maximum acceptance by our subscribers.

If the same type of creative thinking were to be channeled toward tailoring an audio service for our subscribers, what would the result be?

The first question I get asked when proposing this concept is "Why Bother?? It isn't worth the effort." Let's take a look at why aural service may well be worth the effort:

1. There are no rules or restrictions with regard to aural service. We are free to develop these services with the sole objective of fulfilling subscribers desires.

2. No technical requirements exist for aural services. While the majority of such services will employ standard FM broadcast and multiplexing techniques, the door is wide open for technical innovation.

3. The radio broadcast industry is healthy! As of April 1980 there were 8748 radio stations on the air in the United States.(2) Radio advertising revenues showed a 12% increase in 1978 over the previous year. The average U.S. household now has at least 5 radios. Of the total number of radio stations now on the air, approximately 31% began operation during the past decade.[3] The above trends are indicative of a communications media that is alive, well and growing in spite of the "video revolution".

Figure 1 illustrates the fact that in 1979 Americans spent a total of 9.8 billion dollars on three interrelated audio sources; radio sets, HI-FI phonographs and records.[4]

EXPENDITURES ON LEISURE TIME PRODUCTS (1979)

Radio Sets	$3.5 billion
Hi-Fi Phonographs	$3.3 billion
Records	$3.0 billion
General Interest Books	$3.0 billion
Movies	$2.65 billion
All Spectator Sports	$2.3 billion
Musical Instruments	$2.1 billion
Film Developing	$2.0 billion

FIG. 1 Audio Entertainment Is Big Business!

Let's take a look at what types of aural services could be provided as part of a cable entertainment package and the reasons for considering them.

At this point in time, our prime source of audio service will be derived from local off-air and imported off-air FM radio stations. It should be realized that FM radio is growing at a remarkable pace both in quantity and quality. 48% of the radio stations on the air today are FM. People other than "stereo nuts" actually listen to FM radio. In fact, FM now commands approximately 51% of the total radio audience.[5] Current construction permits exist for 366 new radio stations; 75% of these will be FM. Figure 2 compares the growth of broadcast TV, AM and FM from 1946 to 1981.

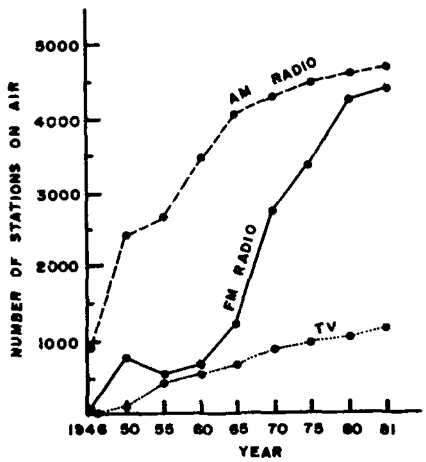


FIG. 2 GROWTH COMPARISON FOR U.S. AM, FM, AND TV BROADCAST STATIONS. AUDIO IS ALIVE AND WELL!

In September, 1979, United Video began providing the signals of WFMT-FM in Chicago as a sub-carrier to their WGN-TV feed on transponder 3. This first radio "superstation" fulfills a need in many markets that have no outlet for consistent high quality fine arts broadcasts. There are currently 500,000 actual or committed cable subscribers capable of receiving the station. WFMT has just received a major industry award as "Best FM Station Of The Year", and generally is regarded as being on the leading edge of technology.

An interesting opportunity for cable radio has been created by the FCC's recent approval of the Magnavox AM stereo system. AM stations will now be jumping on the stereo bandwagon. In fact, many have already purchased and installed stereo production equipment in anticipation of this move. As a result, the public will become even more "stereo conscious" but will probably be reluctant to rush out and buy new radios just to receive the AM stereo signals. This is a golden opportunity for cable systems to acquaint subscribers with the "new sound" from their favorite AM station by taking stereo feed from the radio station and providing a high quality FM stereo signal for home use.

Local origination possibilities for cable FM provide an outlet for economically sound creativity. Covering events such as council meetings, athletic events, etc. can be done with audio for very little capital outlay. Local educational institutions can program aural service for a fraction of the cost of video.

The Catel Corporation has mentioned other audio service possibilities in their literature from time to time. Services such as WWV (accurate time), NOAA weather, synthesized stereo TV sound, and foreign short wave broadcast signals can easily and economically be provided in the FM band. The "product mix" can be tailored to the social and ethnic background of the subscribers base.

There will also be many future aural services available via satellite. In addition to WFMT-FM, at least 7 audio entertainment sub-carriers are or will be available on Satcom I. National Public Radio is currently developing an ambitious program of supplying at least 20 audio entertainment channels via Westar. While primarily aimed at providing PBS radio stations with high quality programming, PBS is interested in working with cable operators to provide outlets for additional aural services aimed at the home market.

SOME GRASS ROOTS MARKETING

Very little has been written regarding actual FM service success within the cable industry. There are, however, many indications that seem to verify the viability of the concept. The public will become even more stereo conscience with the big push for AM stereo and renewed interest has been expressed in stereo audio for broadcast TV. At the recent National Association of Broadcasters convention, NEC America, Inc. described a new UHF TV exciter with stereo audio.

The few examples which relate directly to the cable industry are encouraging. Mr. Neal McLain, in a recent paper[6] indicated that with a well planned and marketed aural service package including 29 signals in the FM band a 16% actual FM penetration was realized. Gill Cable in San Jose is realizing a 27% FM penetration. 12,500 new second outlets were ordered within a few months of initiation their audio service, which includes FM radio, unique radio service broadcasts, and synthesized stereo pay TV audio.[7] UA-Columbia's San Antonio system has approximately 34% of the subscribers to date electing to connect their FM receivers to the cable in spite of the fact that no unique audio services are being offered other than imported broadcast FM.[8]

A recent chain of events in San Angelo, Texas seem to verify my claim that audio services are marketable. The off-air market in San Angelo consists of 4 AM's and 3 FM's with 43% playing country and western music. Prior to September 1979, 5 imported FM's were available on the cable offering additional variety. Beginning in September 1979, a Dallas rock station (KZEW) was added to the San Angelo cable system. Curiousity prompted me to contact several local stereo shops to see if this addition has any impact on their operations. Comments and observations with respect to that little survey were as follows:

1. Since KZEW went on the cable, sale of splitters and RG59 have increased at an unprecedented rate. One store that had not sold 50 splitters in 4 years now orders and sells 50 splitters and 1000 ft. RG59 per month.

2. Shop owners estimate that at least 80% of the stereo receivers they sell are connected to the cable. With at least 2000 units per year (all with 300 Ohm antenna terminals!) being sold in San Angelo, the cable FM market appears significant.

3. The number of KZEW car bumper stickers in San Angelo is amazing. There is no way the people can get the signal by any means other than cable.

PAY RADIO???

As you can probably tell by now, I am sold on the concept that audio is a significant force in today's consumer entertainment portfolio. The time is right for the cable industry to provide a quality product at a reasonable price. UA-Columbia is studying the idea of providing a premium "protected" audio service --- pay audio! Yes that's right --- pay!! The proper blend of market forces and technology exists today to make an "audio tier" a profitable venture. Both positive and negative means of security are under investigation and such a service will be implemented for the purposes of evaluation.

SOME CLOSING "HI-FI SKY" REMARKS

Within the field of audio services you will find a variety of tastes and interests as broad as the span of human interests. You will find several groups of people intensly loyal to (and willing to pay for) one format or another as well as people who listen to a little bit of everything. The point is that by offering an audio service that contains a product mix tailored to the subscriber base, the cable operator can capture a major portion of the total home audio market.

Some "Hi-Fi Sky" predictions that I personally believe will happen during the next 5 years are:

...AM stereo will grow, making the public more stereo conscience. Since AM stereo cannot match FM stereo's overall quality, the result will be even more popularity for FM.

...quad audio will continue to flounder until the industry adopts technical standards.

...the present undercurrent involving better TV audio will result in broadcast stereo TV audio becoming fact. This will be a higher priority than quad audio.

...FM audio via cable will become a healthy profitable part of the cable entertainment service. New satellite services will help cable operators create unique audio packages unavailable to the non-cable subscriber.

...digital audio techniques, just beginning as a commercial venture, will continue to increase the public's demand for quality sound. By 1985, totally digital audio equipment will be appearing in the home.

In summary, take a good look at your radio -- let your imagination go to work --- maybe then you will see the picture better.

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(4) "The Changing Game", BM/E Magazine, February, 1980, p. 44

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(7) "CAFM Yields More Subscribers, Increase Revenues", Catelgram, Vol. 5, 1980, p. 1

(8) UA-Columbia Provides A Free FM Tap In San Antonio If The Radio Is Within 10 Feet Of The TV Set.

CABLE SERVICE: A DATA DISTRIBUTION LINK

THOMAS G. ALBRIGHT

PRINTER TERMINAL COMMUNICATIONS CORPORATION

ABSTRACT: The following paper describes a potentially high profit business for well managed, forward looking cable companies.

There now exists a complete turn key data distribution system that can be simply added to existing cable operations. It requires no additional bandwidth as it can be added as a subcarrier to FM broadcast stations. It can show a substantial profit to the operator as it has the ability to deliver information to customers in a "broadcast" mode. This not only reduces distribution costs, but also allows simultaneous reception of information by a large number of users. This is a highly valuable feature for users of the system that have "time fragile" information (such as price changes) and want it sent to a relatively large number of recipients.

Dubbed LADD for "Local Area Data Distribution", the system is a viable alternative to dial up or leased phone lines for customers with multiple terminals and time fragile information.

The Information Processing Industry now has available a new link-technology between information and the information user. The new link is the local cable service operator. The technology is existing digital modulation/demodulation techniques to achieve digital transmission.[1]

"For the purpose of discussion, we will refer to this new link-technology as LADD (Local Area Data Distribution). LADD . . . is not a data communications network in itself, but a system element. As a system element, it is available for use by all data communications network operators who find it useful.

"One of the beneficial qualities of Ladd is that it is not a leading edge technology which needs refining to be reliable, predictable, and cost effective. Rather, it is simply the union . . ." of existing local cable distribution techniques with digital modulation-demodulation (Modem) techniques to achieve digital transmission. ". . . One of the difficulties in relating LADD to other data communications technologies is the lack of basic data communications research experience in the LADD service frequency range and bandwidth.

". . . The LADD system's configuration, as illustrated in figure 1, includes several components:

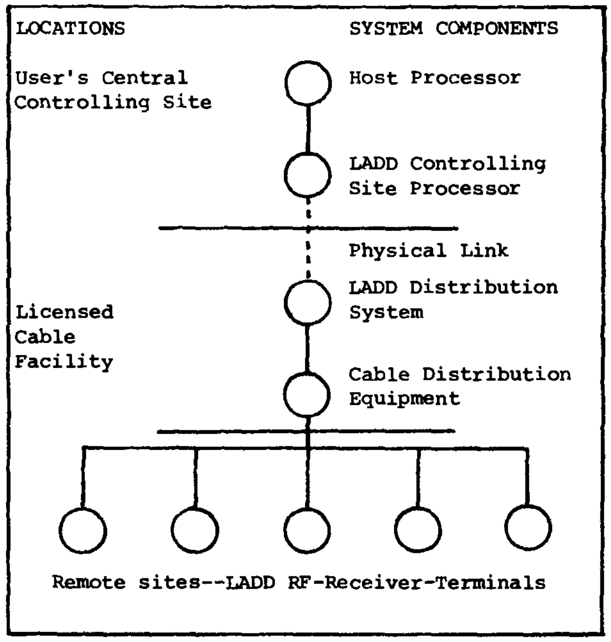

Figure 1 - LADD System Components

"The physical link to the data communications network which is utilizing LADD as a systems element: this link connects the controlling site processor within the network . . ." to the LADD Distribution System. ". . . Normally this link is a conditioned leased line utilizing BSC protocol. More sophisticated means of implementing error detection and correction on this link are possible and compatible with LADD configuration. The capability of a dial back-up of this physical link is built in to the LADD system to improve systems reliability."

The controlling site processor is the gateway from the user's network for data messages that are to be distributed. It regulates the flow of addressed data messages received over the physical link according to user priorities to the LADD transmission system.

The controlling site system, therefore, acts as a store-and-forward device at the customer location. Upon requests from the LADD transmission system it will send data to the LADD unit for distribution via the cable network.

The LADD Transmission System exists at the cable operator's facility. It is linked to the data communications network controlling site processor via the physical link. The LADD Transmission System provides a regulated signal to the cable operator to be injected into the RF transmission stream.

The functions of the Transmission System are:

" - Maintain the physical link protocol to the controlling site processor."

- Provide the transmission signal of data messages which includes encapsulation of data messages according to LADD protocol (see Figure 2--LADD Transmitted Data Organization); multiplexing messages for optimum use of the transmission channel; and modulation of messages to comply with cable service requirements.

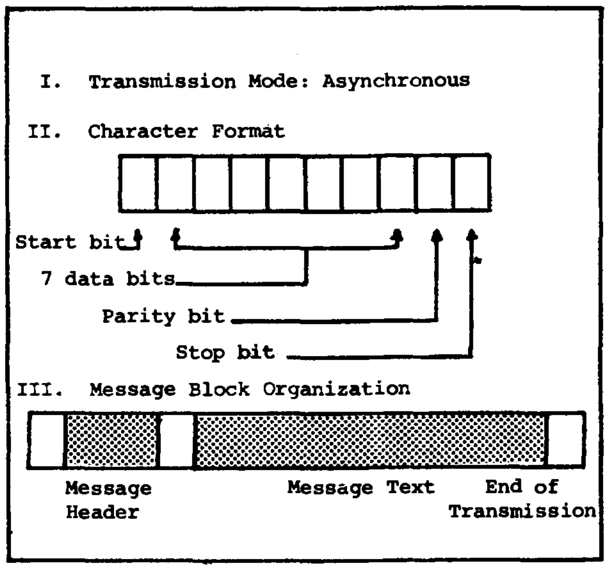

Figure 2 - LADD Transmitted Data Organization

" - Provide selective data message special handling capabilities. Data messages from the controlling site may be 'tagged' to indicate such special handling as encryption, forward error correction (FED), and time and date stamping.

"- Collect accounting data on the utilization of LADD."

- Provide feedback to the controlling site on the status of the LADD Transmission System.

The licensed cable service operator simply accepts the signal from the LADD Transmission System, injects the signal into the transmission stream, and distributes the signal as part of his normal operations.

The LADD RF-Receiver-Terminal is the final component handling the flow of data messages within LADD. The RF-Receiver receives the RF signal and delivers it to the Receiver. The Receiver, upon receiving the RF signal from the cable, demodulates the RF signal to a digital and demultiplexes the signal, preserving only the data message sent to its related Terminal. In addition the Receiver performs necessary receiving-end functions required by selective special data message handling. The Terminal disposes of the digital signal in accordance with the wishes of the user.

The distribution capabilities of the licensed cable service operator are "key elements in the physical organization of LADD with respect to determining applications capabilities. . ." The three major applications-related factors are:

The channel bandwidth authorized for data. This is the maximum allowable bandwidth dedicated for data transmission.

Transmission mode. ". . . The two available modes are broadcast and point-to-point. The difference between broadcast and point-to-point mode is contrasted in Davis et al[2] when introducing Packet Broadcast Systems. The LADD RF data channel inherently has broadcast mode capabilities" as a result of the cable services medium. ". . . Point-to-point mode communications are a result of the channel protocol's ability to selectively address individual terminals. Even when broadcast mode is inherent and point-to-point mode is enabled by channel protocol, the ability to use one mode or the other, within the law, is . . ." a question of regulation.

The normal reception range of the Transmission Service. A LADD message transmitted via cable is only limited by the amount of cable and access to it. Before selling a system, adequate attention must be given to the cable coverage provided or contemplated to assure that the customer's requirements can be met.

". . . It is well at this point to summarize what LADD is, and what it is not.

"LADD is not leading edge technology but is a practical union of RF communication and Data Modem techniques. It is a data communications system but is not a data communications network. It requires no FCC license for the user because transmission capability can be purchased" from cable service operators. ". . . It requires a controlling site processor in order to interface with a data communications network." It can distribute information ". . . in broadcast mode as well as point-to point mode. It is one-way in operation with outbound transmissions. . . .It has primarily voice-grade (300-9600 baud) net transfer rate capabilities.

"With the LADD system described, one has only to review a few trends and events of the 1970's in the areas of Information Processing in order to appreciate how such a capability could fit into data communications network designs.

"New service competitors of Bell System services have emerged and are focusing on the data communications market.

" - Leased Line Services face lower priced competition in all grades: sub-voices, voice, and wideband.

" - Hybrid Services have no significant new competition.

"The Bell System changed from a uniform rate structure (pre-1974) to a Hi-Lo density rate structure (mid-1974 to mid-1976), and then to MPL rate structure, resulting in sharp decreases in long haul rates and sharp increases in short haul rates.[3]

"Decreasing computer prices have stimulated growth in the number of computer sites, especially for mini-computers.

"The microprocessor has become a standard element in most terminal equipment, giving terminals computational capability.

"The demand for data communications, hardware, staff, and services continues to grow at a high rate.

"In summary, more installed computing capability, increasingly dispersed computing capability, and improved Leased Line long haul pricing rates have created a need[4] for local (short haul) data distribution. While LADD cannot satisfy all of this need because of its specific capabilities, it can help satisfy some of it.

"Analysis of the LADD capabilities measured against the general attributes of remote terminals and message traffic within a data communications network yields a means of measuring applicability. Attributes which, when analyzed, measure the applicability of LADD as a system element of data communications networks. . ." are shown in Tables I and II.

"Another way to estimate the applicability of LADD is to analyze it relative to data communications network design constraints. A point by point review produces a general view of LADD specific enough to determine if the technology can be beneficially added to an existing data communications network. The following paragraphs are just such a review based on the design constraints identified in Doll[5] regarding network design preliminary information:

Application Attribute	Application More Desirable	Application Less Desirable
Number	many	few
Throughput	high	low
Movements and changes	frequent	infrequent
Installation Delay Tolerance	must be within a few days	can sustain 6 weeks, 8 weeks, or longer

REMOTE TERMINALS ATTRIBUTES

TABLE I

Application Attribute	Application More Desirable	Application Less Desirable
Volume	high	low
Proportion common to multiple remote terminals	high (broadcast mode) low (point-to-point mode needed)	
Patterns of flow	erratic	predictable
Maximum instantaneous bandwidth required	less than 4800 baud	greater than 4800 baud
Priority levels	many	few
Immediat delivery	required for some of the volume	not required
Delivery within 24 hours	required (or tolerable) for some of the volume	not required (or tolerable)
Security (encryption)	required on a selective message basis	not required
Transmission error detection	not required	required
Transmission error detection and correction (FEC)	not required	required

MESSAGE TRAFFIC ATTRIBUTES

TABLE II

"Number and locations of Processing Sites: A key factor in implementing Local Area Data Distribution (LADD) is that there be a single controlling site regulating the flow of data traffic to be distributed from the processing sites. Therefore, the number and locations of processing sites in a data communications network is inconsequential to the ability to implement LADD. Both centralized and distributed data communications networks will find LADD applicable to their operations.

"Number and Locations of Remote Terminals: The locations of remote terminals is a key design parameter for implementing LADD. All remote terminals located within the range. . ." of the cable service will have essentially equal ability to receive data messages. The number of remote terminals within the service range is not a parameter affecting the physical implementation of LADD.

"Information Flow Patterns between Terminals and Processing Sites: Information flow using LADD is, by definition, outbound only from the processing sites through the controlling site to the remote terminals. Erratic patterns of information flow which would make it impossible to economically install a leased line network to distribute data have no effect on LADD's ability to distribute data.

"LADD can function as the outbound channel in two-way communications, wherein the inbound and outbound data each have dedicated channels. In this way, for example, high volume printing on multidrop networks can be sent via LADD, thereby maintaining low response times for terminals.

"Types of Transactions to be Processed: Transactions of any type can be distributed using LADD. One of the benefits of LADD's being able to operate in broadcast mode as well as point-to-point mode is the additional transaction types which can be handled. An example of such additional tranaction types is outbound policy information such as price changes. This kind of information is usually composed centrally, voluminous in nature, and delivered by mail. . ." Virtually instantaneous distribution of such critical and detailed information to all receiving sites concurrently "cannot be achieved with any other commonly available data link technology.

"Traffic Volumes for Transaction Types: Traffic cannot achieve a net transfer rate in excess of the net transfer rate. . ." of the distribution channel. This value is dependent on the cable service. "Traffic volume is a factor in judging the economy of employing LADD technology. The greater the volume of traffic addressing multiple remote terminals, the lower the cost per message delivered. Increasing the volume of traffic addressing individual remote terminals increases the cost per message delivered.

"Urgency of Information to be Transmitted: Transmission of data to remote terminals is practially instant, up to the maximum net transfer rate . . . of the distribution channel. "When the volume of data to be transmitted at any instant exceeds the maximum transfer rate of the . . . channel, the controlling site is called upon to arbitrate the message sequence priority for transmission. A mix of data messages of several degrees of priority produces the best economical performance of a LADD system by spreading the load evenly.

"Capacity reserved for Traffic Growth: The nature and volume of excess capacity is measured in terms of the maximum transfer rate . . ." of the distribution channel and "the patterns and priority of message traffic. A LADD system will have 24 hours a day availability for use under normal conditions. Generally, a LADD application will have capacity in reserve of twice the prime time capacity.

"Acceptable Undetected Information Error Rates: The information bit error rate of a properly tuned LADD is less than 10^{-7}. This rate can be improved by utilizing link forward error correction (FEC) routines. Error checking and correction routines compromise throughput for improved accuracy by reducing the maximum net transfer rate of information. . ." over the distribution channel by their overhead. "In many LADD implementations, error checking and correction may not be necessary because the technology is intrinsically superior to common carrier links, whose bit error rates, according to Doll[6], range between 5×10^{-5} and 5×10^{-6}.

"Reliability and Availability: The reliability of a LADD system will be directly related to the reliability of the controlling site system, the physical link, . . ." the LADD transmission system, the licensed cable service, and the remote RF-Receiver-Terminals. The cable service is "not only exceptionally reliable by information processing standards, but also usually has a full time on-site engineering staff to correct failures. Certain components of the system such as the physical link. . ." and the LADD distribution system "can be implemented redundantly where improved reliability is required. The availability of the system is generally 24 hours per day less down time due to equipment and power failures.

"Availability of Financial Resources: Most data communications networks with the need for LADD capabilities already have a controlling site system in place. With this environment, adding Local Area Data Distribution capaiblity to the network would include the costs. . ." for the LADD distribution system and RF-Receiver Terminals hardware purchase and their installation, "plus a monthly service charge for the physical link and for. . ." the licensed cable service, "and maintenance charges. The most exciting aspect of LADD for the financial decision-maker is that when utilized effectively it has the ability to make the cost of distributing information less than the cost of the paper it's printed on.

"Because LADD is new, and specific and limited in the applications in which it is useful, it will not be a commonly used link-technology for several years. Most probably, the initial demand will continue to come from large corporate users whose needs are a perfect fit to LADD's capabilities. Additional growth in LADD's usage will come as a surge when the value-added common carriers integrate LADD's capabilities into their hybrid networks.

"Ultimately, LADD link-technology will be just another data communications network building tool and in common use just as satellite and microwave RF communications are now becoming."

NOTES:

1 Sections of this paper contained in quotation marks are taken from Albright and Wallace, "Local Area Data Distribution", 1980 NCC Proceedings, copyright AFIPS Press.

2 Davies, Barber, Price and Solomonides, Computer Networks and Their Protocols (1979), page 155.

3 Italics added.

4 Italics added.

5 Doll, Data Communications, Facilities Networks and Systems Design (1978), page 4.

6 Ibid, page 298.

COMPUTER APPLICATIONS IN CABLE TELEVISION

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The growth of, and changes in, cable television during the past three years have made computer technology cost-effective for cable systems. Computers are no longer optional operational tools, but integral to the conduct of business. Cable management personnel have had to absorb the recent technical and marketing changes in the cable television industry and now have to learn the basis of another technology--the use of the computer. Cable television's management should, therefore, understand available equipment, software, and implementation alternatives sufficiently to successfully apply computer technology. Computer systems, chosen wisely, can help increase penetration, improve operational efficiency, and deliver services that otherwise could not be offered. This discussion highlights the important areas to be explored in the application of computer technology.

New franchise construction is taking place at an unprecedented rate. The volume of record keeping is increasing substantially. Franchises are increasing penetration by adding new services; these services require additional information storage. Many services require close monitoring operationally and from an accounting viewpoint. Computer storage offers the most efficient method of organizing and updating large amounts of detailed information.

Cable is growing so rapidly that there is a lack of experienced personnel to fill available positions. Because cable is becoming more sophisticated the industry is competing for more sophisticated personnel; employees are becoming more expensive. Properly implemented computer technology can maximize each employee's effectiveness and increase the ratio of subscribers per employee.

UNDERSTANDING COMPUTER TECHNOLOGY

Computer-use decisions can have serious effects on growth and profitability. The choice of the wrong computer system can limit growth. Also, the computer that is not reliable and/or underdesigned can decrease profits.

Computer technology is dynamic and, like cable, is still in a stage of rapid growth. Computer technology is not monolithic. It encompasses a continuum of equipment and services, as well as various types of suppliers.

HARDWARE

Availability of cost effective equipment is not a limiting factor to computer applications. There is no other industry with as wide a range of reliable equipment. On-going development continues to reduce initial costs, maintenance costs, energy consumption, and the need for special environmental conditioning. A good hardware base is essential to proper design and implementation. The fundamental issue is the accurate assessment of processing and storage requirements. These requirements will indicate the logical equipment direction--main frame, mini- or micro-computer.

The type of storage technology used--floppy disk, disk cartridge or magnetic tape is closely associated with the company's storage requirements. There is a fundamental relationship between the number of records to be stored, e.g., subscriber records with accumulated payment, work history, and so forth, and the records pertaining to services offered--and the optimum storage technology. The storage technology used represents a significant percentage of equipment costs, and, for data intensive applications, is one of the key issues of good design. Micro computers generally use floppy disks which are low volume storage units, and are used when processing speed or capability is not critical. Random access disk technology is used for applications that are data intensive and require sophisticated manipulation. Magnetic tape drives are associated with applications for which information retrieval speed is not critical but high storage volume is desirable. Main frame and mini-computers are used in large data-processing environments in which both high storage volume and processing speed are important.

SOFTWARE

Software enables the computer to perform specific tasks. For software to be successful, the system designer has to thoroughly understand the industry requirements as well as the equipment's architecture. The development of software is expensive and time consuming. Further, it requires field testing and then commitment on the part of not only software development personnel, but also user personnel in an environment that is a challenge to the application. For each successful computer application three distinct areas of software must be integrated--operating system, data base management, and application programs.

The operating system is the fundamental software provided to make the computer equipment and its peripherals--disks, printers, magnetic tapes, and the like--function as an integrated system. This software is generally not apparent to an end user. (An end user is simply a person using a computer's capability without having a fundamental knowledge of computer technology, much as using a telephone requires no understanding of how it transmits.) The operating system determines whether a computer system is batch (where there is no user interaction during program execution) or on-line (permitting user interaction); whether it is multi-user (the computer's resources are shared) and/or multi-tasking (enabling different users to perform different programming tasks concurrently); and whether it has data communication capabilities (the computer can be used from remote locations via telephone, microwave satellite, or other transmission technology) or distributive processing capabilities (a network of computers that perform in an integrated manner).

Operating systems are supplied and supported by the equipment manufacturer; they are integral to the functioning of the equipment. Operating systems can be sophisticated, as in large mainframe computers, or crude and limited, as in home-user microcomputers. Because the operating system uses equipment resources, its size and efficiency determines how much computing capability remains to run the data and application software; it thus determines the system's cost effectiveness.

The data base management software determines the sophistication of information storage and retrieval. Its structure defines record-addressing capacity, record-format flexibility, and how records can be retrieved, updated, and changed.

The application software performs specific end-user tasks. It is usually the only software with which a user interacts. Good application software is defined by the user environment. Proven areas of application software include on-line order entry, work-force scheduling, construction estimating, accounts receivable, and general ledger. New areas of application include data acquisition, such as amplifier monitoring, and data acquisition/signaling, such as addressable taps/converters. These latter applications call for sophisticated software that interfaces electronic equipment to the computer. These areas of software must function smoothly with a minimum of end-user commands.

SUPPLIERS

Equipment manufacturers fall into two broad categories--end user and OEM; some firms occupy both categories. End-user suppliers sell directly to those companies that will be using the systems. Packaged application software exists, but usually for well developed industries and applications. End users who buy directly from the manufacturer usually bear the responsibility and cost of application programming specific to their needs.

An alternative is to buy a packaged product. This means accepting an organization's solution to a specific set of problems, but usually eliminates the need for any programming by the user. In this instance, the OEM equipment supplier sells to software and systems companies; these companies add special software and/or hardware to meet specific application requirements.

A third alternative is to use computer service bureaus. The user buys specific services. The user deals not with the computer system but with the service bureau which supplies specific application sources, such as accounts receivable and invoice generation.

ASSESSING CABLE OPERATING PARAMETERS

A company should accurately assess its expected growth for at least three years. Implementing computer technology means long-range planning. This is the only way to ensure the company's investment.

The size and geographical distribution of the company's franchises and the services these franchises offer are important in determining the scope of the application.

The geographic distribution of operations poses the problem of how to implement an application that can serve all facilities in the most cost-effective manner. Cable management must analyze communication costs, additional equipment costs, the operational logistics involved with managing remote offices, etc. Certain decisions are dependent on a company's profit/loss operating philosophy. Where should such functions as invoice printing, payment processing, and collection activity take place?

A parallel of where the cable industry is today with computer applications can be made with the telephone companies and their use of the computer only 10 years ago. In 1969, digital computers were mainly used for billing and solving engineering problems. Most applications were traditional batch programming. Today sophisticated digital switches (another term for computer) are being installed in central offices almost as quickly as manpower permits.

The computer industry and the telephone companies saw the potential and made the investment. Supplier competition helped change the entire technology of telephone transmission. This same kind of competition is helping to change the technology of the cable television industry.

Making the correct long range decisions on implementing computer applications in light of the rate of change taking place in cable will not be easy, but, by making the effort to get educated, seeking information and advice from proven suppliers and in the finality making a commitment to use the technology, the cable operation will continue to help advance cable's dynamic growth.

CONSIDERATIONS FOR IMPLEMENTING TELETEXT IN THE CABLE SYSTEM

John J. Lopinto

Home Box Office

ABSTRACT

In a few years, commercial teletext service will begin in the United States. Technical standards, regulatory considerations and semiconductor designs will have been established to permit the feasibility of a teletext service for every market segment. The cable industry has an opportunity to exploit the versatility inherent in any teletext service. This paper is intended to identify the key parameters within the cable environment as they impact on the implementation of teletext.

A BASIC TECHNICAL DESCRIPTION

The term teletext refers to an electronic system where a data base of information is constantly transmitted via existing television signal paths to home TV receivers which are suitably modified or supplemented. The TV viewer, through a control box, can access and display this information in lieu of the normal TV program which is carrying the teletext signal.

The teletext signal, unlike the normal TV program, is a data signal. It is transmitted along with program on unused scan lines in the vertical interval. As viewed on a TV receiver, these lines are not normally displayed as they are located above the top of the picture. This is the same vertical interval where test signals to monitor transmission performance (VITS) and to provide automatic color adjustment in the home TV (VIR) occupy non-picture scan lines. Table 1 illustrates this vertical interval region. The line numbers which teletext occupies, at present, varies from user to user since there are no standards, as yet, governing this.

PRESENT VERTICAL BLANKING INTERVAL USAGE

LINE	FIELD 1	FIELD 2
10		
11		
12		
13	Teletext	Teletext
14	Teletext	Teletext
15	Teletext	Teletext
16	Teletext	Teletext
17	VITS*	VITS*
18	VITS*	VITS*
19	VIR*	VIR*
20	S.I.D.*	Unassigned
21	Captioning*	Captioning*

*F.C.C. Broadcast Standard Allocation

TABLE 1

The data present on the scan lines are in the form of bits. Groups of bits can represent, when decoded, letters, geometric forms, colors or merely system housekeeping. Figure 1 gives a basic illustration of the hardware used for a teletext system.

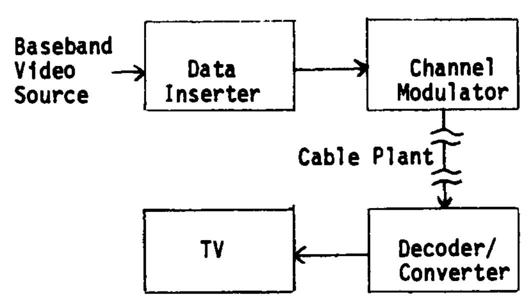


Figure 1: Basic Teletext System

The viewer gains access to this information through a decoder which is either internal to his TV or a set top adapter. The viewer controls the mode of teletext display with a calculator type keypad. He can select either normal TV programs or one of several teletext display modes. These modes may be full screen display of teletext, overlay of teletext on program, captioned teletext, or conditional display of teletext. The teletext information can be organized as pages and magazines. A page is a full screen of text and/or grafic information. A magazine may be composed of several hundred pages.

The number of pages present in the data base to be transmitted along with the data rate at which they are transmitted will determine the maximum waiting time (access time) for display of a page which the viewer randomly accessed. Pages are transmitted sequentially by number with the sequence repeated when all pages are transmitted. The number of TV lines used to transmit teletext will determine the data rate. A general rule of thumb is a transmission rate of 1.7 pages/second for each TV line used to transmit teletext data. In a four scan line system, 100 pages would have a maximum access time of 15 seconds. This, however, varies considerably with the type of data encoding used and the density of the pages transmitted.

Graphic information can be transmitted on a teletext system. Pictures are composed of colored squares placed in such a manner on the TV screen to give a low resolution picture much like a mosiac. Systems have been proposed which can produce a high resolution graphic display with a more advanced decoder. These graphic techniques are called Alpha-Mosaic and Alpha-Geometric.

A final term should be introduced here. Viewdata refers to the transmission of data via ordinary telephone lines for display on a modified home receiver. Instead of the information entering the home via a television signal, it enters through the home owners telephone line where it connects to a decoder for display on the TV receiver. It is an interactive system in that the user accesses information directly from the data base computer through his telephone. The data transmission rate is about one-tenth that of teletext but, because it is interactive, it need only transmit the information requested by the user. Most teletext systems were originally viewdata systems. Hybrid schemes are possible, where the user requests information via a telephone line but receives the requested information over a television channel, either cable or off-air.

THE TELETEXT DECODER

The standards which will eventually be adopted will be primarily concerned with over-the-air broadcast teletext transmission. Only a few lines in the vertical interval will be used for teletext as this is all the braodcaster is allowed for this type of service. While this will be fully compatible for the CATV operator, it will fall short of the potential he has.

The system operator has the ability to send teletext on all TV lines instead of programming. This will greatly increase both throughput and the amount of information to be delivered to the subscriber. In addition, the cable system has the ability to provide an interactive system which is considered the logical extension of teletext.

The important thing to realize is that if the subscriber has available to him a TV set with a conventional teletext decoder in it, then the system operator can do no more than provide teletext service in the same manner and format as do the broadcasters. What must be developed is an upward compatible system which will allow cable to expand and exploit the conventional teletext service and TV set decoder to fully utilize the available bandwidth on cable.

The teletext decoder can take on many forms. Basically the decoder accepts an NTSC baseband video input with the teletext data encoded on it. The output is usually Red, Green, and Blue signals to drive the picture tube in the TV set directly. This is illustrated in Figure 2. The set top decoder would have circuitry to convert the R, G, B signals to an NTSC video signal modulated on a TV channel frequency.

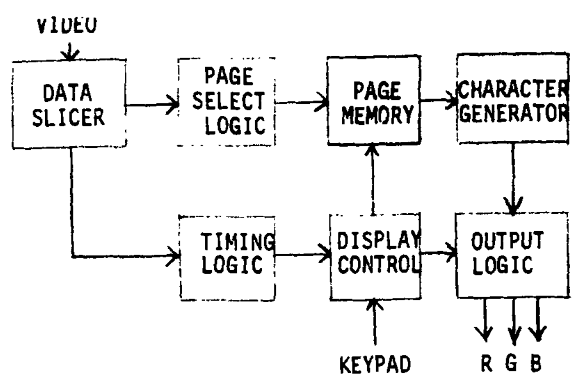


FIGURE 2: Basic Teletext Decoder

For cable, however, this set-top decoder function can be made an integral part of channel converters and descramblers presently used for cable TV. The converter already performs channel selection. The IF can be demodulated, decoded and remodulated. Teletext functions and channel selection can share a common keypad.

Teletext decoders will be offered by TV receiver manufacturer's as an integral part of the TV set. Initially, however, there will be a market for external decoders to be used with existing TV receivers. The combination converter/decoder can be offered at a premium to cable subscribers giving them the ability to make use of existing teletext services. The implementation of the decoder function in the converter, need only be the addition of field installable circuits so that a separate box need not be inventoried.

THE TRANSMISSION OF THE TELETEXT SIGNAL

The system operator can implement teletext by simply allowing teletext on his off-air signals to be passed on to his subscribers for decoding by subscriber provided decoding equipment (i.e., teletext TV set or set-top adapter). Unfortunately, this does not allow the operator to generate any additional revenue.

The next level of implementation is where the operator buys teletext generating equipment, the same the broadcaster buys, and inserts teletext the same way as the broadcaster, into the vertical interval of his locally originated channels. He would then generate revenue from his locally originated teletext service. The main drawback to this scenario is that initially there will be very few teletext TV sets or decoders owned by subscribers. In addition, the relatively high cost of teletext generating equipment will probably make the approach unfeasible during the infancy of teletext. An alternative to this approach would be for the system operator to rent teletext set-top decoders to his subscribers as previously described.

A third approach would be one where a system channel would be dedicated to teletext service. It can be made compatible to existing commercially available, broadcast standard, decoders. Let us say that broadcasters use three lines in the vertical interval for teletext, say lines 14, 15, and 16. The system operator, on a full channel basis, has 240 lines or 80, three line channel slots available. A set-top decoder can be developed for the cable industry which would select any one of these 80 teletext/data services and "down convert" them to the standard three vertical interval lines. It can then be decoded and displayed by the subscriber's teletext TV set. If the subscriber does not have existing provisions for decoding teletext, a teletext decoder can be incorporated into the 80 channel data selector at little additional cost and connected to the antenna terminals of simple TV sets.

The system would generate its revenue by "renting out" these 80 data channels to various information suppliers or use several of them for his own purposes. Each one of these 80 data channels would have the capacity to transmit the equivalent information of 10 billboard channels as they now exist on a system.

One final extension of this type of system would be where the operator would take the broadcasters teletext signal and place it on one of these 80 data channels and offer one package containing all the teletext information available on his system channels.

Some thought has been given to using the CATV channel as a wideband data channel without "packaging" it on TV lines. This would make distribution of the data impractical since it could no longer be monitored by conventional TV test equipment and no longer be handled and "dealt with" like a TV signal. A new frame of reference and way of thinking would need to be established by the system operator in maintaining such a service.

COST PROJECTIONS

It is assumed that the cost of the decoder during the first years of teletext service in the U.S. will determine how many consumer users there will be. It is for this reason that the cost of the teletext decoder is so sensitive an issue. The various proposed systems presently being evaluated reflect themselves differently in decoder costs.

Basically, four or five LSI integrated circuits form the nucleus of a teletext decoder. The complexities of these circuits varies from systems presently being proposed. These circuits are going through iterations in design but are still awaiting a firm U.S. standard before accurate pricing is made.

Based on proposed designs of systems presently in use, it has been projected that a complete teletext decoder chip set will cost about $35 - $40 in large production quantities. This would mean a retail cost of about $200 to $250. It should also be kept in mind that with the large quantities of units that can be sold in the cable market, the possibility exists for a custom LSI to be designed to cost-effective implement the functions I previously described.

Information provider terminals or the equipment necessary to generate and store teletext pages will be priced at $10,000 to $20,000.

CONCLUSIONS

It should be realized that teletext service will become a practical, widespread reality within a few short years. The cable industry must embark on a design and development plan which will extend the fundamental broadcast teletext service into the wide open frontier of cable.

This paper has not addressed what services would be offered on teletext or precisely how revenue is to be generated. These questions are presently being answered by other professional disciplines. There must, however, be an ongoing dialogue between all those involved with the various aspects of teletext development to insure a cohesive, unified system.

The subscriber's TV set will become open game for anybody who wants to use this consumer display device for uses other than television viewing of movies, sports, and sitcoms. Our industry's bread and butter will compete with yet unknown activities for the subscriber's TV set usage time. We must be prepared to meet this imminent challenge.

CONSUMER SOFTWARE SERVICES VIA CABLE TELEVISION SYSTEMS

CHARLES L. DAGES

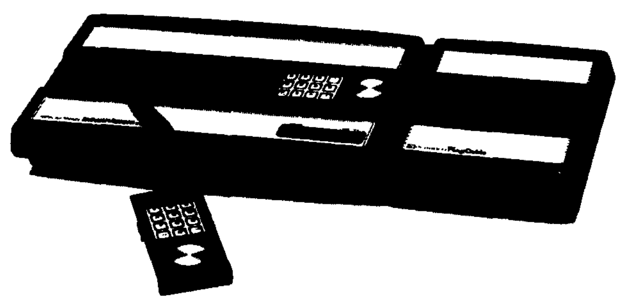
JERROLD DIVISION
GENERAL INSTRUMENT CORPORATION

Application of digital integrated circuit technology to consumer products is increasing at an explosive rate. The wide selection and phenomenal demand for electronically based entertainment devices indicates the beginning of the long awaited "Home Computer Revolution" is at hand. The General Instrument, Jerrold Division's PlayCable™ system addresses this new market segment with a unique offering of advanced home video services with capabilities eclipsing the European Teletext/ Antiope services. Specifically, the PlayCable subscriber video terminal system will be demonstrated to efficiently provide a large variety of entertainment, education and information services, and will provide the subscriber with a useful software service. Technical details of the PlayCable CATV data transmission system are presented, highlighted by a headend computer system which will be the basis for a host of future CATV data services. The unique time/frequency division multiplexing scheme employed to transmit the service will be shown to be spectrally efficient and frequency agile.

INTRODUCTION

Microprocessor and digital electronic circuitry emerged as a revolutionary force in the consumer products industry in the 1970's. From calculators to watches, digital circuitry replaced traditional techniques for accomplishing mechanical or analog functions with increased reliability and lower costs. Additionally, digital techniques are proven to provide features undreamed of at little or no extra cost in the product. Today as we enter the 1980's, this same technology is poised to address the telecommunications and CATV industry in the entertainment field. Complimenting the explosive growth in premium pay programming which resulted from the launching of SATCOM I, such services as Teletext, ViewData, and PlayCable are emerging as potential service offerings for the CATV industry.

In the early 1970's a new form of video entertainment was developed...the TV video game. Primitive by today's standards, these devices permitted the consumer to interact with the display on his TV set. Dedicated to one or two display formats for interaction, the consumer quickly tired of the capabilities of these machines and put them aside. To answer the deficiencies of the dedicated video games, programmable home computer systems were introduced in the mid-1970's. Based on microcomputers, these systems provided consumers with the flexibility of changing format, game rules, colors, etc. This was accomplished by simply inserting a new program cartridge into the game system; video resolution and sound effects were increased to give added appeal.



Intellivision PlayCable Adapter

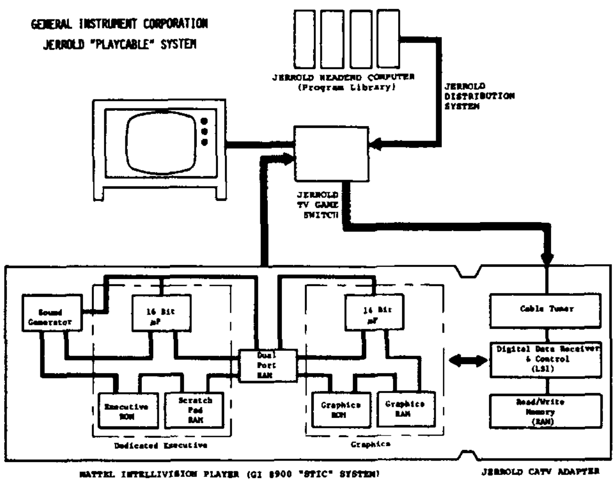
Today, a new generation of digitally based home video system is being introduced through PlayCable. PlayCable is the trademark for a computer in the home service. Utilizing any one or two-way CATV system, digital software is transmitted to a sophisticated home video terminal. A CATV subscriber has access to a wide variety of digital software programs. Such offerings as NFL Football, Major League Baseball, and even Speed Reading or Income Tax Calculations may be processed. The subscriber never again needs to purchase cartridges or tapes containing the software programming to operate his Intellivision Master Component. In addition to games and educational program offerings, PlayCable can provide information services that would be provided by Teletext systems.

THE PLAYCABLE SYSTEM

The system consists of three major building blocks:

1. Headend computer - data modulator
2. Jerrold Adapter
3. Mattel Intellivision Master Component

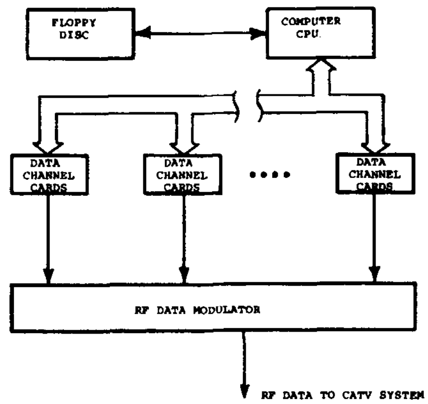
The heart of PlayCable is the headend computer. Based on the Digital Equipment Corporation - PDP11/03 computer - the architecture of this system utilizes the advanced concept of distributed processing for high reliability. The computer reformats the data for compatible transmission over the CATV system in a vacant portion of the spectrum. The Adapter receives the RF data, processes it, and stores it in the random access memory. Once the entire program is processed, the Mattel Intellivision Player interprets this software program and generates the appropriate video sound information for display on the subscriber's TV set.



HEADEND COMPUTER SYSTEM

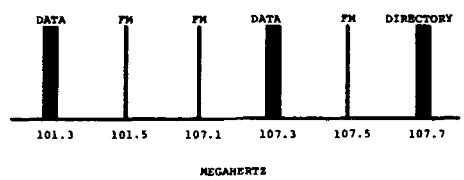
The headend computer consists of a PDP11/03 computer, floppy disc storage drive, data channel cards, and an RF data modulator. The program software offerings are received on a periodic basis in the form of a floppy disc. The floppy disc is inserted into the drive mechanism and read by the PDP11/03 CPU. The information contained on the floppy disc is interpreted and placed into a predesignated data channel card. These data channel cards contain memory for program storage and a microprocessor which formats the data in serial data streams. Each channel card is capable of providing two serial data streams to the RF data modulator.

The headend data modulator is an FSK signal generator which converts the serial data streams into a form for suitable transmission in an unused portion of the CATV spectrum. The output from the data modulator is then combined with other signals from the cable system.



Jerrold PlayCable Headend

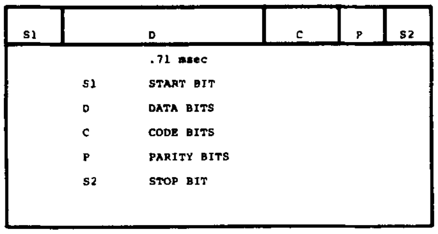
The computer is designed to be completely self operating. During instances of power outages or the introduction of new program material, the computer automatically "boot straps" itself into operation.



Frequency Division Multiplex

RF DATA STREAM

In the PlayCable system, both frequency division multiplex (FDM) and time division multiplex (TDM) data transmission techniques are used for maximum flexibility and minimum access time. Within one spectrum assigned to PlayCable, a specific frequency is dedicated as the "directory channel". The directory provides all the necessary information for the PlayCable Adapter and Intellivision Master Component to select and receive a software offering from the cable library. The data containing software program offerings may be spaced either in a continuous portion of a dedicated spectrum at 200 KHz spaces, or may be interspersed among other services such as FM channels or data channels providing services such as addressability,



Data Transmission Word Format

security, etc. Additionally, within each data channel a time division multiplex scheme is used for packing various programs. On any one data channel, multiple program offerings may be recycled on a continuous basis. Use of both FDM and TDM data transmission techniques provides an average access time from program selection to the time it is displayed on the screen, of ten seconds.

MASTER COMPONENT AND ADAPTER

The Adapter is designed to be an integral part of the Mattel Intellivision Master Component system. The unique architecture of the Intellivision system incorporates two microprocessors. One 16-bit microprocessor performs the executive supervisory system control of the Intellivision system. The second microprocessor is dedicated to interpretation of program instructions for graphics and sound display. This dual system concept provides unexcelled computational, graphics and sound capabilities.

Operation of the system is as follows:

1. Upon starting up the PlayCable terminal, the 16-bit microprocessor polls the system and interprets which peripherals are connected to the system. When the adapter is present, the 16-bit microprocessor instructs it to load the directory channel into random access memory.

2. The information contained in this memory is then interpreted by the 16-bit microprocessor and transferred to a second 14-bit microprocessor which is responsible for the generation of the visual graphics on the TV set. The system remains in a stable condition until the consumer has selected the appropriate programs from the menu.

3. The 16-bit microprocessor instructs the adapter to tune to the proper frequency associated with a particular program. Additionally, it continues to interpret incoming data until the proper program on that data channel is received.

4. The program information is loaded into the random access memory and monitored for errors. Once the entire program has been loaded into the adapter, the executive microprocessor then initiates the start of the particular program. This instructs the graphic microprocessor to display the information appropriate for that program.

The adapter is capable storing up to 80,000 bits of program information for interpretation of program control. However, the capability exists for software offerings which require more than 80,000 bits of storage. The system is capable of automatically retrieving additional information from the cable system as the need arises.

TABLE 1

DATA TRANSMISSION SPECIFICATIONS:

• Transmission Method	FDM/TDM FSK Carriers
• Maximum Data Rate	13.982 KHz
• Maximum Channel Capacity	30 channels @ 200 KHz spacing
• FSK Deviation	±75 KHz
• Signal Level	-24 dBmV (typ)
• Effective Data Rate (Alpha/numeric)	34.95 lines/sec

TABLE 2

PLAYCABLE RECEIVER/INTELLIVISION SPECIFICATIONS:

• Display Resolution:	
Alpa Numeric	20 x 12
Graphic (Pixels)	160 x 96
Colors	8 x 16
• Maximum Frequency Display	2 MHz
• Sound Capability	Digital Analog

TABLE 3

HEADEND SPECIFICATIONS:

• Minicomputer Based	PDP 11/03
• Storage Media	1 Megabyte floppy disc
• Automatic error sensing and program loading	
• Capacity	21 games plus catalog
• Access time	10 seconds average

SUMMARY

In the coming years, the digital software services to the consumer will increase in importance. The PlayCable system currently being tested in four trial systems in the United States is just a beginning. Capable of providing Teletext type service, educational offerings, games, and self-improvement courses, the PlayCable hardware offerings will expand in the coming year to a full computer in the home system. The technology and the marketing knowledge necessary for the CATV industry to pioneer these services to the consumer is being tested today on PlayCable.

CONTROLLING CABLE TV HEAD ENDS AND GENERATING MESSAGES BY MEANS OF A MICRO COMPUTER

Robert E. Schloss Steve Erley

Omega Communications, Inc.

Abstract:

The purpose of this project was to program an Apple Micro-Computer to perform the following functions in Omega's cable system in Brazil, Indiana.

1. Channel Switching
2. Character Generation
3. Perpetual clock and calendar

The clock calendar function and the keyboard command functions interact with the computer to produce output voltages. These voltages switch coaxial switches to perform the above functions. Audio switching is similarly performed with the computer output voltages. The video output of the computer is used as a character generation and is routed to the switcher as an input. Upon command the computer will play messages and/or advertisements which the switcher will route to an output channel. At a cost of less than $3500 complete, the Apple II computer and switcher is an economical controller and character generator.

1.0 Introduction

A modern cable television system has a need to control multiple imputs (normally television signals) into a limited number of cable television channels.

The system needs to control these signals by time of the day, day of the week, and day of the month. For example, in Omega's cable system in Brazil, Indiana, we wished to share our cable T.V. channel 5 among Pay T.V., C-Span, and messages. A further need in our system was to control our time-weather-public service channel among time and weather, public service messages, Pay T.V. previews and advertisements.

Utilizing an Apple II micro computer and custom switcher, the computer will control three audio and video inputs into one output channel and any three audio and video inputs into a second output channel. One of these video imputs can be the video output of the computer which we have utilized as a message and advertising imput to our two channels.

2.0 System Configuration

The Apple II Computer is configured with 32K BYTES of ram memory, "BASIC" language in read only memory, a Mountain Hardware real time clock/calendar, and a single minifloppy disk drive. The operating program, message, and an event file of times of channel changes are stored on the disk and loaded into the computer when needed.

The actual switching of video and audio is accomplished by means of a custom switcher built by David Moffett of the Home Computer Center in Indianapolis. This unit is designed to switch two separate channels, each of which has three possible inputs. The Apple Computer has built into it a four bit parallel output port normally used for game paddles. These four bits are decoded by the switcher box and amplified to drive six double pole, double throw coaxial relays. The data format being used defines the most significant bit as a flag indicating which relay is to be energized on the previously selected channel.

The Double Pull-Double Throw coaxial switch made by Amphenol, is actually two separate SPDT coaxial switches with a common coil. One section is used to switch the selected audio signal to the output and the other section does likewise with the video. Any video signals not currently being used are terminated into 75 OHM resistors mounted on the relays because the outputs of all relays on each channel are wired in parallel. Only one relay on each channel can be energized at any one time.

At this writing, the switcher is controlling our local time/weather channels as channel one, and our premium channel as channel two. The three inputs connected to the time/weather channel are:

1. Weather scan video with local FM audio
2. Premium channel video and audio
3. Computer color video with local FM station audio

The three inputs to the Premium Channels are:

1. Premium channel
2. C-Span
3. Computer video with local FM audio

This is used to present public affairs programming (C-Span) and messages on our premium channel during the day when the premium channel is not in use.

Any video and audio sources could be s bstituted for those listed above and extra relays could be wired in parallel with the coaxial relays. For example, the computer could energize a remote controlled audio cart player or video player whenever it's video output was selected by the computer. In our Brazil system, we are controlling a Magnavox Scrambler with a parallel relay.

3.0 Program Design

The computer program was written by John Turpin of the Home Computer Center in Indianapolis, consists basically of three parts:

1. A message entry program to input messages and store them on disk.
2. An event entry program to input times and dates of events and store these in chronological order on the disk.
3. An event handling program to compare the time from the real time clock with the times in the event file and carry out the specified events as necessary.

The message entry program is "Menu Driven", that is it presents the inexperienced user with a list of options. This program accepts messages from the keyboard; allows them to be modified if desired; and stores these messages on the disk for future use. Two formats are available - full page message or a single line crawling across the center of the screen.

The event time entry program also is menu driven. It accepts the time and date you wish to change, which relay to energize on the desired channels, and in the case of computer video being used on one of the channels, which message to print and how many times to repeat it. Table I shows part of a time file. Under the column headings Ch. 1 and Ch. 2 imprint three is the computer video message number.

Item	Mo	Day	Hour	Min	Sec	Ch1	MSG	Ch2	MSG
0	4	24	15	0	0	1	0	3	8
1	4	24	15	28	0	2	0	2	0
2	4	24	15	28	30	3	10	3	30

All data entry takes the form of a question and the operator responding with appropriate data.

The event handling program, which runs at all times except when one of the above two programs is in use, constantly checks the time from the Apple clock and compares this with the next time stored in the event file, when these times coincide, the switching information is routed to the output port to turn on or off relays as required. Table 2 shows the computer output video when it is not switching or playing messages.

Status:
Current: As of 4/24 15:28:00
Chan 1 Switch 2
Chan 2 Switch 2
Next switch at 4/24 15:29:00
Chan 1 Switch 3
Chan 2 Switch 2
Time 4/24 15:28:20

Table 2

3.0 Restoration after Power Outage

Upon the restoration of power after a power failure, the computer will reload its program from the disc. The internal clock has a back up power system which will maintain the time for up to 3 days. The computer will compare the time with the last switch time and reset the appropriate relays. The ability to restore and reprogram itself is a unique capability which is not available in most commercial controllers.

4.0 Strengths and Weaknesses of the System

The most important strength of the controller is that the system is "software" controlled rather than "hardware" controlled. Any system changes and additions require only additional programming. The computer's ability to reprogram after a power failure is unique. The system has the ability to play up to 50 messages and switch channels based upon its internal clock to an accurancy of one-tenth of a second.

Among the weaknesses of the system are the limited time file. Although the time file will hold switch information for 20 consecutive days, the number of events able to be specified is only 130 with 32K of memory and 200 with 48K as presently programmed. If the system is utilized to play messages or advertisements on a hourly basis, the number of events for 20 days would exceed the computer's capacity.

The computer is presently being reprogrammed from a calendar date table to a day of the week table. In the new table, the user will program each hour each day of the week by means of a calling up of standard hours and non-standard hours. Standard hours could be programmed for the insertion of ads based upon the time of day and day of the week. The user will input switch changes only as needed to reflect changes in a particular day or in standard or non-standard hours. This change will increase the number of events able to be stored to over 500.

Another weakness of the system is that the system uses the output of the computer as a character generator. The output is legible but is not, as presently programmed, as legible as the output of a commercial character generator. A commercial character generator could be easily interfaced with the Apple Controller.

5.0 Future Design Goals

The head end controller can be utilized for other tasks in the typical cable T.V. head end.

Through the use of telephone interconnections devices (modems), the computer at the head end can be remotely programmed. The cable T.V. office could change the event file without going to the head end. Similarly, any advertizer could access the computer and change his advertisement on a daily or hourly basis.

Head end security and a temperature alarm device can be implemented by a latching relay which would activate an audio switch in the switcher. The audio switch would place a tone on the audio channel of the time-weather channel. A weather alert radio tuned to cable channel frequency would sound the alarm.

A number of manufacturers are building computer output cards that have isolated relay contacts for their outputs instead of voltages. With this card, one could go directly to a Daniels Industries Coaxial switcher. These output cards would extend the number of inputs and outputs which could be controlled by the computer.

6.0 Price vs Performance

The above described Apple II system with 32K RAM memory, disk drive, custom switcher and programming sells for less than $3500. This price compares favorably with a low priced character generator without any controls functions. The price also compares favorably with a head end controller without any character generation functions.

7.0 Summary

The Apple II Computer and custom switcher provides an economical and practical means to switch channels and insert advertisements and messages based upon an internal clock. Because the computer is "software" controlled, the system can be expanded and modified to suit the needs and desires of individual cable systems.

8.0 Acknowledgements

The authors wish to acknowledge the work of John Turpin of the Home Computer Center who did the programming; David Moffett, Service Manager, of the Home Computer Center who built the switcher; and Terry French, General Manager of CWY Electronics who supplied the elecyronic parts.

DISTRIBUTION EQUIPMENT FOR 400 MHz CO-AXIAL COMMUNICATIONS SYSTEMS

JAMES R. PALMER

C-COR ELECTRONICS, INC.

ABSTRACT

Comments on 400 MHz systems have been "on the record" in my monthly commentary newsletters. Generally, 400 MHz systems must be reduced in length from that of 300 MHz systems to produce the same quality. Perhaps as many as four times as many hubs will be required due to the reduced reach.

C-COR is very happy to design, manufacture and sell equipment for 400 MHz systems. It is going to cost more and you are going to need a lot more amplifiers. Where does C-COR stand?

1. Mainline Passives

   400 MHz splitters, directional couplers and other mainline passives devices will be in production in June. These units will take the place of the 350 MHz units now in production.

2. Trunk Amplifiers

   Trunk amplifiers will be in production for shipment in September. These amplifiers will be available with TV carrier automatic level control as an option in addition to our standard modulated pilot automatic level control.

3. Distribution and Line Extenders

   The single hybrid line extender for 400 MHz use is in production now, being built with 300 MHz hybrids. When a 400 MHz 33dB gain block is available from the hybrid manufacturers this unit can be immediately shipped.

   We have developed a 2 hybrid line extender for 400 MHz. This unit is available to place in production if and when the necessary hybrids are available in quantity.

   C-COR has near completion the development of a quad line extender. This unit will be available to start shipments in September on a first come, first serve basis.

Both hybrid manufacturers, Motorola and TRW have had difficulties in supplying 300 MHz hybrids to industry demands. Both have reneged on orders that had been accepted by them and have gone to allocation of their production. They are both supplying sample quantities of 400 MHz devices that are essentially 300 MHz units tweaked to function at the 400 MHz.

I am skeptical concerning announced improvements in hybrids with lower noise figure and higher outputs. Both manufacturers have had difficulties doing development to an announced time schedule. If the historical delays in new development can be translated to the future, it is my opinion that it will be a long time before we see any improved performance.

C-COR is firmly committed to the 400 MHz product line. With three different approaches to the line extender, the item using the most solid state devices, I believe that we have a good hedge to give amplifiers to those that place early orders. Most equipment for 400 MHz requires 400 MHz hybrids and that supply is going to be slow and problematic. Our line extender with the quad does not have that problem.

EXTENDED BANDWIDTH CABLE COMMUNICATIONS SYSTEMS

I. SWITZER, P.ENG., PRESIDENT

SWITZER ENGINEERING SERVICES LIMITED
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ABSTRACT:-

The need for extended bandwidth in cable communications systems is obvious. The rapid growth of cable systems in the U.S.A. is encouraging the proliferation of program services for cable distribution. The tree structured broad- band nature of cable systems means that capacity must be provided for all of the service to be distributed irrespective of relative popularity. Cable losses follow a square root of frequency law which makes bandwidth extension attractive as a means of increasing channel capacity. Reducing the number of amplifiers in cascade and the use of coherent carrier systems makes it possible for extended bandwidth cable systems to handle the additional channel loading with no more distortion than in present 35 channel systems.

THE NEED

The cable system constructed in any community will be, for practical purposes, the "only game in town". This system will have a "natural monopoly" on cable delivery of television and other services. As long as regulation and availability severely limited the number of services available there was no need for substantial increases in cable system capacity. Our earliest subscribers, in the 50's, were satisfied with five channel systems. Our very earliest subscribers had only three channels. System capacity was increased as technology, demand, regulation and availability of services all developed more or less simultaneously. Sometimes these developments were not all in step and one aspect of the service equation got ahead of the other. At this time technology has fallen slightly behind but can quickly catch up if we allow it to.

The very rapid recent growth of the broadband cable communications industry and the very apparant immediacy of substantial further growth in the number of cable TV subscribers is attracting a substantial number of additional service offerings. Further federal deregulation is in prospect. There are presently about 16 million cable subscribers in the U.S. This figure will at least double within three to five years. How many more "superstations" will be available for carriage? How many more PAY TV services of various kinds will seek a share of this immense new market? What kinds of brand new services will be developed in response to this huge market potential? How many channels will be required to serve purely local commercial and public access needs? How much system capacity will be needed for non-television services? How many channels will a cable television system need?

Three? Five? Twelve? Twenty? Thirty-five? Fifty-four?

Before we try to answer the question let us examine the basic nature of a cable system.

A cable system is like a water distribution system. We start from the purification plant and pump water out through water mains which spread out through the community. Pipes run up and down each street. Service pipes are run from the mains into each home that wants service. A water system delivers only one product - water. A cable system uses a single pipe to deliver a large number of separate and distinct products (services) simultaneously. The cable services are separated by operating each on a different frequency (channel). The various channels are like the keys on a piano, each with a different pitch (tone) and all being played at the same time. The cable subscriber selects the desired service by selectively tuning the desired channel from all the channels and services which are simultaneously presented to his receiver.

<u>All of the services on the cable are delivered into the subscriber's home whether he wants them all or not</u> (with some minor technical exceptions). Even in systems which do control to some extent what services actually go into the subscriber's home the control is right outside the home - all the services are present in the distribution cables. The subscriber makes his choice by

tuning the desired channel. Some systems may restrict the number of channels the subscriber can tune by means of special tuning converters or the system may restrict certain channels from entering the subscriber's home. The cable distribution system, however, carries all the channels that subscribers will get. The range and variety of services available to any subscriber is determined and limited by the carrying capacity of the cable distribution system. An individual subscriber may get fewer than the full number of channels and services available in the cable distribution system, but he can never get more.

The need for system capacity is therefore not related to the service tastes or desires of any individual subscriber. We must deal with the aggregate of all subscribers. If we are to provide a specialized channel of interest to only 1% of all the potential subscribers we occupy a channel throughout the whole system. It does not alleviate the systems capacity "crunch" to say that most subscribers will not use a particular service. As long as we feel obliged to provide it to even one subscriber we must occupy a channel throughout the whole system. We have no means of selectively delivering a service to one subscriber without impacting on our capacity to deliver other services to other subscribers.

It is wrong, therefore, to say that we need not expand our system capacity because the additional channels will have minimal utilization. Such a restriction reduces our ability to serve the few subscribers who do want to receive the additional less popular services.

Cable television has been hailed as "the television of abundance". System capacity could be increased by replicating the cable system - using dual or triple cables to multiply system capacity and costs. This expansion by replication of cables could go on indefinitely. There must, however, be some kind of limitation on the capacity we provide, since system capacity is not without cost. The limit is set by consideration of cost/benefit relationships. We believe that extending the bandwidth and hence the capacity of the present single coaxial cable system is an extremely beneficial cost/benefit trade-off. The cost increment is small - less than 15% in capital cost and negligible increase in operating cost. The benefit is substantial - an almost 50% increase in channel capacity!

HOW?

The bandwidth of a coaxial cable is virtually unlimited. Coaxial cables are routinely used by cable systems in connection with satellite receiving stations at frequencies of 4,000 MHz (ten times the 400 MHz frequency we are presently proposing). We are extending the usefull bandwidth of the cables we use from the present 300 MHz up to 400 MHz. The practical limitation on the operating bandwidth of the coaxial cable in our systems is the "loss" or attenuation of the cable. The cable dissipates some of the energy of the signals travelling it. Higher frequency signals are dissipated to a greater degree than lower frequency signals. The signals in the cable must be reamplified periodically before they are reduced to so low a level that they are intolerably affected by the intrinsic "noise" of the system. The usual present practice is to reamplify signals after about 20 decibels (dB) of loss. A dissipation (loss) of 20 dB means that the signal has been reduced to 1/100 of its original power. The amplifier then restores the signal to its original power by applying 20 dB (100 times) of power gain. Amplifiers apply less gain to lower frequency signals since the low frequency signals have suffered less attenuation than higher frequency signals.

Systems with nominal 35 channel capacity use frequencies in the 50-300 MHz range. A high quality coaxial cable used for main line purposes will typically have an attenuation of about 0.36 dB/100' at 50 MHz and 0.84 dB/100' at 300 MHz. Since the repeater amplifiers will be inserted after 20 dB of loss at the highest frequency used (300 MHz) the cable length between repeater amplifiers would be

20X100/0.84 = 2,380 feet.

Cable losses do not increase linearly with frequency, i.e. if we double the frequency we do not double the attenuation. Cable loss goes up by only the square root of 2 (1.414) if we double the frequency. If we go from 300 MHz to 400 MHz we do not increase cable loss by 400/300. Cable loss increases by the square root of 400/300 = 1.155. The actual measurement on the cable cited above is 0.98dB/100' at 400 MHz an increase of 16% which is very close to the predicted loss. The amplifiers previously spaced at 2,380 feet now have to be spaced at

20X100/0.98 = 2,040 feet

Amplifiers are thus approximately 15% closer together so we will need about 15% more amplifiers to cover the same area with a 400 MHz capacity system as we did with 300 MHz system. Alternately we may use lower loss cables than have customarily been used. Lower loss cables can restore the previous 300 MHz amplifier spacing situation. The additional 100 MHz represents 16 additional TV channels, and increase of almost 50% over the previously available 35 channels.

It is obvious that a further 100 MHz extension to 500 MHz would add 16 more TV channels with only 30% more amplifiers (each TV channel occupies 6 MHz of spectrum). We would have almost doubled system capacity with only a 30% increase in the number of amplifiers.

WHERE SHOULD THE BANDWIDTH EXTENSION STOP?

If amplifiers were perfect we wouldn't stop. We could go on to 1,000 MHz and beyond. A 1,000 MHz system would carry about 160 TV channels or equivalent other services. The cable loss at 1,000 MHz would be about 1.55 dB/100' and amplifiers would be spaced about 1,300 feet apart, not an impractical proposition. Many European cable systems do indeed operate at frequencies up to 900 MHz, but with very few operating channels, usually less than ten, spread across the available cable system spectrum.

The main problem is the imperfection and limitations of present amplifiers. An amplifier can handle only a limited total power of the signals passing through it. Each individual channel requires a certain minimum power to keep it comfortably above the "noise" of the system. Signals which are less than 40 dB (10,000 times) above the power of the noise of the system appear to have perceptible "snow". As we add channels we increase the total signal power to be handled by the amplifier. As total signal power goes up the amplifier begins to perceptibly distort the signal passing through it making them unacceptable to the subscriber. This distortion usually shows up as unacceptable interference bars and patterns across the screen. Since we pass the signal through many amplifiers between source and subscriber the distortion in each individual amplifier must be kept very, very small, so that the cumulative distortion after passing through many amplifiers is acceptably low. If we decrease signal levels to reduce distortion we risk excessive noise in the pictures. Some older systems use as many as fifty amplifiers between source and the furthest subscriber. Most present generation 300 MHz/35 channel systems limit the number of amplifiers in cascade to about 25. We are familiar with the amount of distortion that can be produced by a single "high fi" music amplifier. Imagine the cumulative distortion produced if we repeated the music through 25 such amplifiers in succession! The specification for the distortion in a typical cable TV amplifier is about -90 dB. This says that the power of the distortion product is about 0.0000001% of the power of a single TV signal at normal operating level. Compare this with the specification of your home "high-fi" amplifier.

The problem to be solved in expanding the number of channels in a cable system is not the bandwidth of the system. The problem is improving the capability of the amplifiers to handle the increased channel loading without creating intolerable distortion.

I was an early proponent of significant cable system bandwidth extension. Prior proposals had been made for marginal bandwidth extension by "tweaking" 300 MHz amplifiers to reach 320 MHz. I was prepared to extend bandwidth to a more significant degree by proposing a new upper limit of at least 400 MHz. The "square root" law is very tempting, but I felt constrained by a requirement for credibility and confidence in the upper frequency limit which could be reached at an early date and without requiring major amplifier or hybrid redesign. I was also constrained by my personal view of the additional channel loading that I could confidently undertake. My resolution of these constraints was 400 MHz.

I believe that I would undertake a further 100 or 200 MHz extension with 16 or 33 further additional channels after some experience with 400 MHz systems and a further appraisal of potential new developments in the solid state amplifier devices available for cable TV amplifier use. I expect that wider bandwidth systems could be implemented about two years from now.

Some TV receiver mnanufacturers have indicated that 400 MHz would be a convenient upper frequency limit for them. Some of them are deisgning new varactor tuners that would tune the entire cable TV spectrum plus the UHF-TV band. These new tuners would be double conversion designs with a high first IF. A first IF somewhere between 400 and 470 MHz would be convenient, to allow tuning of these two major bands (the

VHF-TV broadcast band would be a sub-part of the cable TV spectrum). Limiting the cable spectrum at about 400 MHz would therefore be convenient for these tuner designers. The cable TV industry would probably not accept such a restraint. The potential impasse might be resolved by using the 400-470 MHz cable spectrum for non-TV uses and beginning TV utilization again at 470 MHz (corresponding to the UHF-TV band).

HOW DO WE HANDLE THE AMPLIFIER LOADING PROBLEM?

1. We reduce the number of amplifiers in cascade.

Our present design specification is that 80% of our subscribers will be served by no more than 8 trunk amplifiers, one bridger amplifier and two line extender amplifiers in cascade. The maximum amplifier cascade to any subscriber will be 12 trunk amplifiers, one bridger and two line exten- ders. Although the distortion introduced in each amplifier may be somewhat greater with the additional loading, the total cumulative distortion will be no greater than that in present 25-35 cascaded amplifier systems operating with fewer channels.

These individually smaller distribution systems are fed from "hubs" near the center of each service area. We try to design the reduced service areas and the hub locations to coincide with generally accepted neighborhood or local political boundaries. We have been using the concept of hubs and reduced cascade lengths for at least five years to improve the performance of 300 MHz/35 channel systems which we were building. The improvements in system performance, reliability and maintainability are proven and substantial. The concept may be extended to 400 Mhz/54 channel system design with considerable confidence and experience.

The hubs are connected to a "master head-end" by means of a "transparant" multi-channel signal transportation system. Alternately we may replicate most of the "master head-end" at each hub. In most cases we choose a multi- channel microwave system provided by Hughes Microwave Products, called "AML" (Amplitude Modulated Link). This microwave system provides multi-channel transmission in the 12.7 - 13.2 GHz band. It is very effective over distances up to 12 miles. It can be used over greater distances with a small compromise in transmission reliability. These microwave systems are "transparant" in that they contribute no significant noise or distortion to the channels being carried. The use of AML allows large areas to be provided with high quality expanded capacity service by breaking the area down into smaller service areas interconnected with the "master head-end". There is more than ten years of experience with AML transmission systesm in several hundred installations. AML systems are very reliable, usually more reliable than the long "super- trunk" cable transportation systems that they replace.

In situations in which AML systems cannot be used or are undesirable, special "supertrunk" systems using FM transmission, feed-forward amplifiers, or optical fiber transmission could be used.

We minimize the effect of increased cable attenuation at 400 MHz by using cables with lower attenuation than those which are commonly used. We prefer "fused disc" cable manufactured by General Cable. This cable uses air as the dielectric - the space between the inner conductor and the outer sheath. This cable has about 15% lower loss than the foamed polythylene plastic types commonly used in 300 MHz/35 channel systems. The following table compares the two types of cable:-

3/4" trunk cable

Maximum Loss dB/100' at 68 deg F

Freq.	COMMSCOPE PIII+ (foamed plastic)	GC FUSED DISC III (air dielectric)
300 MHz	0.90	0.80
400 MHz	1.05	0.93

The 13% improvement offered by the fused disc type cable makes up for the 15% closer amplifier spacing that might otherwise be required. The fused disc cable has about the same loss at 400 MHz as the more conventional foamed polyethylene cables do at 300 MHz.

2. The use of improved transmission technology, specifically harmonically related coherent carrier systems (HRC).

The individual channels in the cable system may be compared to the keys of a piano. The low channel numbers correspond to low frequency or pitch, the higher channel numbers corresponding to higher pitched keys. The channels on a cable system are not "tuned" with any particular care or regard to their interaction with each other. All the channels "play" at the same time, like a great 35 note chord. If the channels are not all in proper "tune" the resulting "dissonance" due to amplifier distortion is very annoying. In an HRC system the channels are all in "perfect tune" having a simple harmonic relationship to each other. There is no "dissonance" when they all "play" together and the impact of amplifier distortion is significantly reduced. The benefit of HRC is real and substantial - so substantial that a 54 channel HRC system will "play" as well as a 35 channel conventional system.

Extensive testing of coherent carrier systems has shown that they allow at least 5 dB higher operating levels with the same distortion levels as experienced with non- coherent carrier systems. Alternately they create reduced distortion at the lower operating levels. The effect is to allow amplifiers to handle the additional channels without any more distortion than when 35 channels are handled in a non-coherent system.

3. By having additional transmission techniques in reserve for future further improvement of system performance.

More than five years ago we published papers describing the technical limitations on cable system performance and outlining the techniques available for improving system performance. One of the techniques described but dismissed at that time (NCTA convention, May, 1972) as costing too much money was "video synchronization". This technique is now affordable in large systems. It would add about $400,000 to the cost of a large system master head- end - a substantial sum of money but considerably less than the $1.5 million that the technique would have cost five years ago. Drastic reductions in the cost of digital technology has reduced the price of video synchronizers. The cost may drop still further as the cost of digital memory is further reduced. Digital frame synchronizers that cost $25,000 per channel a year ago are now available at $12,000 per channel.

Synchronizing pulses define the "edges" of the TV picture. They are the "black frame" around the picture but masked from view by the frame of the TV set. These synchronizing pulses are the highest power part of the the TV transmission. If we synchronize the sync' pulses on all the channels we have the power peaks occuring simultaneously on all the channels. The worst amplifier distortion occurs during the synchronizing pulses and affects all the channels being carried. If these synchronizing pulse peaks occur on all channels simultaneously the worst distortion occurs in the part of the picture which is the "black" frame, out of sight at the edges of the screen. The effect is as though system operating levels were reduced by 2.5 dB. This technique is still expensive, but now affordable in large systems.

WHEN?

CABLE:-

Now!

We tested available cables more than two years ago. Every one of ten reels of main line trunk and distribution cable tested (foam-dielectric type) had acceptable characteristics beyond 400 MHz. Since that time COMMSCOPE, one of the leading manufacturers of foam-dielectric type cables, has announced the general availability of cable specified and guaranteed to 450 MHz (COMMSCOPE PIII+).

We tested General Cable's fused disc type cable and found that the cable was acceptable except for a narrow frequency band around 308 MHz. General Cable has modified their manufacturing process to overcome this deficiency and is now delivering fused disc cable specified and guaranted to 400 MHz. General Cable is the largest American producer of telecommunications cable after Western Electric.

We have tested a number of reels of our preferred service drop cable and have found that the performance to 400 MHz is quite acceptable - a normal extrapolation of the present performance at 300 MHz. We have negotiated with the manufacturer to obtain a guaranteed specification to 400 MHz for cable TV service drop use.

We prefer the fused disc cable for trunk and distribution use in larger 400 MHz systems because of the low loss and the improved characteristics at 400 MHz. The higher loss foamed-dielectric cable would be quite acceptable in smaller systems.

Air-core cables become more attractive at higher frequencies because the foam-dielectric cable departs somewhat from the square root law at higher frequencies. The foamed-dielectric cables are higher in loss at 400 MHz than the square root attenuation law predicts. Similarly we prefer foamed-dielectric drop cables at 400 MHz even though we have usually used solid-dielectric drop cables at lower frequencies. The foamed-dielectric has a greater air content than the solid-plastic dielectric and hence has more attractive attenuation characteristics at higher frequencies.

Various other air dielectric cable constructions are possible. We have no doubt that other cable manufacturers will soon announce alternative air core cables for cable TV application.

AMPLIFIERS:-

Very soon!

We have assurance of amplifier supply from at least three major manufacturers - Jerrold, Scientific-Atlanta (S-A) and Texscan-Thetacom. Jerrold and S-A have made public announcements to that effect. Both have accepted orders for 400 MHz systems. S-A and Thetacom have assurances from Motorola that thin film hybrid amplifier modules (the electronic heart of a cable amplifier) are available. Thetacom has accepted orders for 400 MHz line extender amplifiers for May delivery. Jerrold has actually shipped some 400 MHz amplifiers and initial deliveries from S-A are expected within a few weeks.

Motorola recently announced (1980 February 05) that 400 MHz hybrids (a pair of 17 dB gain blocks) were indeed in production. Parts numbers, prices and detailed specifications have been provided to amplifier manufacturers. A 34 dB "hybrid" gain block (used by some manufacturers in line-extenders) is in development and will be available in about six months. Motorola's spokesman said that the new hybrids had improved characteristics yet retained all the reliability features of the 300 MHz versions. The new 400 MHz hybrids have better characteristics at 300 MHz than the previous 300 MHz versions. He said that there was no "bad news" associated with the introduction of the new 400 MHz hybrids. The new hybrids are priced about $10 higher than the 300 MHz versions at this time. TRW announced, at the same meeting, that they would make similar product production announcements within a few weeks. Motorola and TRW are the sole suppliers of thin film hybrids to the industry. Both manufacturers now have facilities for testing and checking the specifications of hybrids to 400 MHz with up to 54 channels of loading.

S-A and Thetacom are now confident of 400 MHz hybrid supply from Motorola and are moving toward 400 MHz amplifier delivery. We have been promised early delivery of trunk, bridger and line-extender amplifiers from S-A beginning in June, and line extenders from Thetacom beginning in May. Jerrold uses its own "thick film hybrids" in one of its amplifier lines and found that it could upgrade this particular amplifier to 400 MHz operation with its own technical resources and without any wait for delivery of 400 MHz thin film hybrids. The remainder of Jerrold's amplifier line will be upgraded to 400 MHz as soon as Motorola and TRW make the necessary hybrids available (later this year).

All three of these manufacturers have checked the detail of their amplifiers and associated passive devices (splitters, taps, connectors, etc). Some changes are necessary. Power passing filters have been redesigned to operate past 400 MHz. Equalizers and automatic gain and slope control circuits have been redesigned. One minor compromise seemed general. It may be necessary to restrict the up-stream return path to the 10-35 MHz band instead of the usual 5-35 MHz band. This eases the frequency extension to 400 MHz since a full octave (5-10 MHz) of bandwidth has been removed at the low end in favour of a partial octave (300-400 MHz) 100 Mhz bandwidth extension at the upper end. This is an acceptable trade-off. Subsequent development will probably restore the 5-10 MHz spectrum.

We confidently expect that additional amplifier manufacturers will announce and/or show 400 MHz amplifier equipment at the National Cable Television Association (NCTA) convention in Dallas, in May.

Passives (splitters, directional couplers, subscriber taps, power-inserters, etc.) have been no great problem. We have checked the characteristics of many manufacturers' types and have found them to be acceptable or easily modified. The change of specification range from 5-300 MHz up to 10-400 MHz has eased the problem since the ferrite material commonly used in such devices can be chosen for higher frequency use without concern for tight specification at lower frequencies (below 10 MHz). The current boom in the cable system equipment business has attracted sveral new suppliers who are designing devices with attractive specifications past 400 MHz. A number of these new lines will be shown at the NCTA convention in May with deliveries availabe immediately afterwards. These lines include power dividers, directional couplers, power-inserters, subscriber multi-taps, subscriber splitters and baluns.

The 400 MHz amplifier hybrids use no more electric power than the 300 MHz versions. There is no greater heat dissipation problem or power feed problem than with 300 MHz amplifiers. Hybrids have traditionally been operated with greater amounts of current and heat dissipation as greater channel loadings were imposed on them. We are using other means to accomodate the extra channel loading and we are not increasing the current and heat dissipation of the hybrids in our 400 MH amplifiers. A few more amplifiers might be used so that as much as 15% more power might be required. The use of air-core (fused disc) cable instead of foamed dielectric cable makes up the difference in amplifier numbers if power feed and amplifier number is a concern.

The air core cables which we prefer have a larger center conductor and hence reduced ohmic losses for cable power distribution. Cable power distribution is significantly more efficient with these air dielectric cables than with comparable size foamed dielectric cables.

We are using 400 MHz amplifiers with the same gain at 400 MHz that similar amplifiers previously had at 300 MHz. Reduced amplifier gain has sometimes been used as a means of handling additional channel loading and/or reducing amplifier distortion. We are using reduced cascade lengths (12 trunk amplifiers) and improved transmission technology (HRC) to handle the amplifier loading and distortion problems.

<u>CONNECTORS</u>:-

Now!

We have tested cable splice connectors and find them quite satisfactory up to frequenices beyond 400 MHz. The amplifier and passives manufacturers supplying our requirements have tested the connectors associated with their products and have found them to be satisfactory with few exceptions. Acceptable connectors are certainly available to replace any connectors that have unacceptable deficiencies at 400 MHz.

<u>CONVERTERS</u>:-

Soon!

Even 300 MHz/35 channel systems require the subscriber to have a supplemental tuning converter to tune all the channels. A 400 MHz/54 channel system certainly requires the use of subscriber converters. S-A has developed an all new digitally tuned 400 MHz/54 channel converter, including the RF tuner section. Deliveries will start in the middle of this year. Jerrold has announced a new digitally tuned "cordless" 400 Mhz/54 channel converter which will be shown at the May NCTA convention. Deliveries will commence soon afterward. Lindsay will show "cordless" 400 Mhz/54 channel converters at the NCTA convention with deliveries to start a little later in the year. GTE/Sylvania has indicated that a 400 MHz version of their popular digitally tuned converter will be announced at the May, 1980, NCTA convention. Oak will make a similar announcement at the convention. By December of 1980, when large quantities of converters will be required, they will be available in several models and from several sources.

Converters for 400 Mhz/54 channel operation will probably all have "digital" keyboards for tuning selection. Mechanical slider, push-button or rotary switches become ungainly when 50 or more tuning selections are required. Digitally controlled converters have been available from GTE/Sylvania for almost two years in a 40 channel version. Their practicality has been proven by large scale production and acceptance of the GTE/Sylvania version. The new 400 MHz/ 54 channel converters are patterned after the techniques and devices proven in the GTE/ Sylvania model. These converters make extensive use of digital integrated circuits including a microprocessor to offer additional convenience features with small increase in cost. The digitally tuned GTE/Sylvania model has enjoyed great acceptance and popularity in new 35 channel systems.

The ability of converters to handle additional channel loading is similar to that of system amplifiers. The converters are broad band electronic devices which are subject to signal distortion if overloaded. The use of coherent carrier systems (HRC) benefits the converter in the same way as the system amplifier. 400 MHz converters will not require "preselection" to reduce the loading burden on the mixer stage. Coherent carrier systems allow greater channel loading than non-coherent systems. This is borne out by years of experience with tens of thousands of converters in those present 300 MHz/35 channel systems which now use harmonically related carrier technology.

TEST EQUIPMENT

Now!

Laboratory equipment presently has the bandwidth to work with 400 MHz systems. We have spectrum analyzers, tracking generators, frequency counters, etc. from manufacturers such as Hewlett-Packard and Tektronix which operate to 1500 MHz and more. Our more routine system test equipment such as sweep generators and return loss bridges have had 400 and 500 MHz capacity for several years. As an example the Wavetek 1801A CATV sweep generator with 1-500 MHz range has been available since mid 1975. Much of our equipment is routinely purchased with frequency range to 1,000 MHz in order to deal with UHF receiving equipment. This equipment is presently available from experienced cable system test equipment suppliers such as Wavetek and Texscscan. Texscan has undertaken to extend their popular test equipment line, including signal level meters, to at least 400 MHz. Mid-State Electronics has also undertaken to extend the frequency range of their popular test equipment, including signal level meters, to 400 MHz. We have quantities of 400 MHz signal level meters on order from several manufacturersd for July, 1980 delivery.

PAY TV CONTROL EQUIPMENT

Now!

"Negative" trap equipment requires checking and verification of performance to 400 MHz. All of the present manufacturers of such traps are actively bidding on our requirements for 400 MHz systems already under onstruction and suitable negative traps have been ordered from at least one such supplier (VITEK) for new 400 MHz systems under construction in the Detroit area.

Some "positive" trap systems require redesign for 400 MHz.

The operating channels for both types of "trap" systems are chosen to be moderately low in frequency, even in present 300 MHz/35 channel systems. The choice of channels for the "VITEK" type negative trap, which has "third harmonic response", must take into account the system bandwidth expansion to 400 MHz. We have worked out the channeling problem with VITEK and have assurances of immediate availability of suitable traps for use in 400 MHz systems.

"Descramblers" are usually associated with converters. Both Jerrold and Scientific-Atlanta have offered their descrambler systems associated with their new 54 channel/400 MHz converters and operable on all channels right up through 400 MHz.

AML MICROWAVE EQUIPMENT

Soon!

Hughes is completing the modifications necessary to modify their AML system to accomodate input channels up to 400 MHz. They have accepted our order for additional channels in the 300-400 MHz range to be "bolted on" to 300 MHz equipment delivered earlier. The 300-400 MHz add-ons are scheduled for December of this year. Hughes advises us that no special problems have been encountered and they are confident of meeting their December delivery commitment.

RETROFITTING

No!

We do not recommend retrofitting older systems to 400 MHz/54 channel operation, and we have no plans to do so. Older systems which we wish to upgrade to 400 MHz operation will probably require complete rebuild with subscribers cut over to the new plant in an orderly fashion as the new distribution system is activated and the old plant retired. Many older systems require new service drops as the older drops were generally single-shield copper-braid cables. These single-shield drops do not provide adequate shielding even in 300 MHz/35 channel systems. We have found in general that older twelve and twenty channel systems require extensive rebuild even when upgrade to 300 Mhz/35 channel operation is desired.

FIBER OPTICS MEDIATED TELECONFERENCING

Anand Kumar

Times Fiber Communications, Inc.

Fiber optics transmission system can play a key role in the development and implementation of multi-capability local networks. Integrated teleconferencing has been proven to be an effective interactive medium for making day-to-day work decisions and a viable substitute for certain types of business travel. A prototype, intracorporate, fiber optics supported integrated teleconferencing system layout and details are discussed in this paper.

Introduction

Broadband transmission and distribution facilities are finally coming into commercial use as the privacy and security aspects as well as the cost effectiveness of in-house local networks are beginning to be appreciated. The local networks encompass a wide variety of service offerings that include various types of data transmission systems, monitoring and control systems, and video systems. It is expected that the much talked about integrated video teleconferencing capabilities will become a commercial success with the help of the enhanced transmission medium--namely fiber optics. This medium provides a commercial system provider with a flexible, reliable and a high growth capacity facility that not only accommodates traditional operations but adds value by providing new revenue sources. Fiber optics development, which is significantly supported by defense related R & D funds, is viewed from the CATV perspective by organizations such as Times Fiber Communications who bridge the special marketplace of intra business teleconferencing and the new technology. It is the intention of Times Fiber to develop components, methods and practices that are in conformance with the current CATV industry practices so that an orderly transition to the use of a new transmission technology could be effected in a painless way. This presentation is an attempt to look at the development of one commercially attractive service offering that a present CATV operation could offer over a fiber optics trunk. While the plans are for a dedicated teleconferencing link, it is conceivable in the near future for it to be an 'overlaid' service function that adds value to traditional video transmission links.

Integrated Video Teleconferencing

Many studies in the last decade have outlined the advantages of an integrated video teleconferencing service to aid business discussions while reducing the time and travel costs. Integrated teleconferencing refers to the accessibility of data, voice, video, and graphic modes of interaction for the participants of a conference. For large corporations with centralized operations regular use of teleconferencing has been found to be an effective decision making tool. At the middle management working level the integration of various interactive media capabilities such as graphics and data displays would be required to supplement the visual capabilities. The advantages of such systems have been recognized by large carriers such as AT&T and SBS who have definite intentions of offering commercial integrated teleconferencing systems by the early 80's. While the revenue forecasts of such a service linking major cities have been estimated to be in multiples of millions, similar opportunities in an intra-city or community setting have not been widely recognized.

Recognizing the fact CATV systems might be interested in a full capability local network system for servicing the business community, Times Fiber decided to experiment with Integrated Teleconferencing concepts. Obviously ultimate forms teleconferencing service would involve direct business access on a contractual basis, at various points in a CATV network facility connected, if necessary, to long-haul facilities. These facilities would, in addition, carry most of the intra organizational special types of information streams that are generated and are increasingly demanding expensive transmission links.

Teleconferencing Facility Design

Parts of existing building complexes were chosen as the areas to be converted into two teleconferencing rooms. These areas will be aesthetically treated--both in terms of special wall treatments and partition structures--to be non fatiguing environments for meetings. The number of participants will vary depending on the size of the room--but the rooms were designed to accommodate four to six conferees.

The aim of the facility was for it to be totally automatic--namely obviate the need for special assistants to conduct, control or operate the equipment. Once the equipment was turned 'on', only the chairman would have overriding control over an automated voice-cued video system. Broadcast quality color video and high quality spatial-imagery audio system add to the sense of real live participation. Both an overview video scene and select speaker video images are to be transmitted and displayed on monitors. Graphics display capabilities are built-in to be at hand for the participants. A high speed digital facsimile will be located in an adjoining room. Given this combination all hard copy, slide and transparency material can be presented for viewing and comments by the conferees. The objective is to provide quick access within a few seconds, to any type of prepared visual material with sufficient resolution.

The following diagram (Fig. 1) illustrates the system lay out end-to-end. Only one of the two fiber interactive links is shown for the sake of simplicity. Cameras chosen are broadcast quality color cameras that are cued to react in less than 10 ms. to display the image of the speaker. Similarly high quality electret microphones are used for each speaker. While these are the 'lavalier' type, coded FM microphones will also be tried out for ease and convenience of use. The video information as well as the mixed audio information are modulated by an FM carrier through the use of special 8 MHz deviation FM Modulators. These were chosen to provide a 25 dB S/N enhancement that will yield an acceptable level of end-to-end video performance. All these channels of information are multiplexed with the FSK stream from the digital facsimile--essentially added--as they are already appropriately positioned in frequency. The optical transmitter TFC OTL-1101 driven by this multiplexed information stream will be connected to the 11 km length of fiber separating the two facilities. At the other end the optical signal is reconverted by the receiver TFC OR-2111A and after it is demultiplexed is fed through the demodulators. The demodulated signal streams are connected to color video monitors and the high speed facsimile machine. Audio signal recovered is amplified and fed to low-distortion wide dispersion speakers.

A simple sketch of the transmission link (Fig. 2) indicates that the link will be run with two duplex repeaters TFR/A 3000D spaced approximately 3.7 km apart. While only two fibers are required for an interactive conferencing link a six-fiber cable will be installed for experimentation purposes. The cable will be installed in a combination of aerial, direct, buried, and conduit settings. As can be seen in the figure the link loss for each 3.7 km segment is estimated to be about 28 dB. The decision is to use 600 MHz 6 dB/km fiber that is expected to yield an effective bandwidth of about 180 MHz. Considering the different installation methods required to set up the link a fairly rugged cable design that can withstand better than 250 lbs. of installation stress was selected. Special design factors that would prevent thermally induced optical characteristic changes of the fiber were incorporated for longer life span of the cable. Various splices that will have to be made at different points in the cable run will all be done with a fusion splicer. (TFC Model 2030). This fusion splicer can be operated in a portable mode with built-in rechargeable batteries. The splice arc is interlocked and enclosed for field operator safety and typical splice losses have been in the 0.1-0.2 dB range. Special ramping of the fusion arc at the beginning and the end of the heating cycle provides for considerable reduction of thermal stress on the fiber.

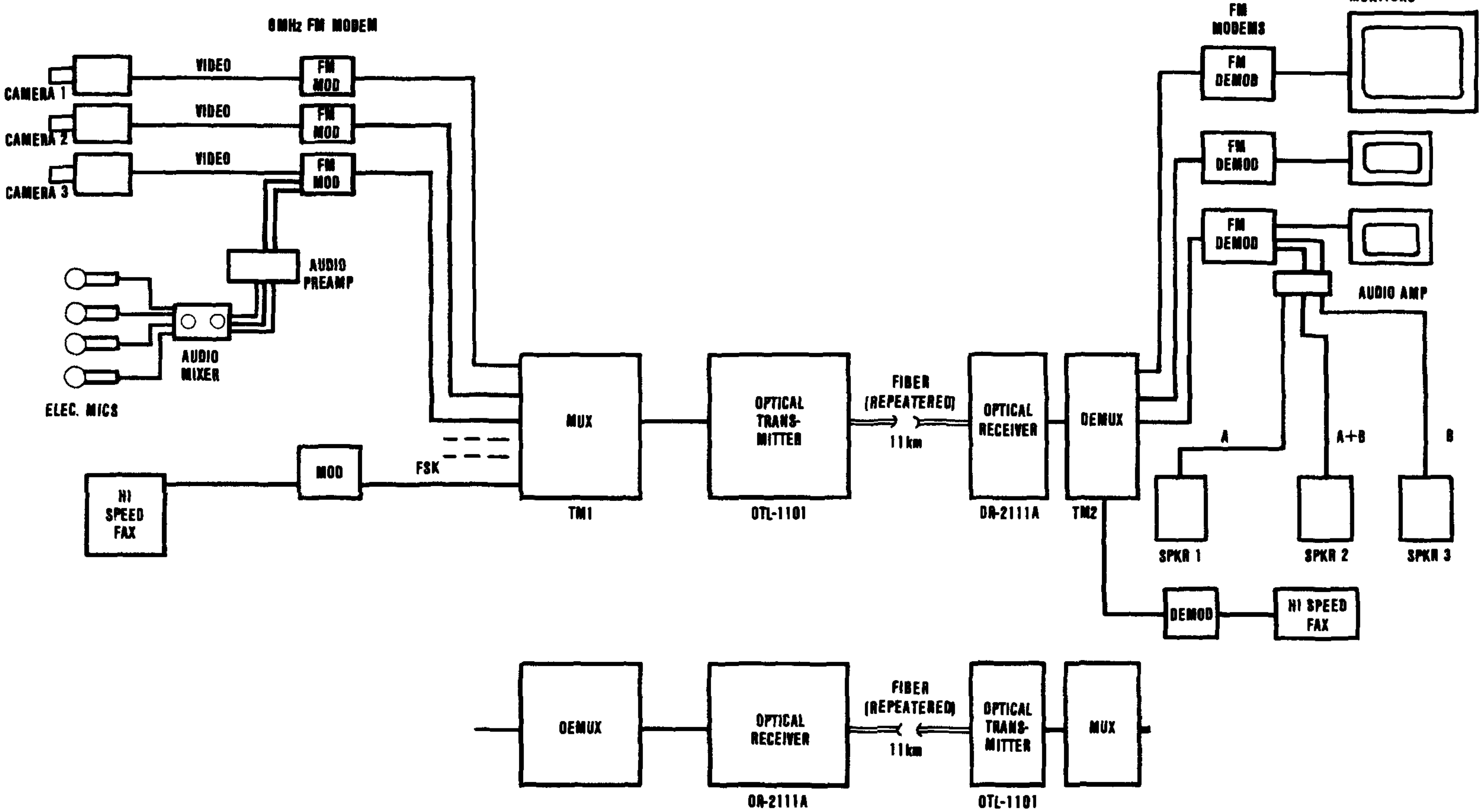
Design performance levels for the teleconferencing system end-to-end are indicated in the table attached (Fig. 3). We expect to achieve better than 50 dB S/N for the video transmission with the use of large deviation low noise FM Modems and reliable fusion splices. Realistic teleconferencing environment can only be achieved by a large dynamic range, low noise audio environment. Availability of program quality channels in the fiber optic transmission medium will help us realize better than 55 dB S/N for the audio link. A transmission medium that is of very high capacity, linearity and reliability still is not enough to make a business teleconference successful if the terminal ends are not designed properly. Some of the key considerations given to the terminal design parameters are listed in the figure. These values represent an environment that is ideally suited for non-face-to-face deliberations that can be carried out over long periods of time. Considerable attempts have been made not to design a broadcast studio environment as this would both intimidate and fatigue the conferees.

Conclusion

We have made an attempt to marry two significant trends in the telecommunications arena, namely teleconferencing and fiber optics. This seems to be a logical evolution as the fiber optics medium provides for a number of significant advantages. Chief among them are the following: 1) Flexibility 2) High capacity 3) Reliability 4) Security and 5) Economic Viability. As long as our energy costs are in an upward spiral, the concept of teleconferencing facilities that can be added on or considered as part of a local private network makes great economic sense. It is not just enough to look at the substitutable savings in such a system, but also necessary to consider the stimulative new application areas that will open up in an organization that decides to install an integrated teleconferencing system.

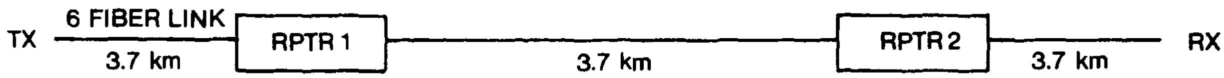
TELECONFERENCING SYSTEM LAYOUT

TIMES FIBER COMMUNICATIONS 1980

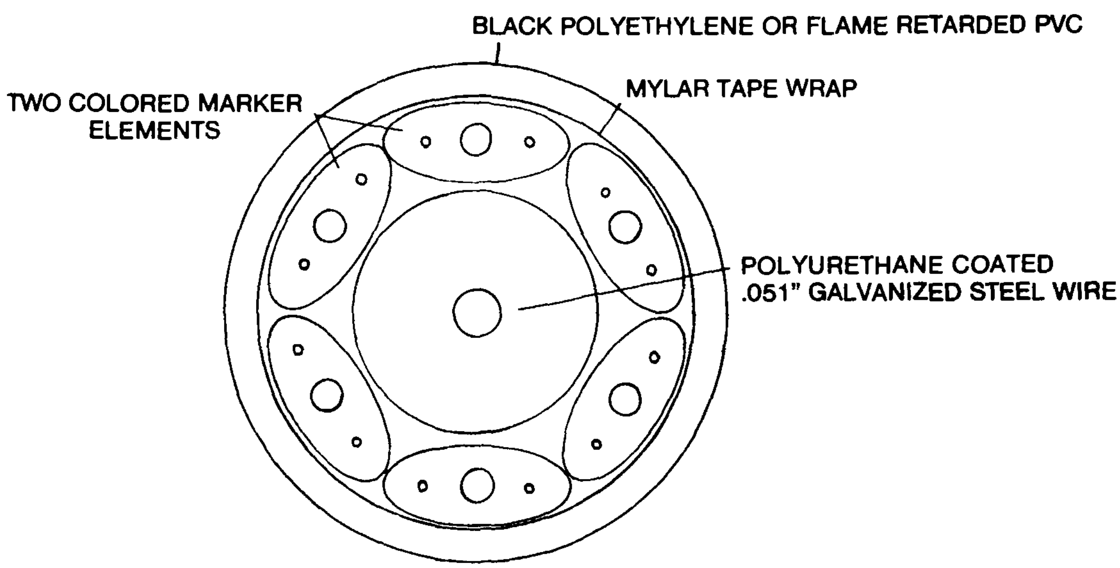


TELECONFERENCING CABLE DETAILS

TIMES FIBER COMMUNICATIONS 1980



POWER LOSS PER SEGMENT - (CONNECTORS + SPLICES + CABLE) ≅ 28dB
(600MHz/km, 6dB/km FIBER)



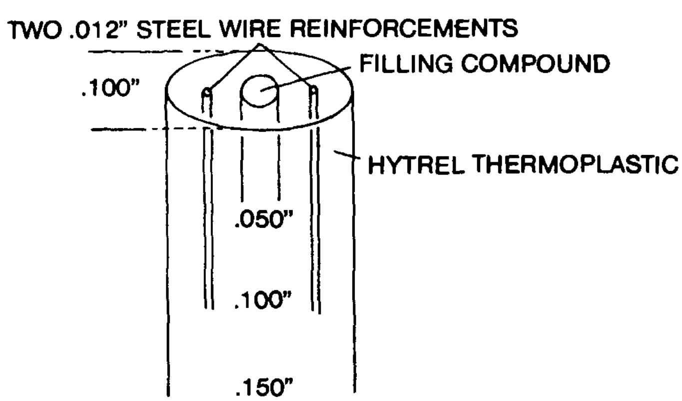


FIG. 3
TIMES FIBER COMMUNICATIONS 1980

EXPECTED PERFORMANCE LEVELS

TRANSMISSION

S/N (WEIGHTED)	≥50dB
DIFF. PHASE (10% to 90% APL)	2°
DIFF. GAIN (10% to 90% APL)	5%
LOW FREQUENCY NOISE	≥55dB
REST CONFORM TO NTC-7 STANDARDS	

CONFERENCING FACILITY

DIMENSION	MINM.: 12' x 20'
ACOUSTICS	≤40dB SPL (A WEIGHTED) ≤0.4 SECONDS REVERBERATION TIME
LIGHTING	≥400 FOOT LAMBERTS ≥40 FOOT CANDLES (MEASURED FROM THE CAMERA ANGLE) BACKLIGHTING TO SEPARATE CONFEREES
GENERAL	TEMP. RANGE (70°F - 75°F) AIR MOVING CAPACITY 7 - 10 TIMES/HR.

HIGH-SECURITY CABLE TELEVISION ACCESS SYSTEM

CLARENCE S. OST
CHARLES E. STERN
ELECTRONIC MECHANICAL PRODUCTS CO.

[57] **ABSTRACT**

A poach-resistant system enabling cable television subscribers to receive upon request certain programs otherwise unavailable (i.e., "secure") while precluding such reception by non-requesting subscribers as well as nonsubscribers. Before transmission of such a secure program the roster of subscribers is scanned at a central control station having compiled subscribers' requests for that program, and a resulting string of pulses corresponding in sequence to the respective subscribers is punctuated with program command pulses timed to designate those subscribers who have requested the program. Transmission of the resultant program command signal string over the cable to junctions with leads to the respective subscribers' television sets results in unblocking of such junction for each of the requesting subscribers only.

The old saw has it, that opportunity knocks but once. This is probably true of those investment opportunities whose potential can only be described as mind boggling. Imagine if Henry Ford had offered the opportunity to become his partner. We are now confronted with just such an opportunity in the future of the entertainment industry. DYNAMITE seems to be the word that most comes to mind when thinking of profits to be made in the proper entertainment vehicle. For instance, in a period of just 10 days, eight million people rushed to see "JAWS".

One of the biggest success stories of TV is that of the cable companies. In 1975 there were over 3000 cable systems in the U.S. serving ten million homes. This figure is now over 4000, and is expected to go much higher. But, as with everything else, there was a negative side to the story. In spite of this tremendous proliferation of cable systems, their pentration (the proportion of the people who could sign up for cable TV and actually did) is not what the cable operators had hoped for.

An encouraging answer to this problem was the advent of the H.B.O. concept which helped its affiliates to attract new customers, thus improving their penetration. The opportunity for penetration has encouraged the increased proliferation of cable systems, which in turn increases the demand for H.B.O. In our own area, Teleprompter upon the introduction of H.B.O., sold the concept to 1000 of its subscribers in less than a month with the cable company receiving 40-45% of the H.B.O. subscription fee.

Taking the projected growth of the cable industry, added to the fact that H.B.O. has a penetration rate of 40% in those areas where it has been available for some time, it doesn't take much imagination to find ten million households on Pay TV this year, and fifteen - twenty million by 1985. Growth of this sort gives tremendous financial muscle. In fact, Everett N. Erlick, Senior VP, General Counsel of A B C says that approximately one half of the nation's homes could be converted to Pay TV for about ten billion, while it would take approximately two hundred fifty billion to wire and convert the other geographically more scattered half. Pay TV, he says would need only a fraction of the first half of the homes and none of the second to siphon off the best of what the networks have to offer. It is pretty difficult to imagine the motion picture industry refusing first run films to such a strong medium. This is especially true in light of the fact that a great many who used to go to the movies once or twice a week now only go once or twice a year. With Pay TV the movie companies have the fantastic opportunity of getting viewers back again by screening the films in their homes. This is not to mention the vastly increased market that Pay TV offers to the promoter of major sporting events and the producer of Broadway shows.

O.K. terrific, but what is Catch 22? Why isn't H.B.O. showing all these great films etc. It is, quite simple, this: When a cable subscriber signs up for H.B.O., a little black box is hooked up to his set. When he wants to switch from regular to H.B.O. programming, all he need do is turn to Channel 13, and flip a switch on the black box.

It didn't take certain do-it-yourselfers long to find out that the "black box" was a standard piece of electronic equipment known as a converter, and that it could be purchased from electronic supply retailers for less than $100.00. With minimum knowledge, any subscriber to regular cable TV could install the converter and poach on the H.B.O. system without paying the H.B.O. subscription price.

Soon there was a long list of viewers waiting for delivery of converters from electronic supply retailers, and soon there were as many nonsubscribers to H.B.O. as subscribers in the three suburban Atlantic County communities described in the example. The same thing happened in other areas where H.B.O. was promoted, sold and installed.

Some systems have sought security by means of scrambled transmissions. Under this system the broadcaster sends out a scrambled signal, rents unscramblers to viewers, then charges the viewers according to how much unscrambling time they run up. This is another "black-box" system, in which the subscriber receives a code number for each offering which he either dials or punches into his "black-box". As with the converter, the unscrambler can be purchased and installed by any do-it-yourselfer. In addition, what is to prevent a group of people, let's say 10, from chipping in to buy one subscription, 9 unscramblers, and have the one subscriber pass on the codes to his nine accomplices; hardly a desirable level of security.

The impact of the problem goes far beyond poaching, for what has happened, is that distributors of movies and promoters of special events were reluctant to allow their high quality entertainment to be seen by as many non-subscribers as subscribers. As with so many arrangements in the entertainment field, their agreement involved a flat fee and a percentage of the "gate", (the paid subscribers revenues). There was no choice but to excessively re-run the few decent events they have and can get and to run current but poor quality foreign films. Subscribers soon became disgruntled and the possibility of losing many legitimate H.B.O. customers poses a threat to the success of the venture.

Unlike the recent past, there now exists a tremendous opportunity for profitable investment in Pay T.V. This is due to the presence of CATV and the amazing capabilities of the coaxial cable. CATV provides the perfect outlet for Pay T.V. According to Reader's Disgest, both the NAB and the NCTA forsee 33 million subscribers for Pay T.V. by the late 1980's or early 1990's.

To appreciate the magnitude of this concept let us hypothesize two probable scenarios:

1. Assume 10% of the subscribers are willing to pay $1.00 to watch an average film. This single showing would produce gross revenues of $3.3 million.

2. Assume 20% of the subscribers are willing to pay $5.00 to watch a blockbuster such as "Jaws"; this single showing would produce gross revenues of $33 million.

The problem of security has now been solved by the development of a truly poach free system by SECURE CABLE SYSTEMS CORP., a subsidiary of The ELECTRONIC-MECHANICAL PRODUCTS CO. (EMPCO) and its Chief Engineer, Clarence S. Ost. EMPCO is the world renowned pioneer of electronic, quality control instruments used in the graphic arts, textile and television industries. S.C.S.'s system is based on the fact that control is in the hands of the cable company, not the subscriber. In the S.C.S. system there is no hardware installed on the subscriber's premises such as the "black-box" of the CATV system. The conventional tap-off located on the telephone pole wires or in a locked pedestal with an underground cable allows the secure channel signal to enter the down-lead without interference. The "black-box" allows the receipt of the pay program which is already in the down-lead.

The unique aspect of the Secure Cable Systems' development lies in its tap-off which acts as an electronic dam. That is, it prevents the secure channel signal from entering the down-lead, until the time that a signal from the head-end, in effect, raises the dam allowing the pay program to flow into the down-lead. This special tap-off leaves the subscriber free to view his regular programming. However, he can only view the pay programming when a signal is sent to the tap-off enabling him to receive the program he selects, which may be on any of the normal channels selected by the cable company. Thus true security is achieved.

In essence, what we have here is a true theatre in the home. A theatre from which the viewer must purchase a ticket to receive admittance. A possible programming format would be as follows: A monthly bulletin would be sent to each subscriber. The subscriber would have a choice of four programs. Each in a different time slot. During the rest of the month the program time slots can be alternated so that each offering can be placed into all possible time slots, thus giving each viewer the chance to see every offering. In order to explain how the above purchase is made, let us again use scenarios. In all the following scenarios, the cable subscriber will receive a program with his monthly statement. Each offering will be identified by a code number.

1. A small cable company. Because of this company's small group of subscribers there is an obvious need to hold capital investment to a minimum. A company in this position could make use of S.C.S.'s manual system which would consist of the subscriber calling the company. Company personnel would manually take the show's code number and the subscriber's account number and punch them out on a keyboard. That data is stored in a memory bank. The memory bank is manually inserted into the command apparatus which sends a signal to the appropriate tap-offs at show time. A ledger sheet for each show containing the account numbers of those subscribers wishing that show will be manually prepared. From that ledger sheet, accounts are billed and distributors paid.

2. In a system of moderate size somewhat more automation would be needed. Orders would still be taken by personnel, however, the keystroke operation would be interfaced with a sophisticated computerized bookkeeping system.

3. In large systems, the highest degree of automation would be essential. In such a system, the subscriber would merely call a special telephone number. The call would be answered by an electronic answering device, which would tell the subscriber to please dial his account his number followed by the code numbers of the shows he desires to see. The information would be electronically interfaced with the command apparatus and the bookkeeping system.

Human nature being what it is, three questions arise; (1) What happens when a subscriber orders a film, and then claims that he didn't watch it and doesn't want to be billed for it? This could be allowed and a credit issued up to a maximum of three times during the subscription year. (2) What happens to a viewer who inadvertantly calls in late? The solution is simple. Just as in any motion picture theatre, there could be two shows nightly. Therefore, the latecomer could watch from the middle of the first show to the middle of the second show or wait until the second show, or watch the show twice. (3) As I'm sure the publishers of T.V. Guide would verify most people don't plan their T.V. watching in advance. Rather, they sit down after dinner, and glance through the program guide making mental notes as to their preference. We can assume that they will act no differently with our system. The question then occurs what happens in a large system where we could be receiving thousands of phone calls in the hour prior to show time. Two options seem to predominate as a solution to this problem. These options could be used singly or in combination. As with any other theatre we could run several shows daily. This option is attractive not only from the standpoint of the above mentioned problem, but from the standpoint of milking all possible revenue from the film. The other approach is to have many trunk lines interfaced with our electronic answering equipment so that thousands of calls could be processed in a short period of time. As mentioned above the two options could be combined to service an even greater number of customers.

If a system were large enough to require 100 trunk lines, we can more than safely assume that three calls per line could be processed every two minutes. Simple arithmetic provides us with the knowledge that we could process 9000 calls an hour. —This is an extremely conservative estimate. The transaction is so brief that it would appear more realistic to double the number of transactions, i.e. 18,000 per hour.

Additionally, it should be pointed out that this system provides an excellent outlet for other vehicles such as stage shows, sports and special events.

Thinking along these lines, it should be remembered that there are several advantages that would accrue to the systems suppliers. For instance, think how much the risk inherent in a Broadway show could be cut, if the producers had the show video-taped and shown on Pay T.V. The paying audience would be tremendously enlarged, by virtue of the fact that millions of people across the country who could never get into New York to see a show, could, at a less expensive price, opt to see it in the privacy of their own homes. The film producer would also have an expense benefit. One of the major costs of filmmaking, is the cost of duplicate prints. An average film, running about 90 minutes, costs about $900.00 per print, as compared to approximately $100.00 for a duplicate video tape.

INTEGRATED SATELLITE AND CABLE BUSINESS COMMUNICATIONS NETWORKS

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ABSTRACT

Innovative communications satellite networks appearing in the early 1980's have the capability of providing, for the first time, a switched wide-band system for integrated business networks offering voice, data, image, and teleconferencing service. This paper considers the current business communications environment, and it describes the architecture of integrated business networks employing satellite backbone and regional distribution networks to interconnect local user networks, local hosts, PBX's, and teleconferencing facilities. Business communication opportunities involving cable TV systems as the regional component of integrated business networks are outlined. Also discussed is a forthcoming local-data-distribution experiment involving integrated cable and satellite transmission links between users in San Francisco and New York City.

1. INTRODUCTION

This paper is focused on emerging business communications opportunities for integrated satellite and cable TV networks. This subject will be considered from the perspective of a communications satellite carrier that offers a full range of integrated communications services. Four aspects of this subject will be addressed:

- The current business communications environment.
- An overview of a switched communications satellite network.
- Elements of a private business network.
- Business communications opportunities for cable television.

2. THE CURRENT BUSINESS COMMUNICATIONS ENVIRONMENT

Timely information is perceived by many observers of the business scene as the key to successful operations (1) (2). However, the gathering, processing, analysis, and distribution of information is no better than the communications that support these information-processing activities. To date, relatively narrow bandwidth communications technology has resulted in the following situation:

Voice	-	Universally available, but dependent for long hauls on extensive terrestrial facilities.
Data	-	Generally available up to 9.6 kbps on the voice network. A few networks in large metropolitan areas with capacities of 50 Kbps or higher.
Bulk Data	-	Special-construction microwave or express service by air or truck.
Conferences	-	Travel by one or more sets of participants to a common meeting site.
Document Distribution	-	Mail or messenger service, limited-rate facsimile.

Wide-band, all-digital, time-division multiplexed satellite communications service, which will be available soon, offers the opportunity to integrate these services onto a single business network. Consideration of a role for the cable TV industry in complementing that opportunity is the subject of the presentation.

3. AN OVERVIEW OF A SWITCHED COMMUNICATION SATELLITE NETWORK

Satellite Business Systems (SBS) is establishing a domestic satellite system, to be operational in early 1981 that will provide private, switched communications networks for integrated voice, data, and image applications. The SBS system is designed to serve the full spectrum of communications needs of a large community of business and government organizations and other communications users. The greatest benefits will be derived from the SBS system by those customers who generate communications traffic at a number of locations geographically dispersed throughout the 48 contiguous states and where requirements include the need for high-speed digital transmission service.

The features of the SBS system concept are shown in Figure 1:

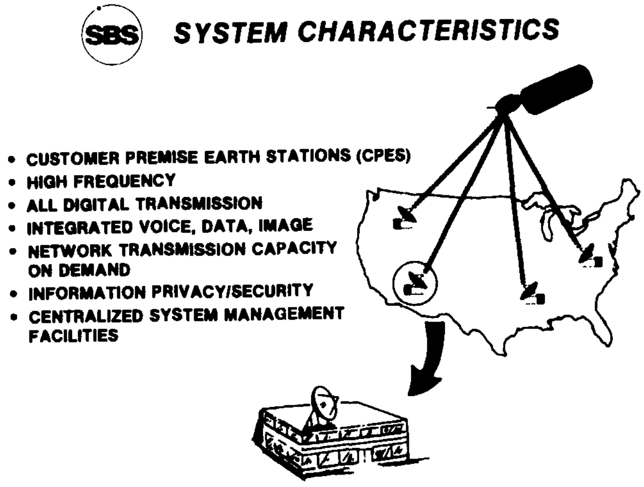

FIGURE 1

By utilizing relatively small earth stations operating at 12 and 14 gigahertz and placed on the customer's premises at his major traffic nodes, the SBS system will permit direct access to a switched, wideband, communications network.

A large, nationwide enterprise may require 20 or more earth stations to support its communications requirements. Through the use of demand assignment, the satellite acts as a central concentrator for a large ensemble of earth station traffic nodes. By permitting continuous real-time assignment of satellite capacity to meet the varying needs of the user, the SBS system will offer an attractive alternative to traditional, long-haul, terrestrial communications systems. Unused communications capacity on the West Coast in a terrestrial system has little or no utility in meeting the traffic demand in the Boston-Washington corridor. In contrast, the SBS system will permit a user's total satellite transmission capacity to be applied to the instantaneous traffic demands of that user without respect to location (3).

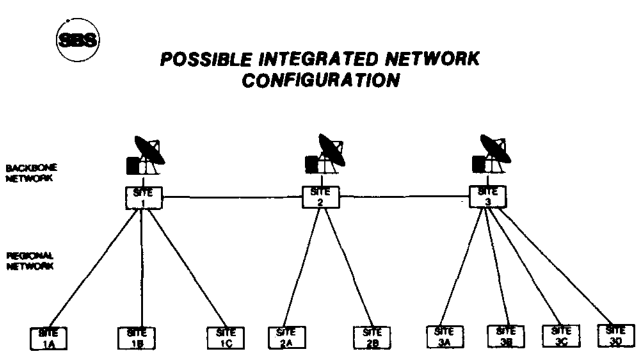

FIGURE 2

4. ELEMENTS OF A PRIVATE BUSINESS NETWORK

As one looks carefully at communications needs in the marketplace, it is clear that a mix of long-haul, regional, and local networks are required to serve anticipated needs. Picture, for example, a regional element of a nationwide corporate network with 12 or more nodes distributed around the region (Figure 2). Of these 12 nodes, three have on-premises earth stations. An area of opportunity lies in connecting customer sites without earth stations to the sites with on-premise earth stations.

A typical private business communications network can be pictured as shown in Figure 3. The inner ring represents the core satellite transmission links. The outer ring represents the boundary of a communications subnet. Note that local interconnect lines, regional extensions, and the necessary voice and data switches are included within the subnet. Users then can interface their PBX's, computers, and terminals to the subnet and concentrate on their primary business.

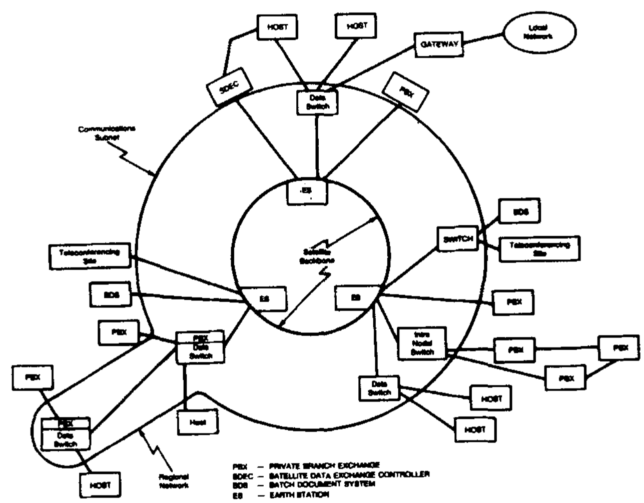

FIGURE 3
TYPICAL BUSINESS COMMUNICATIONS NETWORK

Integration of the multiple communications services of a satellite communications node and a regional network extension can be seen in Figure 4. On the customer premise with the earth station are the voice, data, bulk data, electronic document communications systems, and teleconferencing capabilities that are elements of a total business communications system.

A regional network provides the connections between the earth-station premises node and the off-premises node. This network extension could be a few miles to 50 miles long. At the regional node are communications facilities similar to those found at the on-premises earth-station node.

Bandwidth requirements for the regional network would vary widely depending on local sizing, but should be in the range of:

- o For voice--multiple T1 circuits at 1.544 Mbps (4).
- o For data and fax--56 kbps to 1.544 Mbps.
- o For teleconferencing--up to 3.7 Mbps.

Voice service and low-speed data-communications applications are capabilities reasonably well understood by most users of communications services. High-capacity satellite data channels will create opportunities for users to create new applications that can improve organizational productivity. SBS is supporting the development of three products to demonstrate these capabilities.

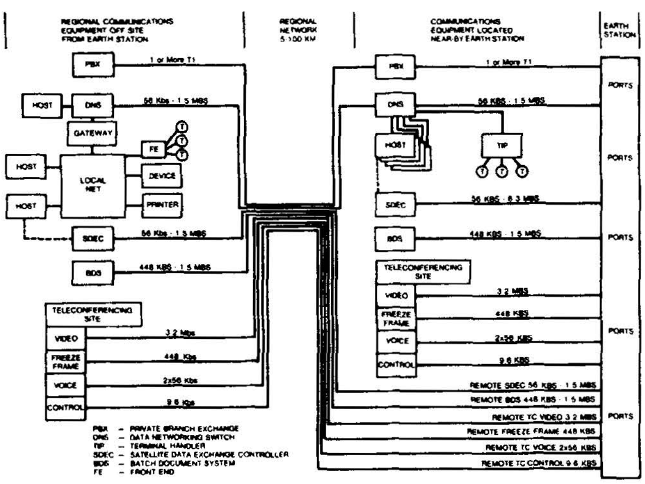

FIGURE 4
INTEGRATION OF MULTIPLE SERVICES

The first is a Satellite Data Exchange Controller (SDEC), which permits high-speed bulk transfer of data between two host computers across a satellite link at data rates up to 6.3 mbps. This device is under development by Bunker Ramo. An efficient satellite protocol is included in this device (5).

The second is a prototype of a new communicating copier that will be able to send and receive copier-quality documents either from point-to-point or to many locations. It will transmit more than 60 pages a minute. At the receiving locations, the pages are automatically collated, stapled, and addressed to multiple addresses. This application has been developed by AM International under an SBS contract.

The third is a prototype teleconferencing system to be assembled by E-Systems, Inc. Figure 5 shows the layout of a teleconferencing room with a video view of another conference site shown on the left screen and a high resolution display on the right screen. An audio system provides a range of frequency response and tonal quality that is superior to traditional conferencing devices. A control console permits

FIGURE 5
TELECONFERENCING ROOM LAYOUT

the conference chairman to select various options such as camera positions, availability of store-and-forward graphics devices, etc. A teleconference site can require data rates of up to 3.7 mbps when video, high-resolution display, audio, and control are included. Figure 6 illustrates possible multisite, multiconference configurations which are feasible.

Plans for business communications networks based on a satellite transmission backbone providing various combinations of voice, data and teleconferencing services are real. Five users are under contract to begin service on the SBS system in 1981.

5. BUSINESS COMMUNICATIONS OPPORTUNITITES FOR CABLE TV

One area of significant opportunity for the cable TV industry lies in providing regional network transmission services for business communications networks. There are a range of techniques for providing regional transmission services, including:

- o Point-to-point analog or digital microwave,
- o Omni-directional digital radio,
- o Fiber optics (6),

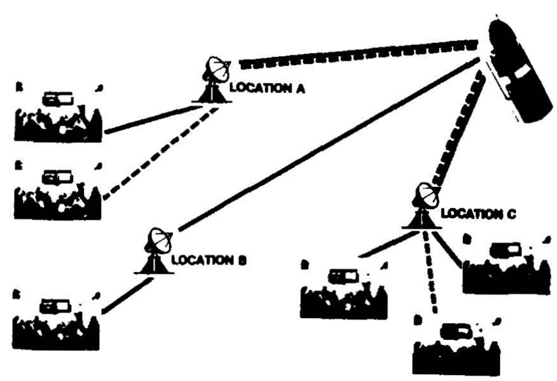

FIGURE 6
TELECONFERENCING CONFIGURATIONS

o Infra-red systems,
o Cable systems,
o Telephone company service.

However, the voice, data, and teleconferencing services that future business communications networks can be expected to provide will require multiple T1 (1.544 Mbps) transmission capacities. Cable systems with data -transmission capabilities are candidates to provide that service by providing bi-directional service and the necessary interface equipment. As a demonstration of that capability, cable systems have been supporting data transmission in Manhattan (7) for several years.

Reflecting SBS' interest in ensuring the availability of cost effective and reliable high bandwidth local loops, we have recently announced our joint plan with Tymnet to demonstrate innovative techniques for intracity distribution of business communications carried between cities via satellite and packet switched networks. This Local Data Distribution Demonstration Program, to demonstrate multimedia distribution techniques, will involve intracity networks in New York City and San Francisco. Although program arrangements are still to be finalized, the plan includes the use of a cable system in at least one of the cities (Figure 7).

LOCAL DATA DISTRIBUTION DEMONSTRATION NETWORK

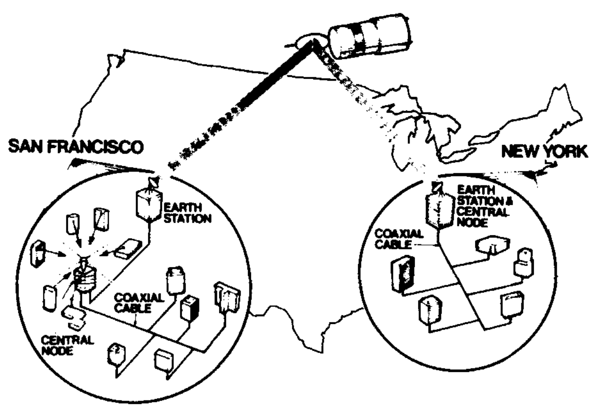

FIGURE 7

A limited number of end-user participants in New York and San Francisco would utilize, on a test basis, the end-to-end facilities established under the program. Digital connections would be provided ranging from low speed to 56 kbps.

The schedule contemplated for the program calls for central nodes and subscriber equipment to be installed by year-end 1980 and for testing to continue through July 1981.

6. CONCLUSION

The phenonmenon known as the information society is estimated to include 46% of our present GNP. This segment will almost certainly continue to grow. Improved communications services are essential tools in supporting this growth by providing the foundation for information processing and information distribution systems. Key to this growth are wideband communications services which satellite and cable systems are capable of providing. Timing for planning regional and local network extensions in support of satellite transmission links is critical as service begins in 1981 with a backlog of additional service demands on hand. There is an opportunity for cable systems to participate in this growth as a regional or local component of an integrated satellite, regional, and local business-communications network. To take advantage of these opportunities, the cable industry will have to consider a number of issues. These include:

o Can the economic feasibility of providing regional network services be established?
o Can reliability standards for business communications be met?
o Are rights-of-way available in areas that would serve business communications users?

Answering these issues is a challenge of decade of the 1980's.

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INTEGRATING TRANSPORTATION INFORMATION SYSTEMS WITH CABLE COMMUNICATIONS

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There are numerous benefits that accrue to the cable operator, the subscribers, the transportation provider, and the local and national governments through the utilization of cable communications for transportation and traffic information dissemination, system management and control. Transportation information can be dispensed at the subscriber's home, at bus stops, major terminals, tourist, convention, and shopping areas, etc. The format and catagories of information is determined after an evaluation of the transportation user needs, the cable and transportation system technology, the institutional and regulatory climate, and the funds available. The cable system can also be used to manage and control the transportation system, i.e., by control of traffic flow, computerized signalization, ramp access control, traffic advisory and vehicle locator systems, as well as for internal management data transmission and report generation.

INTRODUCTION

Several factors make the early 1980's a propitious moment to inject telecommunications technology into transportation systems. The first is the technology: for the cable operator it is character generators, videotext, and teletext; for the transportation system the new technology involves vehicle locator devices and computer data bases. The second factor involves franchise applications. Applications for even the smaller communities now include a second "institutional" trunk. Local officials are overcoming the awe of these huge capacities and are beginning to demand that the operator or petitioner provide applications that will utilize the technology. The third and perhaps the most important factor involves fuel conservation. The fuel savings that arise from the injection of telecommunications into transportation systems are substantial. The U.S. Departments of Energy and Transportation are beginning major initiatives into the conservation of transportation energy through the use of telecommunications.

BENEFITS OF CABLE INFORMATION SYSTEMS

Gaining from these efforts are the cable operator, the subscriber, the transportation operator, and the local and national governments.

Cable system operators benefit in several ways. Increased sales and reduced churn should result from the addition of a significant new information channel. Also possible are revenues from leased lines used to manage such roadway functions as computer coordinated signalization, roadside safety signals, traffic sensors, ramp monitoring, etc.(N.Y.C. has budgeted $40,000,000 over the next five years to computerize traffic controls on 6,000 intersections.)

Public relations and political credits will go to the operator who can proudly point to the new "public service" being operated over the cable system. These credits will accrue to a greater or lesser extent depending on whether it is "free" access channel information, advertiser supported or municipal leased lines.

At franchise renewal time these offerings can be an attractive inducement to the franchisor to continue with the current operator based on this demonstrated cooperative effort.

Similarly, when rate increase applications are submitted, the existance of a new municipal service can have a soothing effect on the expected public outcry.

A final operator benefit arises through the demonstrated vitalness of the cable system. When the cable communication system provides essential community services, i.e. traffic control, the system must generate adequate revenues to guarantee its continued operation in top working order.

Subscriber benefits. By making transportation more available, and by reducing traffic and congestion, the subscribers travel is made more enjoyable and safer. A general improvement to the quality of life should be realized in a community that makes a substantial commitment to the improvement of transportation through communications technology.

By providing information on traffic conditions, fuel prices and availability, and public transportation schedules and routes, the cable system provides the subscriber with information that can be used to reduce transportation expenditures.

Local government benefits. The improved availability of information on bus, train, plane and taxi services will allow more predictable and coordinated service to be offered by the locality. Improved information on vehicle location, and road and traffic conditions, should enable both better management and improved service.

Improved service translates into more ridership and increased revenues.

Improved information should allow the transportation facilities to be more evenly utilized, reducing the need for construction projects aimed at traffic reduction, and the need for additional transit vehicles that congestion and bunching requires.

Public acclaim will go to the municipal official who arranges and/or implements this improvement.

A general improvement to the quality of life should make the community more livable and productive- suitable for business settlement or expansion.

Finally, the local governments transportation planning process will be improved through the information available through the cable system.

National gains. The substantial energy savings that will result from the utilization of cable can reduce our dependance on foreign oil and have a salutary affect on our balance of payments and inflation rate.

It is unlikely that all of the above described benefits will occur in a particular community. They do however, provide an indication of the breadth of the potential beneficiaries.

INFORMATION TECHNOLOGY AND SERVICES

Cable systems can be utilized to provide transportation information in two broad catagories: plane, train, bus, taxi and other mass use transportation information, and traffic control and management systems.

The type of information services that can be applied in either area is dependent upon the technologies of the cable system and the transportation provider.

The technology that a cable operator can use varies from a simple video blackboard of commonly called numbers, to the incredible capabilities that videotext systems allow.

The simplest and most basic form of information is presenting commonly called transportation #'s via a fixed camera on a display board. An audio traffic advisory can be readily added to this video presentation.

The next step in developing a system involves the use of character generators. Varying in price from under $1,000 to over $50,000, these specialized word processors can provide from four pages to an unlimited amount of information. The main limitation of this equipment is the patience of the viewer. Although these machines can provide over 2,000 pages of information, the subscriber has no control over when or for how long the desired information will be on the screen. (Speed reading is essential with this technology.) Through the creative use of such options as varying color characters, video graphics. font intermix, animation, word flash, character flash, etc., can expand this technologies usefulness.

Through the use of teletype input available on the more advanced models, the information can be kept up-to-the-minute with regard to schedule changes or traffic delays.

The cable system architecture also has a bearing on the pertinance of the information provided. If the trunk lines can be designed to follow the transit routes, subdistricting can provide more detailed local bus, train, etc., routes and schedules.

Teletext is the transmission, either over the air or through a cable, of large quantities of information(up to 1,000 pages). By the use of a special adapter, the subscriber can select the page that is of interest and display it on the screen for as long as desired. With this system it is possible to sift through current data(updated every three minutes) on plane, train or bus schedules. The British Ceefax and French Antiope are operating teletext systems which incorporate transportation information. This technology is presently being tested by CBS at KMOX-TV, St. Louis and by KSL-TV, Salt Lake City.

The most advanced- and of course the most expensive-technology for transportation information is the two-way videotext. Developed by the British Post Office, this requires an adapter not unlike that used in teletext. As this is a two-way system, the technology allows the subscriber to transmit data to make or cancell reservations.

Hybrid systems. The use of teletext in conjuction with telephone lines provides the same reservations making capacity as with videotext. Teletext does not, however, have the same volumn capacity as the computer retreivable videotext.

The desirability of schedules and rates is strongly related to their accuracy. As a result of prodding from the Urban Mass Transportation Administration, local transit officials are developing the computer data bases that have long been available to airlines. Interstate bus and train operators have also been developing these data bases. Both have demonstrated a desire to put this information on-line for riders.

A significant improvement to the accuracy of the schedules can be achieved through the use of vehicle locator devices. Through computer interface these allow the constant update of transit schedules. Early results from the Teleride system in Toronto indicates that utilizing this equipment has resulted in shorter waiting times, reduced passenger uncertainty and irritation, and consequently increased ridership and system revenues.

Schedule and route information of this type can be provided to the subscriber at the home, or to the public at terminals and tourist areas. General Motors is now experimenting with public video displays in Cincinatti, with its TIS system.

The second major area for utilizing cable-management and control devices. For many years traffic departments have sought to improve vehicle flow through the coordination of traffic controls via telephone lines. Since 1974, Columbus, Ohio has been using a Tocom, Inc. control system to improve vehicle speeds, reduce stop-and-go situations. As a consequent benefit, increased fuel consumption and reduced air pollution have resulted.

There are several control areas in which cable can be used.

Area-wide signal coordination involves the placing of remote sensors on streets and feeding vehicle count and traffic flow information, via cable, to a control center. A traffic ranger, sitting in a distant control room, monitorsand adjusts the system via switching and route alteration. A slo-scan TV can be used in conjuction with these controls.

By establishing a wayside traffic advisory system, traffic can be diverted to less conjested routes. Signs indicating speed, road conditions and weather advisories, detours, etc. can be controlled by the Traffic Ranger through the cable system.

Highway ramp management. By monitoring and controlling access to highways, considerable improvements in travel time can be achieved. In Dallas, Texas this system reduced travel time by 30%, increased speed by 32%, and reduced accidents by 18%.

Automatic vehicle locators are operable over cable and provide location information on buses and other transit vehicles. The location information is translated by computer into arrival time, and transmitted through the information system with up-to-the-minute data.

A TRANSPORTATION CHANNEL-YES/NO? HOW?

The desirability of a transportation channel will depend on several factors: the extent of the perceived transit/traffic problem; ease of use of the technology; the capacity and effectiveness of the proposed technology; and the regulatory, institutional and financial barriers.

Before incorporating transportation information on a cable system the following should be answered:

What are the information needs of the area?

Are there traffic or transit delays which will be meliorated by a control system?

What are the perceived needs of the community?

What technology is available to the cable operator?

What technology and information systems are available to the transportation operator?

Who is to take the lead in developing the system?

Who is best able to operate the system?

Are the traffic and transit officials in agreement with the system concepts?

What will be the cost of the system, and more importantly, who will pay the development and operating expenses?

Can sponsors be found, e.g., travel agencies or airlines?

What changes to the transportation system will result from implementing the system, e.g., will bus revenues be reduced by the development of an effective taxi group riding system?

Conversely, will good bus service drive the taxi out of business?

In what public areas should the transit information be displayed-bus stops, terminals, tourist and convention areas?

The answers to these questions will differ in each community. Only after these questions have been answered to the satisfaction of all parties should the development of the channel begin.

The initial step in implementing the channel should be small. The blackboard approach described earlier is the simplest and safest approach. Let the system grow incrementally.

When the system is new, careful planning can provide excellent results. When possible be sure to run the trunk within reach of the major roadways. Evaluate if subdistricting willallow improved information delivery. Check the proceedures and determine if interconnection with adjacent or nearby systems is required or advisable.

CONCLUSION

With the recent developments in CATV and transportation technology, and the federal government awakening to the fuel conservation possibilities of utilizing telecommunications to improve transportation efficiency, the opportunitynow exists for the cable operator to provide a vast array of transportation information and management services. Only CATV can deliver on all of the potential applications. However, if the opportunity is not taken, other technologies will move in. The Knight-Ridder experiment in Coral Gables, Florida is capable of handling most of the functionsdescribed above. Viewdata has been licensed to GTE. CBS is experimenting with teletext. Combined these technologies can duplicate the role of cable in transportation.

By moving boldly into these areas the cable operator can benefit both financially and politically. However, action must be taken soon or the area will be preempted.

ACKNOWLEDGMENTS

To Ronald Adams I owe my knowledge of the transportation industry. To Patrica Shubitz I owe this paper, for without her support it would not be.

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IS SCRAMBLING THE ONLY WAY?

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ABSTRACT

A network of distributors must be created within and from the cable industry to market packaged video programming to customers beyond the reach of conventional cable. These companies will specialize in the marketing techniques, siting, installation, and maintenance services for the hardware, and collection of fees for the programming. In this way the unpalatable prospect of scrambled signals from the satellites can be avoided, and at the same time profitable new customer bases will be developed.

To develop and refine this approach while preventing signal theft by unscrupulous dealers and end users will require the cooperation of programmers, cable operators, and manufacturers within the NCTA.

BACKGROUND

Thanks to the efforts of the program suppliers, cable operators, and equipment manufacturers in this industry there is a very large segment of the general population which is aware of, and would like to have, the kind of video programming available to us only from satellites (and heretofore through cable systems). But many of these potential customers do not presently have cable; indeed, many of them have very little chance of getting the cable in the next few years because of their location and the problems of stringing conventional cable to give them service.

There has been much press about the supposed proliferation of inexpensive satellite earth stations falling into the hands of private individuals who erect them in their back yard and steal signals from the fixed C-band satellites currently in use. This in turn has raised the question of whether or not the airways are free; an instant generation of "experts" on communications has developed who cite "examples": from the FCC annuls, or from industry sources, or from congressional representatives to further their particular view on the issue.

I don't know if the airways are free, or not. I'm not a communications lawyer (though they don't seem to know either!). I do know that the FCC was very clear in its deregulation order in October of 1979 in which they said in part..."domestic satellites are a part of the modern telecommunications network and all existing satellites have been designated as fixed, not broadcasting satellites...signals transmitted over existing domestic satellites are radio communications intended for a specific audience, not for the general public. Hence, we conclude that the protections of Section 605 remain applicable to existing domestic satellite communications. Moreover, we recognize that as an alternative to legal enforcement of Section 605 programming parties have the option of scrambling the signal transmitted and thus making unauthorized reception and use much more difficult...we wish to emphasize that we are concerned about illegal interception of common carrier transmissions...however, we do not believe that our objectives of minimizing the regulatory burden in this area should be held hostage to those individuals who may be inclined to commit illegal acts."

TECHNICAL CONSIDERATIONS

Some industry representatives have reacted to this situation with proposals that we scramble the signals from the satellites.

Two primary interests served by securing the video message are that only a properly designated end-user may view the decoded signal and that the encoded signal is not fit for redistribution or sale by any unauthorized party.

The encoding or scrambling of the video may take place at baseband or at RF depending upon whether the originator or an intermediate distributor who handles the RF signal is responsible for securing the program material.

Independent of whether the scrambling

of the signal is accomplished at baseband or at RF, it is the amount of security and the quality of the final signal which dictate the degree of sophistication and the cost of a given scrambler/descrambler implementation. There are two general cases which will serve as examples of scrambling needs;

1. Prevention of viewing by unauthorized end user.

   Techniques which are low in cost and also low in security, relatively speaking, are often used for this purpose. Some techniques used are:

   a. Inversion of the composite video signal; this can cause improper clamping and loss of synch at the receiver,

   b. Insertion of an interfering carrier in the passband of the signal. This can cause AGC saturation, loss of synch and severe distortion at the receiver.

   While these techniques may be simply implemented they also may be defeated relatively inexpensively and in the case of the second example leave a residual distortion which cannot be removed.

2. Prevention of unauthorized reuse of a broadcast quality signal.

   The security and performance characteristics required for this purpose necessitate sophisticated techniques and high precision in both the scrambler and the descrambler. Virtually no residual distortion must be present in the decoded signal and decoding the signal must be possible only at great expense. The development and implementation costs of this system are substantially higher than those of case number 1.

   If secure audio is to accompany the video transmission, the degree of security is generally commensurate with that required for the video, as are the cost comparisons. Digitizing the audio immediately provides a moderate amount of security at modest expense and provides one step toward highly secure audio scrambling.

OPPORTUNITIES FOR NON-TECHNICAL CONTROL

Scrambling of packaged video programming will penalize us all in terms of the cost of the programming, system reliability, industry logistics, hardware costs technical quality, and consumer acceptance The issue, it seems to me, isn't really whether the airways are free. It's what we are going to do with the existing opportunities we have with our knowledge of satellite distribution, the wonderful programming available only to us, and our strengths as an industry. We should not be spending energy, dollars, and time developing devices to prevent prople who want it from paying for our services. And they are willing to pay!

While there are certainly ways to secure video transmissions using technical devices, I submit that there are other non-technical ways to essentially secure the video transmissions...the satellite programming that we are all so vitally concerned with.

I do believe that we've got to take pro-active steps to capitalize on an opportunity. We have been given (indeed many of us fought for) a marvelous chance to slightly modify our thinking and approach to the way we use satellite distributed programming. Manufacturers, for example, must respond with new equipment ideas, programmers must develop new rates for new markets (and some of them have) and begin to expand their concept of what an affiliate is, and cable operators need to create subsidiary companies to specialize in the marketing and service of these new areas.

We can't afford to limit our growth and ability to compete against other distribution technologies by thinking of ourselves as being only in the business of stringing cable to add subscribers.

Let me tell you why.

EXISTING MARKET OPPORTUNITIES

There is most emphatically a market for this programming that we are not now serving. There are more than 1,000,000 homes in the U.S. that receive no television at all; another 5,000,000 homes receive two or fewer channels of inferior quality broadcast television. Many of these will be customers. There are 230,000 multiple unit dwellings in this country representing 18,000,000 potential subscribers, many of whom do not have cable services. Several million of these households cannot be effectively served by conventional cable, but stand-alone earth stations represent an ideal solution to their needs. There are 37,000 hotel properties representing 2,000,000 rooms and it is certainly no secret that the lodging industry is clamoring for programming whether they have cable or not. There are 7,000 hospitals with 1,400,000 beds where patients, in many cases, are heavily influenced by amenities such as television when they select doctors and thus hospitals. And all of these are markets for today...in many cases they lie within your franchises but you haven't reached them with your cable because they lie in remote corners of your franchise or in areas with low single home density.

Some of you now may be thinking, "But I can't put up an earth station there. How do I control the reception of programming? That's not like the cable business!" Well, let me share a few things with you. Yes, people can buy an earth station and just take the programming... they're doing it.

DISTRIBUTOR IS IMPORTANT

But I've talked with some of these people, and in many cases they aren't so thrilled at all. Consider the problems being experienced by the unfortunate few who have bought cheap earth stations from irresponsible pirate dealers...they're already having service problems, their dishes are blowing away, they have discovered in vivid color the real meaning of impulse noise. Some of these units will be discarded in disgust...because they weren't bought from a responsible distributor who knew how to market, professionally install, service, and provide the programming for these earth stations.

Should we really get into such a stew over these "backyard boondoggles" and scramble the life blood of our entire industry to cut them off the air?

Remember, I just quoted the FCC as saying that we should not be "held hostage" to these people. It is not necessary!

When we think of the need to secure the video which we all play a role in distributing, we must begin to think of ways to do that without degrading the signal, without reducing system reliability. Let us not hold ourselves hostage to a very small number of dedicated hobbiests who are willing to overcome significant obstacles to get satellite television.

We've talked about opportunities; we've taken note of the fact that homeowners, apartment managers and innkeepers are willing to pay from $10,000 to $30,000 for satellite reception as proof of the opportunity we all have. The public wants our service...why must we necessarily make drops from a coaxial cable suspended on poles? Why can't that drop be an earth station? We've looked at one alternative: that is the marketing of this equipment through a network of distributors who understand the industry, the programming, and the hardware. We've seen that specialized hardware can increase user acceptance of the product while at the same time maintaining security of the transmitted video and program revenues for the distributor.

DISTRIBUTORS PROVIDE SECURITY

I prefer not to talk about direct satellite-to-user broadcasting at C-band with our present space craft...the system clearly was not designed to operate this way and the present industry structure certainly does not support this.

At Scientific-Atlanta, for example, what we are doing is not "direct". Our distributor (the cable operator) just as he always has, markets a service, installs the necessary hardware, collects programming fees, and provides maintenance. In some cases he owns all the hardware (as for a condominium or apartment) and in others owns the critical system component in the event that he doesn't lease the entire system.

We have developed special user interface devices which contain security and allow tuning of the microwave receiver only to those channels which have been marketed through our distributor (and by the way, greatly facilitate his installation as well as the user acceptance of the equipment).

Fig. 1. Remote Control Tuner with Security

The distributor provides service, maintenance, and financing and the whole range of services that are necessary to have any kind of a viable on-going business. Can you imagine buying a video tape recorder off the back of a pickup truck parked near a busy intersection outside of town? Would you buy it from a dealer who couldn't also sell you video tape and pre-recorded program material? I think the market for such a thing would be very limited indeed.

INDUSTRY COOPERATION

Let's think for a moment what else we can do together as an industry to help extend our businesses into new areas to grow and to compete from a basis of strength.

Programmers can help by establishing special rates for stand-alone earth stations - like ESPN has done for example. Manufacturers could perhaps pay a royalty fee to some kind of a tribunal for later distribution to programmers for every unit of product which they deliver to certain markets, or they can form joint ventures with large program suppliers and cable distributors for complete packages which contain hardware allowing only the specified programming to be tuned. Competition among programmers is intense and new entrants with lots of cash are coming into the field as the future of our industry gets better all the time. With their fresh approach they are investigating new ways to distribute their programming to as many customers as they can possibly identify. There are many sources of programming, and hardware for the specialized job.

Now is certainly not the time to lapse into a protectionist mode and scramble signals. This is the time to move out aggressively as an industry to find new ways to capitalize on our strengths and compete for profitable additional business. I am pleased to have the opportunity to speak at NCTA on this because I think it is exactly the forum for this discussion - not the courts, not the FCC. NCTA should establish an industry committee to address this area, identify and recommend ways to move ahead without scrambling.

JERROLD DATACHANNEL - THE OPTIMAL INFORMATION DELIVERY TECHNOLOGY FOR CABLE

KENNETH L. COLEMAN

JERROLD DIVISION
GENERAL INSTRUMENT CORPORATION

The purpose of this paper is to provide a marketer's perspective on our PlayCable product line in the context of new information services delivery over cable systems.

Normally, a marketer's job is to research the marketplace and then predict future customer needs based on current trends. The problem with the new information services revolution is that that just doesn't work that way. The information revolution that's now taking place, both within cable and without, is certainly fueled partly by a pent-up demand on the part of consumers for more information.

However, that in itself is not nearly enough to explain the phenomenon. Equally important is the rapid change in technology which enables information services to be available at much lower costs than previously. As a result, products and services which have been uneconomical in the past, suddenly become economical, but you sure can't tell that by asking the customers what they want.

Obviously, this information revolution is a marketer's nightmare from the standpoint of forecasting exactly which products consumers will buy at a given point in time. Said another way, it's easy to create new information hardware with exciting new features. It's very hard to build a product which is really a good investment for cable operators in terms of predictable revenue and pay back.

A second important difficulty in discussing information services products for the cable industry is that all of us are treading in new territory to some extent; territory which can also be occupied by the telephone companies. Constraints which have previously been imposed by regulation, either have been relaxed recently or may well be relaxed in the future, with the result that the competitive framework in which we all live is changing dramatically. Therefore, we've got to consider the impact of switched network technology as well as cable network technology as we develop products for our industry. We have to be realistic about what we can deliver with a competitive advantage over the telephone system. Most of us haven't spent enough time thinking about telephone technology and products to have a comfortable feel for the upcoming competitive battle for the consumer's dollar.

With these uncertainties as a backdrop, we at Jerrold have been working for some time to develop a comprehensive plan for an information services product line dedicated to the cable industry. Here are some of our basic considerations:

First, consider the whole universe of information services. Figure 1 plots

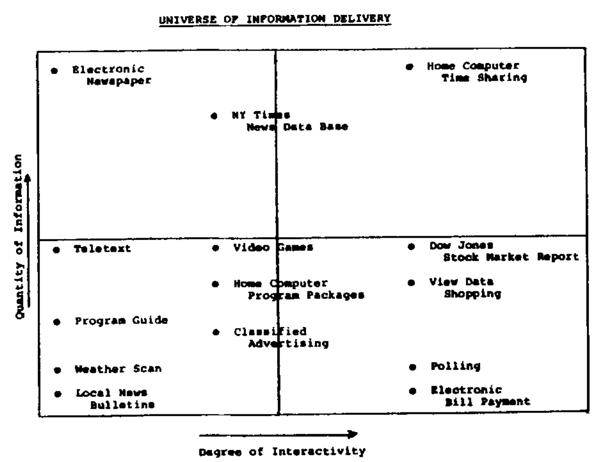


Figure 1

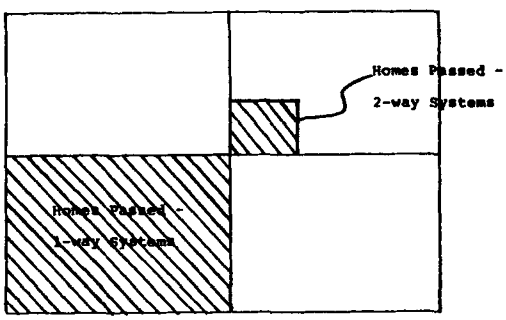
various information services (which have been identified and discussed here at this convention) in terms of the quantity of information they contain and the degree of interactivity. For example, you can see that the cable system program guide contains only a very moderate amount of information and requires very little interactivity and so is located in the lower left quadrant of this chart, whereas, electronic bill-paying or polling requires a relatively small amount of information, but a high degree of interactivity, and therefore is located in the lower right.

Home computer time-sharing requires both a large amount of information in order to operate in real time and a high degree of interactivity with remote software and so it's in the upper right quadrant. And then there are products like packaged programs or video games which can be downloaded completely into home computers' local memory for local interactivity only. These fall somewhere in the middle.

What we've been attempting to do is segment all the possible information services in a way which is useful for defining a product line. Now let's look at Fact Number 2.

As you can see from Figure 2, today the cable industry is primarily one-way. Any

CURRENT CABLE SYSTEMS



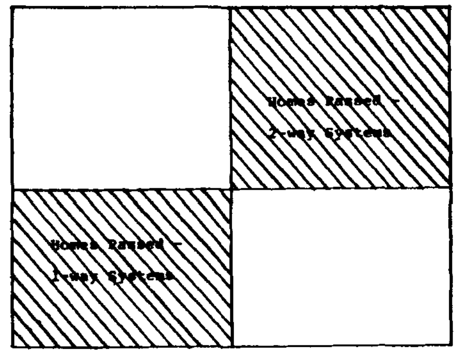
1980

Figure 2

product developed for the cable industry must be developed with this in mind, if it's to be useful to a large segment of the industry today.

You might say, "Well, yes, that's <u>now</u>, but many of the major <u>new</u> systems being built are two-way. Won't most cable systems be two-way very soon?" Obviously, this picture is changing, especially in the new urban franchises where expanded channel capacity is the rule, two-way cable systems are commonly proposed, and all the most recent bids have contained proposals for interesting new interactive systems for security or other data services. As Figure 3 shows, we predict that by 1985 with the explosive new build rate of today continuing, approximately half of the country's cable systems could be two-way.

CABLE SYSTEM IN 5 YEARS



1985

Figure 3

From all this, we conclude that we must consider the one-way market, and it would be desirable that our new product be useful both in today's existing one-way cable systems, and tomorrow's two-way market as well.

If you refer back to Figure 1, we can see how these considerations come together. By segmenting all of the possible information services in terms of quantity and interactivity, we have identified a large number of potential services in the lower left quadrant which corresponds to services which can be delivered effectively over one-way systems. We have combined these considerations in the conclusion that our first product should be operable on a one-way system in order that the industry have the widest possible opportunity to implement it now and to experiment with customer demand for new information service offerings. That is our first criterion, as shown in Figure 4.

CRITERIA FOR INITIAL PRODUCT

INFORMATION SERVICES

- One-way
- Profitable for cable operator
- Consumer interest and value
- Use cable bandwidth effectively

Figure 4

Any investment in information services hardware by cable operators is a risk - because consumer demand hasn't been tested yet. So we've decided our second criterion should be one which minimizes the risk for our customers. We don't want our product to sell chiefly because it is useful in franchise applications. The payoff from that is too indirect. Instead, it must generate a clearly identifiable incremental revenue stream from subscribers - from the beginning.

The plain fact is that consumers don't have very much experience at all with electronic information services, so they don't know how to place a value on them. They may become very enthusiastic about their newness, or they may take a long time to sign up. We just don't know. And that translates into a larger than normal investment risk for cable operators. So our third criterion is that the new product must create consumer interest. They must perceive a value more than they are required to pay. A technically interesting concept - no matter how advanced - is not enough.

One final criterion: In the past two years we've analyzed the existing cable data delivery systems in an attempt to define the best approach in the long run for cable. Of course there is the existing news wire reception/modulation approach using full video channels. We have looked at Teletext, using the vertical blanking interval. We've looked at the variety of new two-way data service systems, some of which are exhibited here at the convention. And of course, we've looked at telephone as a natural competitor to interactive types of services. In doing so, we developed yet another criterion which I'm sure you'll agree is important. The cable industry has one obvious advantage over other forms of electronic media delivery, broadcast and telephone, and that's our bandwidth. Therefore, we established as one of our criteria that we should utilize cable's bandwidth if it would allow us to develop more economical information delivery systems.

Since the Teletext system uses no apparent bandwidth in the cable sense, and since our initial product was required to work over one-way cable, we specifically used Teletext as a reference point for our new technology.

Let's look at our future product, let's name it DataChannel for now, and see how it compares with Teletext.

	Teletext	DataChannel
One-way	Yes	Yes
Use Cable bandwidth effectively	VBI 5.7 MHz data rate 3840 characters per second per channel 52 channels max. • High-speed data acquisition circuitry • Bi-polar technology • $125 terminal	200 KHz data channels 13.983 KHz data rate 1271 characters per second 160 channels available outside video channels 1750 channels max. • Low-speed data acquisition circuitry • MOS technology • $100 terminal
Consumer interest and value	?	? • Sound
New profits for cable operator	?	?

Figure 5

As you can see from Figure 5, both operate on one-way systems, satisfying one important criterion. DataChannel certainly uses more of the available bandwidth than Teletext, but it has some important advantages which are inherent in utilizing that bandwidth. As you can see from the chart, Teletext, using the vertical blanking interval delivers 3840 characters per second per channel and has 52 available channels using the latest cable technology (Jerrold's, I might add!) Using the DataChannel approach, of 200 KHz channels, there are 160 channels available outside of the video channels, but within the cable spectrum. I suppose, theoretically, there are 1750 channels maximum, if you use the full 400 MHz bandwidth, but restricing ourselves to the non-video portions of the spectrum, you see that there's much more flexibility in utilizing the DataChannel approach compared to the vertical blanking approach.

In terms of information delivery rate, a single vertical interval DataChannel can deliver roughly 3 times the information per second as DataChannel, however, as I pointed out, there are 3 times as many channels available outside of the video spectrum and so that from the standpoint of capacity, it's more or less a wash. The important comparison is the data rate. Teletext uses what we call a high speed data acquisition circuitry approach using bi-polar technology, while the data channel approach with a much lower data rate, 13.983 KHz, operates with low speed data acquisition circuitry, using MOS technology. Therefore, the really important differences are not only the flexibility of location of channels and the number of them, but in fact, the terminal cost. Using comparable cost structures and margins, we computed that we could deliver a Teletext Decoder Terminal for $125.00 based on today's state-of-the-art electronics, but by comparison, deliver a DataChannel Terminal for $100.00. In other words, the Teletext technology is 25% more expensive. Regardless of what the absolute numbers are, as electronics costs follow the normal curve over time, inherent in the technology of DataChannel is this competitive cost advantage.

So this is the building block, this basic DataChannel technology which we believe utilizes cable's bandwidth more efficiently than the Teletext approach and therefore is more appropriate for our industry. From the cable system operator's standpoint, especially in medium to large systems, these inherent differences could become very significant in terms of total investment.

However, focusing on our remaining two criteria, we feel that neither Teletext nor DataChannel are particularly strong in these categories. DataChannel does deliver sound, which is an interesting feature, but generally speaking, we don't know whether the basic services that can be delivered over these systems will capture consumer interest and therefore whether the cable operators will be able to profit from their investment in the equipment. Overall, I'd say Teletext is a fair product and DataChannel is a little better, but in the context of our present market we need to go further.

DataChannel might actually be the best basic data service for the future, after consumers have more experience with information delivery services and there is a segment of the market which is willing to spend money for that service alone. But for now, a different kind of service is needed, one that gets the consumer involved with electronic data in his home and starts him on the learning curve.

It occurred to us, that consumers have limited experience with one kind of information delivery service - video games. Given that such products are selling, consumers obviously perceive value in this kind of entertainment. Equally important, these games can simulate two-way interaction over a one-way cable system.

Jerrold in partnership with Mattel developed PlayCable. We believe it's an information delivery service that not only meets all of our criteria for the immediate market, but also allows us to test market an initial product which can establish the basic DataChannel technology in the cable marketplace so that a more complete product line can be made available in the future after consumers are comfortable with electronic information services.

Once again using Teletext as a reference, let's take another look at the third and fourth criteria, this time comparing Teletext to PlayCable (See Figure 6). The

CABLE OPERATOR PROFIT

	Teletext	PlayCable™
Profit to Cable Operator	• $125 terminal cost	• $ 50 adaptor cost
	?	• $100 profit on sale of Intellivision
	?	• $120/yr. revenue

Figure 6

differences are in revenue and cost. First of all, PlayCable requires only a $50.00 per subscriber investment in the terminal on the part of the system operator. Relative to our DataChannel future product, the PlayCable adaptor is lower in cost because it contains a lot less memory circuitry than is required in a free-standing DataChannel unit. This is because many of the functions are taken over by the Mattel Intellivision set, with which it is a companion. Importantly, this initial investment may be offset by approximately a $100.00 gross profit from the sale of the Mattel Intellivision module to the household. Although most cable operators are not currently selling hardware to their customers, this additional dimension of the PlayCable project means that before a household even receives the service, the cable system operator could be in the black or at least break even, considering his installation cost. PlayCable therefore can be inherently less investment than Teletext for the cable operator.

This still leaves out one, and perhaps the most important part of the equation, however, the consumer. So let's take a look at our last criterion (Figure 7).

CONSUMER INTEREST

	Teletext	PlayCable™
Interest and value to Consumer	• Text and data	• Text and data
		• Video games
		• Educational programs
		• Simulated 2-way interaction
		• Sound
		• $300 Intellivision
		• Games worth $450 for $120/yr.

Figure 7

The consumer spends $300.00 for the Intellivision Master Component in order to have all these video games and services, and clearly he get's a lot, as you can see from this chart. But is it worth it? Quite honestly, it's too early to tell, but we have every reason to believe that we will be successful. We are already proceeding with our market tests in four cities and we've endeavored to make sure these tests give us valid information from which to project the total cable marketplace. I believe PlayCable will do well because it offers a cost savings to the consumer, compared to purchasing the same products in a free-standing mode. Instead of buying the game cartridges for $20.00 to $30.00, depending on the cartridge, PlayCable subscribers can receive unlimited service for a fixed monthly charge, later on they will automatically have new programs as they are developed. In comparison to the service offering of PlayCable, the customer would have to pay over $450.00 to buy separate cartridges. Therefore, we are confident that as Mattel completes their first year of marketing the Intellivision through retail channels, PlayCable will look like a pretty attractive cost saving alternative from the standpoint of the consumer.

To sum up, the PlayCable technology is inherently less expensive than competing cable delivery technology. It offers cable system operators a direct path to new revenues, and it offers the consumers a product that at least some of them want, at a cost advantage.

I don't doubt that the next few years will see quite a few two-way cable systems built and many different packages of data delivery technology and services. We intend to compete in that area, but that's not the place for most of the industry to start. At Jerrold we recognize this fact, and we've directed our initial efforts to delivering information over today's cable system to today's consumer.

MEASURING METHODS AND EQUIPMENTS FOR DATA PACKET BROADCASTING

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ABSTRACT

Introduction to and description of new services using D.P.B. (Data Packet Broadcasting) on the TV channel. Definition of some parameters specific to the data signal and methods of measuring them.

Considered as an analog signal, the data signal can be examined as a video signal. However, due to its specific structure, it can be broken down in the time domain into a series of elementary intervals inside which the signal shape is perfectly determined at point of origin.

From a digital point of view, the data signal can be described as a bit sequence. Its quality is then measurable by parameters linked to binary states, the lowest level of information being the bit.

Some equipments required for both analog and digital measurements will be described.

1 – DIDON – DATA PACKET BROADCASTING SYSTEM

1 – 1 – Introduction

All the new services for social communications, which are under study and will use the television broadcasting networks as a support, have one feature in common : they use data signals. For this purpose a D.P.B. system (DIDON* system) [1] has been defined and studied at the CCETT laboratories in Rennes (France). This system allows to use the T.V. networks in their current design to broadcast data signals in addition to the conventional television service. These networks, which have been developed to transmit an analog signal, allows an immediate a coverage of almost the whole population.

This system can be used in two different ways :

– First : during analog programs : some of the lines of the field blanking interval are free, and are available for data broadcasting.
– Second : outside of the normal program hours, or on networks providing a great number of channels, such as cable distribution or satellite broadcasting, almost all the lines of the T.V. frame can be used for data broadcasting.

1 – 2 – The system design

The fundamental choices governing the design of the D.P.B. system are based upon two considerations :

– The set up of the system take advantage of existing networks.
– The system is to be used by different kinds of services.

*DIDON is an acronym for DIffusion de DONnées (= D.P.B.).

The consequences of these considerations on the design of the system are now examined.

1 – 2 – 1 – Requirements for compatibility with existing standards and equipments

The ressource available for the data broadcasting system must be investigated from two points of view : time and frequency spectrum.

– time : the examination of a television signal shows that certain time intervals are not used by either the picture signal or the synchronization signal. These intervals consist of a number of line time slots in the field blanking interval.

Our purpose is to standardize the use of these line time slots and to extend this technique to all television signal free lines while television programs are not beeing broadcast. Therefore the available ressource is discontinuous (composed of free line time slots) and time-dependent (according to the use of the T.V. channel). The system designed, on such a principle, is therefore asynchronous.

– Frequency spectrum : though the active time of the video signal line is about the same in all the commonly used standards, the spectral bandwidth allocated to the video signal may be very different depending on these standards. To design a system edaptable to any value of this parameter, the data signal spectrum must be chosen in accordance with the video bandwith. This means that the bit duration may not be the same for all television standards. Therefore the system must allow an arbitrary slicing of data flows.

1 – 2 – 2 – Use of the system by different services

Different kinds of services are already under investigation and others will certainly be imagined in the future. To preserve the possibility of being used by all these services, the system design must take into account the following two points :

– Differences in the nature of the services : to avoid any limitation the system must be transparent.

– Simultaneity of the services : the system must provide multiple access.

1 – 2 – 3 – The fundamental choices for the design of the system

Let's sum up the above conclusions, the system must :
- be asynchronous,
- allow arbitrary slicing of the data flows,
- be transparent,
- provide multiple access.

Data packet multiplexing organization satisfies all these requirements. The basic sequence of operations is the following : assembly of the packet from the data source, the labelling of the packet according to data origin, the broadcasting of the packet within the video signal and the selection of the packet by the receiving equipment. The packet is made out of two parts : the header and the data block. Photos n° 1 and n° 2 give an example of a data packet and the detail of its header.

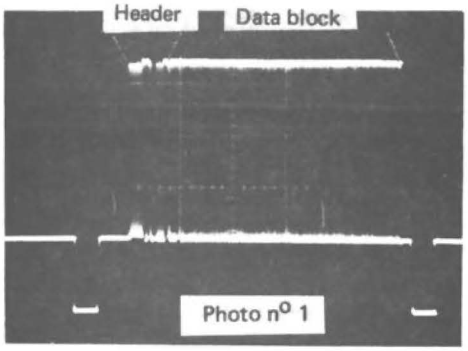


Photo n° 1

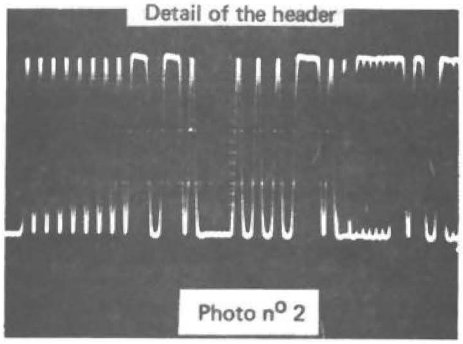


Photo n° 2

1 – 3 – Description of the techniques implemented

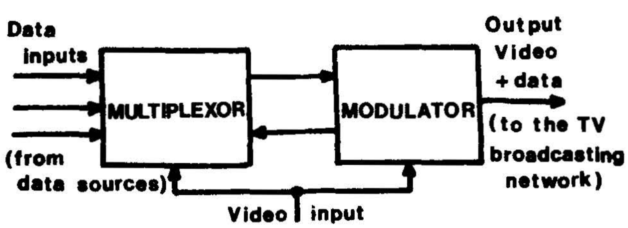
They consist of the transmission techniques and the receiving techniques.

1 – 3 – 1 – Transmission techniques

The transmission techniques are those used at a given point of the television broadcasting network to insert the data into the video signal. The basic technique is T.D.M.A. (time - division - multiple - access) at two levels :

– multiplexing of packets generated by different sources
– multiplexing of these packets within the video signal, using the free line time slots.

The first operation, which is a digital multiplexing, is carried out by the part of the equipement named the multiplexor. The second, which is an analog operation, is performed by the modulator (figure 1).



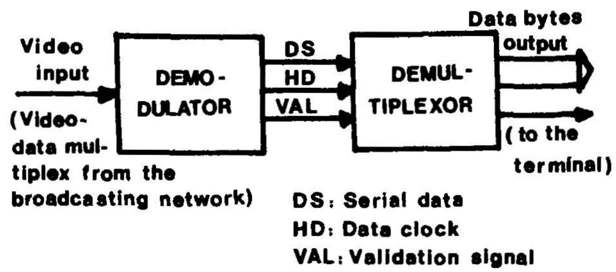
– Figure 1 –

1 – 3 – 2 – Reception techniques

The reception is the extraction, from the possibly impaired video-data multiplex, of the data carried on a digital channel. This operation is performed by the two parts of the receiving equipment (figure 2) :

– the demodulator, which determinates a slicing level, and delivers the data signal, to the next circuit, with a correctly phased clock, and a validation signal.

– the demultiplexor which, after having taken care of the synchronization byte, processes the header information in order to select the data carried by a digital channel (the link created by the D.P.B. network between a data source and a terminal) and to deliver them to the terminal.



– Figure 2 –

2 – MEASUREMENTS NECESSITY AND OBJECTIVES

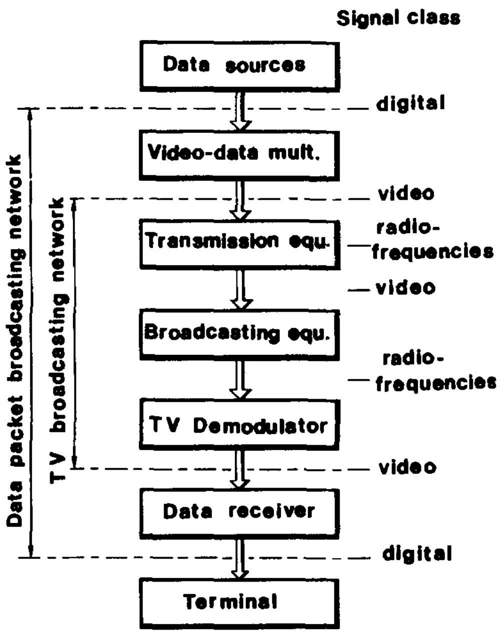
The video data multiplex signal can be impaired, at emission, during broadcasting, or at reception. The introduction and the development of services using data broadcasting necessitates the specification of equipment quality and the determination of the area inside which the reception of data is expected to be correct. To achieve these objectives, specific parameters must be defined and methods of measuring these parameters must be set up. The specificity of data broadcasting methods implies the study and development of new measuring equipments.

Although the parameters, currently used for the picture analog signal and measured with the I.T.S. (insertion test signals), can be taken into account to characterize the broadcasting network, it is necessary to use, in addition, new parameters which are specific to the data signal.

Figure 3 shows the structure of the data packet broadcasting network. It creates digital channels between data sources and receiving terminals. This network includes the TV broadcasting network (it was designed to be fully compatible with the existing standards and equipments) ; it implies, in addition, a transmission equipment (the video-data multiplexor) and a receiving equipment.

One of the measurements objectives is to define the quality of the data broadcasting network, statistically, as it is usually done for the TV broadcasting network. These measurements are made during field trials [2].

A second objective is to caracterize the performance of each equipment of the data broadcasting network with respect to the data signal. The equipments under test may be specific (data receiving equipment) or included in the TV broadcasting network (transmitter or TV demodulator for example).



– Figure 3 –

3 – CHARACTERIZATION OF THE VIDEO CHANNEL – PARAMETERS

Before examining in detail the specific characteristics of the data signal, it is interesting to recall the impairments due to the TV channel which can affect the video signal, and to determine the most important parameters with respect to the data signal.

The TV channel is the source of impairments which can be classified in two parts :

– intersymbol interferences due to linear (amplitude and phase) and non linear distorsions,

– addition of noise to the useful signal, which increases the effect of the distorsions.

The effects of these distorsions on the TV picture quality are now well known. Several parameters can be measured by using I.T.S. signals built up to characterize the most sensitive distorsions with respect to the TV picture quality (taking into account vision physiology).

The experiments have shown that some of them, especially the 2T pulse and the noise measurement line, are useful to characterize the effects of the video channel impairments on the data signal.

4 – CHARACTERIZATION OF THE DATA SIGNAL – PARAMETERS

As a part of the video data multiplex, the data signal can be considered as a particular case of the video signal ; however, its particular structure allows a precise characterization. Inside a data packet, this signal can be split up into time intervals inside which the shape of the signal is perfectly determined at the emission level. The superposition, on an oscilloscope screen, of the shape of the data signal during the successive time intervals, gives what we call an «eye pattern». This diagram provides an idea of the data signal quality, independently on the last part of the network : the receiving equipment.

From an other point of view, the data signal, contrarily to the picture signal, carries a digital, and therefore very easily exprimable, information. Thus its quality can be measured by parameters which can be directly interpreted as specifying the quality of digital channels.

4 – 1 – Analog characterization – Parameters

The analog characterization of the data signal quality is appreciated from the eye pattern. This diagram is generally drawn on an oscilloscope screen, but other means of display such as a plotter can be used.

Two kinds of diagrams can be obtained, linked to the horizontal sweeping :

– a «Y» pattern (figure 4), if he horizontal sweeping is linear with respect to the time,

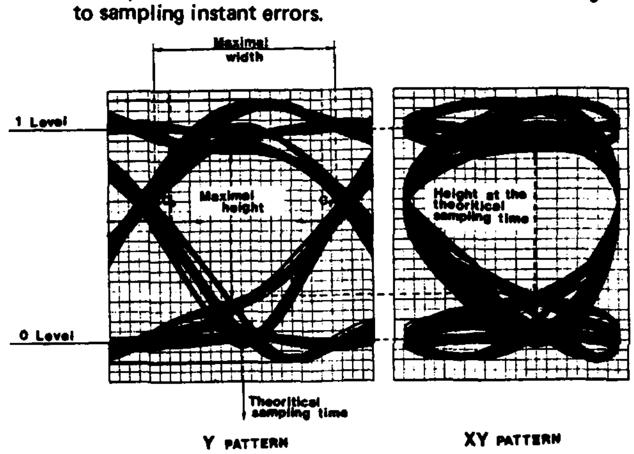
– an «XY» pattern (figure 4) if the horizontal sweeping is a signal made of an alternate suite of 1 and 0 transmitted on the same network as the data signal. The pattern is a LISSAJOUS diagram.

The interpretation of the eye pattern is linked to the way the data receiver's demodulator works : it determinates a slicing level to distinguish logical 1 and 0 status, and a sampling time to memorize a bit value.

The two most important parameters which can be measured on the eye diagram, are linked to these operations :

– the eye-height, which is the aperture at the sampling instant expressed in percentage of the difference between the steady-state «1» and «0» levels.

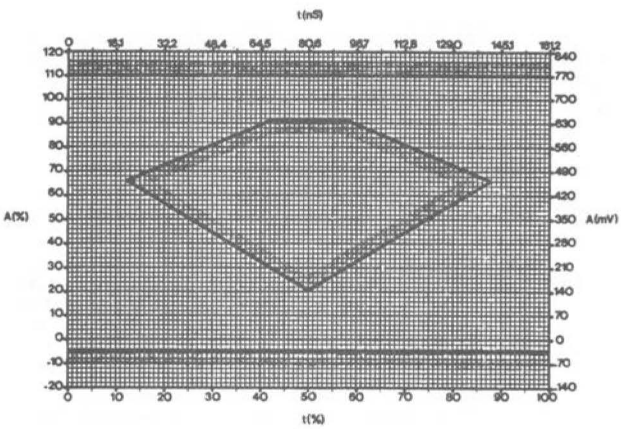
– the eye-width : indicates the sensitiveness of data signal to sampling instant errors.



– Figure 4 –

Some other parameters characterize the corruption of the data signal by the elements of the broadcasting network.

However, the different parameters which can be measured on the eye pattern are not directly, individually, linked to the quality of the received data signal, because the functioning of the receiving equipment is more or less corrupted by each of the analog distorsions of the data signal. On the other hand, each element of the broadcasting network is the source of impairments, which are not sufficient, individually to corrupt the digital signal (which can be regenerated). It is the reason why it is useful (particularly to test a specific equipment of the network such as transmitter [3] or TV demodulator) to draw a frame of the eye diagram. An example of such a frame is given on figure 5. This frame has been established by computer [4] for the test of a TV transmitter in L standard (positive modulation). This diagram is asymetric because of the non linear quadrature distorsions due to an envelope detection demodulator usually used for transmitter testing. The value of the bit frequency is 6.203125 MHz as used in France.



— Figure 5 —

4 — 2 — Digital characterization — Parameters

As we have seen above, parameters which can be directly interpreted and easily measured to specify digital channel quality must be defined.

The impairment of the analog signal, due to network distorsions, generates, when it is sufficiently important, errors on the data stream in the packets. Generally, these errors will appear with the same probability in the two parts of the packet: the header and the data-block. However, in the digital multiplex, these errors have a different effect according as they are located in the prefix or in the data block.

Errors located in the data block, affect only the data using the digital channel. Some redundancy can be added by concatenating a suffix to the data block allowing to correct one error per block.

Errors which appear in the packet header will cause, if they are not corrected, using the Hamming correction code implemented for the header bytes, the loss of the whole or of a part of the information carried by the data block of this packet.

Two parameters have been defined to specify the quality of digital channels :

— The bit error rate which is the ratio of the number of bits incorrectly received to the total number of bits received.

— The loss rate which is the ratio of the number of bits not received to the number of bits sent.

These two parameters are mean values computed from the observations. It may be interesting to complete these observations by the error and loss distributions. These informations will be very useful to set up error detection and correction procedures.

5 — MEASURING METHODS

5 — 1 — Measurements on the video channel

These measurements are well known, and do not need a special development. It is possible to find on the market a certain number of equipments allowing to measure all possible parameters on the I.T.S. and to display them or to print them on a ticket.

Some specific oscilloscope plug in units also exist which allow to select the appropriate horizontal and vertical calibrations in accordance with each measured parameters.

5 — 2 — Analog measurements on the data signal

As we have seen in § 4 - 1, our purpose is to draw the eye pattern. Whatever the method is, some precautions are required, concerning the drawing duration.

— Y pattern

The method consists in triggering an horizontal linear sweeping, inside the data block, in synchronism (with a constant delay) with the emission data clock. The data blocks examined, must contain all the possible configurations of the data bytes : pseudo-random sequences, also used for digital measurement, fulfill perfectly this condition.

Whatever the equipement is, the method has two successive steps :

- the selection of the TV lines carrying pseudo-random sequencies. This can be done in different ways, the better being to the use of a receiving equipment to select the digital channel subject to measurements.
- triggering of the linear sweeping, in synchronism with the data clock. This clock must be locally regenerated with a minimum of jitter.

— XY pattern

The first step is the same than above. The second requires a special synchronizing signal to be inserted at the emission level on the line preceding the pseudo-random sequence. This line, carrying a data signal of alternate «1» and «0», is delayed by the TV line duration, and used (without shaping) as horizontal sweeping signal. Practically, oscilloscopes have not a sufficient horizontal bandwidth and this method requires a sampling plug in unit.

5 — 3 — Digital measurements

5 — 3 — 1 — Principles

The method is as follows : information with a known structure is sent over a digital channel and differences with the original structure are analyzed at the receiving end. To be sure of obtaining valid results, the original reference information must cover the entire range of possible configurations which the transmitted information may take.

As the transmitter and receiver are generally distant, the original structure cannot be communicated to the receiver.

The structure of the reference information should be such that it can be regenerated locally by the receiver itself. Lastly, as we have seen, the reference information must be such that the two parameters specifying the quality of the digital channels can be readily apprehended.

Pseudo-random sequences meet these requirements.

5 — 3 — 2 — Properties of pseudo-random sequences

Given an integer n, a pseudo-random sequence will be a series of $2^n - 1$ bits having the following three properties :

a) If $q = 2^n - 1$, the sequence contains $\frac{q+1}{2}$ bits «1» and $\frac{q-1}{2}$ bits «0».

b) The autocorrelation function $\tau(d)$ of the sequence is constant and equal to :

$$\tau(d) = \frac{1}{q} \text{ if } d \neq 0 \ [\text{mod } q]$$

c) The longest series of 1s is $\ell = n$ and there is only one such sequence.

For ℓ between 1 and $n - 1$, any series of 1s of length ℓ appears twice as frequently as a series of 1s of length $\ell + 1$.

These properties are typical of a series of bits taken at random, each having a probability of 1/2 of being a «1».

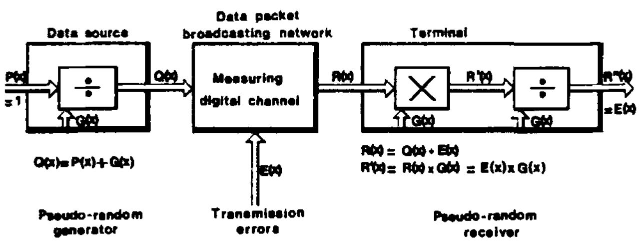
5 – 3 – 3 – Generation of pseudo-random sequences

Pseudo-random sequences are generated by feed-backed shift registers.

If we make the analogy between sequences of bits and a set of polynomials with modulo 2 addition, we express the pseudo-random sequence as the result of the division of a polynomial P by a polynomial G, called the generator polynomial. The polynomial P is expressed by the initial state of the positions of the shift register and G by the feed back coefficients.

If the register has n positions, the polynomial G must be chosen from the irreducible polynomials of degree n to make the resulting sequence of length $2^n - 1$.

5 – 3 – 4 – Measurement of the error rate (shown fig 5)



– Figure 6 –

The pseudo-random sequence is transmitted, using a measurement digital channel, and is received with errors which are expressed by a polynomial E(x) called the error polynomial.

The error number can be measured by counting the «1» coefficients from E(x).

The error rate can be deduced from the error number by the knowing of the measurement time and the useful bit rate of the measuring data channel, or by counting the number of received bits.

5 – 3 – 5 – Measurement of the loss rate

We have seen that the loss of information generally results from the loss of a whole data packet because of impairment of its header.

It is shown that in this case the operations described above lead, after a loss, to an error polynomial E(x) with an apparent error rate of 1/2. This is called a desynchronization.

This property is used to detect the loss of a packet. We may note that with a simple procedure we can resynchronize the process of extraction of the error polynomial automatically after each loss of information.

5 – 3 – 6 – Statistics on errors and losses

The method described above only allows to tally errors and losses and does not give any information on the event distribution. This information can be get by recording the error polynomial E(x) and certain packet header bytes (continuity index). These recordings are processed on a computer to get :

- the error and loss rates
- graphic results concerning loss and error distribution.

5 – 3 – 7 – Conclusion

The method chosen to measure the quality of the digital channels is simple and objective.

This method, using the error rate and the loss rate, provides an intrinsic channel quality specification without being necessary to take into account the type of information to be transmitted, which will depend on the user.

Due to the multi-access property of the D.P.B. system, a digital channel permanently dedicated to the broadcasting of pseudo-random measurement sequences can be used. Quality control can thus be carried out at any time and at any point without interrupting or interfering with data transmission on other channels.

6 – MEASURING EQUIPMENTS

Some equipments defined by our laboratories are under development and will soon be available ; they are :

– ENERTEC* n° 5547, which is an oscilloscope plug in unit allowing to draw the Y eye pattern. It also incorporates a digital part to count errors and losses and to calculate automatically error rate and loss rate.

– ENERTEC n° 5376 is a digital measuring equipment, having the same digital characteristics as the 5547.

Other equipments have been built and tested in our laboratories ; they are :

– an eye-meter, allowing to measure the eye-height, defined as the difference between the two slicing levels generating a given error rate.

– a TV-meter (patended) was designed to check the ability of TV demodulators to receive data signals. It draws an eye pattern on the TV screen.

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* ENERTEC (Schlumberger subsidiary)
Département Instruments
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42030 Saint Etienne (FRANCE)

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OPERATIONAL CONSIDERATIONS ASSOCIATED WITH TWO WAY CABLE SYSTEMS

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Donald J. Schiller

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Las Colinas is a 6,500 acre land development served by a two-way cable system owned and operated by the Las Colinas Association. By virtue of being a multi-user land development consisting of residential, commercial and industrial facilities, it provides a unique opportunity for evaluating the full range of issues associated with the utilization of two-way capabilities. In particular, their experience indicates that there are four areas concerned that must be addressed by the cable operator: 1) plant and product reliability; 2) alarm signal receiving and processing procedures; 3) design and installation of proprietary systems; 4) special purpose local origination capabilities.

INTRODUCTION

The Las Colinas Association cable system currently comprises 12 miles of active plant. There are approximately 11 miles of plant under construction at this time. Installation of a triple trunk underground plant was begun in 1974 using .500 and .412 trunk and feeder cable, most installed in conduit. A combination of Tocom, Magnavox, and RCA amplifiers were utilized.

The three trunk cable system affords a wide variety of capabilities, many of which are being utilized at the present time. Cable "A" (45-300 MHZ) carries the c wnstream in television programming and polling signals for security and data systems. Cable "B" (5-110 MHZ) provides the upstream return signals for the security and data systems. Cable "C" possesses both upstream (5-108 MHZ) and down-stream (174-300 MHZ) capabilities. Currently "C" cable is utilized to bring entrance and exit gate video back from remote guardhouse locations to central communications control where it is viewed by on duty security officers and may be videotaped. Shortly an interface will be complete between a community college campus and LCA's system head end, thereby permitting live and taped broadcast to be offered over the system. LCA is currently participating with Tocom, Inc. and Dow Jones, Inc. in the demonstration of two-way data retrieval services over a cable. Six installations have been utilizing these services since the spring of 1979. Additional uses of the "C" cable under immediate consideration include: return of local and audio-video programming from remote locations (such as golf course fairways) and viewing of traffic control from various points within the Development.

PLANT RELIABILITY

Plant reliability has become a major factor in two-way cable systems because of the security and interactive data services offered over such systems. Loss of service due to system outages can directly cause a disruption in business service. In the case of alarm monitoring, failure to detect an emergency signal due to a system outage could result in considerable property loss due to theft and fire damage. For these reasons, it is our belief that the design of two-way cable plant must incorporate such features as redundant amplification, stand-by power, status monitoring and alternate path routing.

To minimize service disruptions, an overall program has been undertaken by the Las Colinas Association which incorporates a number of technical and operational considerations. The system has been redesigned and a physical upgrade begun to incorporate .750 cable for trunk runs, use of some of the existing trunk for feeder, and eventual replacement of all trunk amplifiers with Jerrold JV-300 equipment. Jerrold JV-300 amplifiers were selected for trunk amplification because of the redundant amplification and status monitoring features they provide. Stand-by battery power for all power supply locations, stand-by battery, an uninterruptable power supply and a stand-by gas powered generator for the systems control center have been installed to reduce a vulnerability to power outages and brownouts.

Alternate path routing has been incorporated as a strategy in the LCA system. It attempts to provide a minimum of two feeds into major subdivisions of property within our cable plant. If the primary feed fails, either manual or automated switching to the second feed will permit the outage to be localized anad service restored to unaffected areas beyond that point as soon as possible.

PROPRIETARY INSTALLATIONS

Another aspect of two-way cable plant design that has to be reconsidered over cable relates to proprietary plant installations such as hotels, apartment complexes and office and industrial facilities. With the introduction of security service over cable, these establishments are much more attracted to the introduction of cable systems within their premises. This will open up for the cable operator an altogether new market for their services, but it simultaneously poses some significant plant design problems.

Perhaps the most important consideration to be addressed in facilitating proper design of proprietary installations and interfacing them into commercial cable plants is the development of a series of specifications which describe and pictorially illustrate what such installations should look like in highrise facilities. We have prepared a set of typical drawings which architects and engineers can utilize when attempting to incorporate a cable plant configuration inside a new facility. A "typical" tap illustration for each floor on a highrise facility is depicted in Figure 1.

We refer to the proprietary plant "typical" as a "Backbone System" for use in a proprietary installation. It consists of a line extender at the point of entry into the facility and the installation, on each floor, of a directional coupler mounted inside an 18x24x4 inch electrical box.

A critical factor in the design of a "Backbone System" is the fact that, except for hotel and apartment properties, the final utilization of the office space in a highrise facility is often unknown at the time that construction begins. As a consequence, it is necessary to design for an intensity of use based upon assumptions about overall use rather than actual plans. We have elected to install a directional coupler on each floor so that the installation of additional drops can be accomplished without disrupting service to other floors.

The introduction of a typical "Backbone System" configuration has greatly facilitated the orientation of architects, engineers and contractors. It has made two-way cable capabilities within proprietary installations far more likely of occuring in the majority of new facilities to be constructed in Las Colinas.

SECURITY OVER CABLE

Cable operators considering the introduction of security alarm monitoring services over the cable plant will find themselves confronted with a number of basic issues relating to the actual accomplishment of this objective. In general, cable operators will need to fully acquaint themselves with the signalling devices, transmissions modes and processing approaches that companies that are presently involved in alarm monitoring employ. Among the issues which the cable operator must consider are:

TYPICAL TAP CONFIGURATION

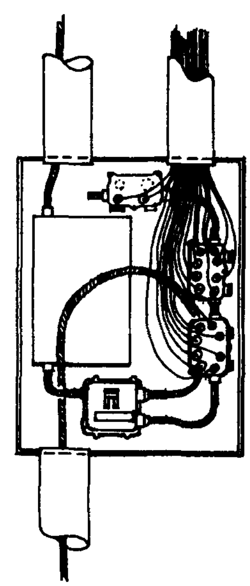


Figure 1

1) The determination of which entity or entities will receive, process and initiate appropriate response to alarm signals transmitted over cable;

2) The determination, if access tc cable channel space is provided to private security alarm companies, of the manner in which the communications interface will be accomplished between the cable operators head end facility and the private security company central station alarm monitoring facility;

3) The determination of which entity or entities will install the actual devices and alarm circuits inside protected business and residential properties and the manner in which licensing of these designated installers will be achieved;

4) The determination of which types of sensors, control equipment and basic alarm circuits may be utilized in an installation;

5) The determination of the extent to which the installation at the premise must incorporate features designed to increase overall reliability and to provide adequate notice to the occupant of system malfunction.

Access to the cable plant by private commercial security firms would greatly reduce the extent to which the other items will require in depth inquiry on the part of the operator. It is our considered opinion that the preferred method of operation would be one in which the cable operator provided access to the plant by one or several security companies and refrained from becoming directly involved in alarm monitoring, processing and emergency response.

Because of several unique circumstances, the Association elected to undertake centralized alarm monitoring itself. As a result of our early experience with the receipt of the alarm signals over cable, interfaced with an automated alarm monitoring system at the head end, we have become aware of the fact that alarm monitoring services incorporate a considerable number of procedures not immediately obvious to the cable operator. Without attempting to enumerate the many difficulties involved in the operation of a central alarm monitoring facility, sufficient to say that the automation of these procedures has proven to be very difficult.

Of the basic issues described above, the considerations associated with local premise equipment reliability and occupant notice would appear to be the most critical. It is in this area where a considerable amount of liability for personal injury can occur if equipment failure prevented an alarm message from being transmitted to the monitoring facility. It is essential that the occupant be able to readily ascertain if the alarm sensors and transmitting devices are operational and capable of transmitting such a signal.

The Las Colinas Association has elected to deal with this problem by the introduction of minimum specifications for a basic installation package in the home, apartment or business. Specifications are currently being drafted which will require that the local installation incorporate a standby battery and a timing circuit interface board which can sense when the local RF transmitter has failed or has otherwise lost communications with the receiver at the head end facility.

If system malfunction occurs, a change in status will be indicated by a red LED. If the malfunction continues beyond five minutes, a timing circuit will activate a local annunciation panel at the premise. In addition, we are going to stipulate that single family and business installations, must also incorporate a digital communicator which can transmit a signal via telephone line into a digital receiver at the head end. This approach provides an attractive, relatively low cost means to substantially improve overall reliability by providing alternative transmitting mechanism and a separate communications link with the head end.

We are presently completing the design of necessary interface boards to support these revised specifications. At this time, no such interface electronics are readily available, therefore necessitating the development of an altogether new, specialized application for our purposes.

VIDEOPHONE

The emphasis upon security services rather naturally led Las Colinas to the consideration of the introduction of access controls systems over the cable plant. One such type of system, incorporating video monitors and audio intercom is currently undergoing development at Las Colinas.

The videophone, a one-way video, two-way audio communications devise, originated in Italy. The normal installation of this equipment is used to provide private visual and audio review of a visitor to an area. It has application in secure villages, residential apartments, commercial facilities and some limited use in single family dwelling units. Normally, videophone units are hard wired with six to eight conductor wires on a point to point basis.

The basic components of the videophone system specified for installation at Las Colinas in July, 1980 include: a camera unit, a control unit (CPU) and a monitoring unit. The camera unit incorporates two cameras of which one is mounted inside the guard facility and the other outside the guard facility. The CPU consists of the electronic processing hardware required to operate the camera units, a keyboard, monitor and handset. The monitor unit includes a video monitor screen, hand set and push button.

One of the prime features of the videophone system will be the protection of the privacy of the conversation between the guest and the resident. Only the party being contacted by the guard will have its monitoring unit activated and be able to see the visitor and hear the conversation. This will be accomplished through an encoding/decoding circuit in the videophone CPU unit.

The technical specifications of the RF videophones were designed for a two-way plant on a downstream frequency of 294 MHZ and an upstream of 30.75 MHZ. The levels run 20-40 dBmV downstream to 35-52 dBMV upstream. The video portion of the screen is currently on television European standard, however, the final units will meet American TV standards and will be UL listed.

The logic and control system provides: a decoding of the incoming signal from the control unit; receiving video and audio signals; transmitting of the audio signal and enabling the call from the resident to gate attendant; filtering of the incoming spurious frenquencies with suppresion of those over 40 DB; protection of reception of binary code signals from the CPU against interferences; automatic control of the signal level variation of the line amplifier; automatic turn off of the monitor when handset is returned to the holder; and quartz control of all frequency generated by the monitoring unit.

Future options on the videophone may include; operation from multi location guard gates, multiple monitor unit installations within a single residential or commercial unit, two-way video (guard would be able to see resident or information from resident's location) and color video presentation.

The discussion presented above clearly illustrates that a wide variety of applications are possible over a cable plant possessing two-way capabilities. Because the active utilization of two-way cable plant is so limited at the present time, the ability of a cable operator to introduce a variety of two-way services is seriously impeded by the lack of proven applications and firms competant in the installation of such applications. The success of early attempts by cable operators will therefore be a direct function of the ability of the cable operators resident technical staff to undertake a great deal of development effort in house. It is unlikely, therefore, that widespread application of two-way services will occur in the near future. Even so, a number of individual projects are currently underway, offering the prospects for more and better information on this subject within the next year or two.

ORGANIZATIONAL MARKETING ®

By Thomas B. Cross

Boulder Communications Company

ABSTRACT

The role of management and the function of information will merge in the mid-1980's. Management structures creating environments in which people can work will cause evolutionary, if not revolutionary changes in corporate life. Developing these new concepts is one aspect of Organizational Marketing (OM)*.

MANAGEMENT FOR THE 1980's

New forms of management will be required in tomorrow's automated offices. Technology, coupled with a changing society, will cause management to rethink corporate structures. Organizational tools of the 1970's will give way to more creative and demanding systems of management. Electronic information systems will give management more information about department or corporate activities than has been available than ever before. Competition between departments, based on 'selling your product or services', will be measured against the corporate rate of return. Understanding these strategies will be the key for managing corporations in the 1980's.

There are growing indications that many organizational structures tend to isolate upper management from the employees. In this information age, much of the corporate product is contained within 'the heads of workers,' not in warehouses. Effective use of new information systems can bring the manager and employee closer. Information systems control can cause more wide spread change throughout the organization than any other factor.

Many of the innovative managers in the telecommunications industry know the corporate tele/information network is the nervous system of the corporation. These managers, for the most part, have provided only the pipeline for communications to occur. Technology is allowing Management Information Systems (MIS) to both manage and massage the information.

Much of the efforts of organizational developers will be devoted to communications structures, gaming, and strategies. One of these, called Organizational Marketing (OM), uses marketing information systems as a management tool. The key is sales techniques coupled with technology, where department goals are accomplished using marketing concepts rather than service bureau policies. Advertising is one of the principal promotional vehicles. In one corporation they are changing the names of the telecommunications analysts to salesmen to more closely reflect OM concepts.

Developing management concepts which not only utilizes, but is based on, information as a political power source requires developers to reevaluate the meaning of organizational communications. Organizations are faced with enormous communications problems in terms of people, technology, and corporate profits.

Marshall McLuhan is having a renewed impact on corporate organizational structures. His global village concept has become a reality in the global corporate community. Management Information System (MIS) designers are pushing the concept of distributed data processing to extend their realm of management control.

"The status of the system is the status of the business," said Stephen Dickson, Corporate Auditor with the National Center for Atmospheric Research (NCAR) in Boulder, "We are creating a system where any one of our locations can use the computer conferencing as a management information tool not just a reporting device. In fact, we are approaching the point where if it's not in the system the transaction didn't occur.

The advent of the stored-program telephone switching systems provided the opportunity for corporate telecommunications managers to begin thinking like data processing managers. The telephone system of today possess new tools for managing the corporation. Least cost routing, call detail recording, network queuing, and network control are features which allow management control of telephone calls as a gatekeeper. With the introduction of data communications traffic in a voice network, new communications network control systems must be addressed and installed.

Some corporations are examining the need for intelligence in many corporate activities.

GROWING NEED FOR SHARED-LOGIC SYSTEMS

- o INTELLIGENT COMMUNICATING COPIERS
- o INTELLIGENT COMMUNICATING CBX TELEPHONE SYSTEMS
- o INTELLIGENT COMMUNICATING NETWORKS
- o INTELLIGENT COMMUNICATING TYPEWRITERS
- o INTELLIGENT COMMUNICATING MAIL SYSTEMS
- o INTELLIGENT COMMUNICATING DDP SYSTEM
- o INTELLIGENT COMMUNICATING FILE CABINET
- o INTELLIGENT COMMUNICATING TELECONFERENCING

GROWING NEED FOR STORAGE SYSTEMS

- o VOICE MAILBOX
- o DATA MAILBOX
- o FILE MANAGEMENT
- o DATA BASE MANAGEMENT
- o WORD MANAGEMENT
- o COMPUTER CONFERENCING AND TELECONFERENCING
- o VIEWDATA/TELETEXT

Correspondingly, the data processing manager is now faced with distributed data processing (DDP) which requires extensive data use of telecommunications networks.

Most of the traffic will be data and video in the future. The network must be able to adapt to changing network demands.

Each type of traffic will be assigned priorities, allowing network managers to utilize store-forwarding concepts.

The much heralded voice storage system will bring about other changes in the office environment. Some companies plan to use disk storage for the assignment and distribution of telephone letters. Other concepts under development suggest the telephone system can perform all the functions of a small business computer, including environmental controls, security, and office systems.

Data processing and telecommunications have been merged organizationally in many corporations. It remains to be seen whether office systems will be functionally addressed in the same manner.

The introduction of electronic technology to the office has caused the most significant revolution since the typewriter. Word processing is not the first technology to impact the office, but probably is the catalyst that will allow the introduction of even newer technologies. Electronic mail, a powerful information tool, is still in its infancy. Dictation through voice recognition systems, a useful tool to certain segments of the corporate world, will grow into the automated office with word processing. Micrographics and reprographics will be intregrated by document distribution communications systems. Voice recognition and optical character readers will be introduced into the office faster than expected.

Even though most corporations are cautiously optimistic about the outcome of this evolutionary process, there are the other true 'pioneers' of the automated office. What remains is for thousands of other organizations to mirror the leaders. "When corporate managers fail to make these decisions which, in some cases, can have significant bottom-line impacts on the corporation, they can be called career limiting decisions," Dale G. Mullen of Johns Manville, "Managers are now in positions of either making the decision and facing the outcome, or not making it and limiting their career." Technology is forcing new consequences in the career path. Some organizations are already moving toward computer gaming and simulations to help resolve corporate problems.

GROWING BUSINESS DEMANDS

GROWING MOVEMENT IN BUSINESS TOWARD

- o TRANSACTION PROCESSING
- o ELECTRONIC FUNDS TRANSFER
- o TELECONFERENCING
- o NETWORKING
- o DISTRIBUTED VOICE/DATA/IMAGE PROCESSING

GROWING PRESSURES ON OFFICE WORKERS

- o IMPROVE PRODUCTIVITY
- o IMPROVE RESPONSE TIME
- o REDUCE INFORMATION FLOAT
- o IMPROVE FINANCIAL FLOAT

TASK PROCESSING IS NOT DATA PROCESSING

The concept of office processing is merging with data processing functions though office processing is not data processing. Large numerical calculations, payroll, accounting, and other such transactions are processed manually in many corporations, large or small. For many businesses, these functions can be performed on a time-sharing or small business computer system. However, typing letters, arranging meetings, coordinating activities, and answering the telephone are office functions critical to improving productivity cannot typically be farmed-out to time-sharing or to automated systems.

Office processing, like telecommunications, may use a stored-program microprocessor-controlled, computer-based system. It can be exactly the same technologically as any computer, but functionally have a different operating concept.

We can alter the concept of technology to perform many other functions. It is the merging of these technologies which can solve organizational management problems which most corporations consider least in cost savings measures.

CHANGING ROLES IN OFFICE PROCESSING - "NO MORE WOMEN"

We have come to accept the encroachment of technology into the corporate structure and, in some cases, have expected a word processor to replace people. We have failed to understand the changes brought on by technology and its impact on the sociological makeup of modern society. Impacts of inflation, legislation, and education have pushed women into the job market.

In addition, corporate management goals are moving women and minorities into higher positions. With all of this uplifting going on, what will be left behind?

CHANGING MANAGEMENT STRUCTURES

- o NO MORE BOSS/SECRETARY RELATIONSHIP
- o ADMINISTRATIVE WORKERS / WORD PROCESSING WORKERS
- o PRODUCTIVITY ANALYSIS INCREASING
- o ANALYTICAL INFORMATION ON OFFICE WORKER
- o INSTANT COMMUNICATIONS/FAST FOOD APPROACH
- o DISTRIBUTED PERSONNEL ADMINISTRATION

WORKER REVOLUTION

UNITED STATES

Percentage of the Working Force	1973	1979	1990	GROWTH
PROFESSIONAL TECHNICAL	13.2	16.0	20.54	+25%
ADMINISTRATIVE AND MANAGERIAL	9.6	11.0	14.95	+35%
CLERICAL	16.7	19.0	26.0	+36%
SALES	6.2	7.0	9.1	+30%
SERVICE	13.0	14.0	19.5	+19%
AGRICULTURE	3.4	3.0	2.5	-17%
PRODUCTION TRANSPORATION LABOR	34.6	30.0	7.4	-246%

LESSER DEVELOPED COUNTRIES

	1966	1979	1992	GROWTH
PROFESSIONAL TECHNICAL	2.7	4.6	11.0	+239%
ADMINISTRATIVE AND MANAGERIAL	0.1	0.2	4.0	+2000%
CLERICAL	2.7	2.6	16.0	+615%
SALES	6.7	7.8	9.0	+15%
SERVICE	6.7	11.6	12.0	+3%
AGRICULTURE	41.3	39.6	11.0	-360%
PRODUCTION TRANSPORATION LABOR	26.8	33.3	37.0	+11%

Source: U. S. Department of Labor - Bureau of Labor Statistics - May 1979 and others

The evolution of workers leads toward the development of a new distribution of managment time as outlined below:

1979 MANAGERS DISTRIBUTION OF TIME

FACE TO FACE	35-45%
FACE TO RECORD	25-30%
IN TRANSIT	5-10%
TELEPHONE	5-15%

1985 MANAGERS DISTRIBUTION OF TIME

FACE TO FACE	65-85%
Meetings	
Presentations	
Computer/Audio Conferencing	
Video Conferencing	
IN TRANSIT	5-10%
COMMUNICATIONS	10-15%
Dictation	
Telephone	
Voice Mailbox	
Administrative	

1979 EXPANDING NEED FOR FOLLOWING SECRETARIAL WORK STATION ELEMENTS

DICTATION, TYPING, AND PROOFREADING	19%
ADMINISTRATION SUPPORT TELEPHONE, MAIL	35%
AWAY FROM DESK	29%
WAITING FOR WORK	12%
ABSENT	5%

1985 EVOLVING ADMINISTRATIVE ANALYST (SECRETARIAL)WORK STATION ELEMENTS

DICTATION, TYPING, AND PROOFREADING	10%
ADMINISTRATIVE ANALYSIS	50%
Meeting Coordination	
Travel Arrangements	
Budget Tracking	
Purchase Order Tracking	
Researching	
ADMINISTRATION COORDINATION AND SUPPORT FOR MEETINGS, TELEPHONE, MAIL	35%
ABSENT	5%

Fewer women will be secretaries. Men will share equally in this position. Men and women will both be forced into non-traditional roles. The impact can be devasting when the corporation forces new office automation systems onto archiac sex-based office roles. From a purely management perspective, the traditional secretary can be eliminated from the organization by technology.

Some functions can be generally automated and the remaining ones left to administrative managers who may also manage the budget and other activities. The real question are the changes in office psychology which are typically unmeasureable but may have sever impacts on the overall office performance.

The implementation of centralized processing areas for office work has been the trend over the last few years. These centers or as some have called them, 'task processing centers,' have been the focal point for major management reorganizations. These centers were not installed because of technological advantages, but for management control. Communications options allow these devices great freedom to move documents about throughout the corporate network.

The designers of word processing centers have hoped that providing word processing centers would result in job specialization and increase office productivity. From all of the studies which have been completed, statistics about the office environment are optimistic but not universally clear in resolving many of these issues.

The office can be thought of as an information tool, processing information from one node to another: personnel communicating to accounts payable about filling a vacancy or purchasing reponding to a request for parts. These are information transfer functions, or task processing. These activities, and many others, do not require paper, oral communications, or real time contact. Information can be used as a tool to measure transfer or tasks. These aspects of activity can be directly measured, and job performance rated.

Memos, reports, and mail are the office tools by which any bureaucracy works. Some of these tools are being developed, such as the action items, coordinating calendars, memoranda, and similar office task documents, on totally automated systems. Another tool used to measure office activities is budgets.

Zero-based budgeting and profit centers are all terms used to measure departmental productivity in dollars. Each of a department's activities are measured against dollar performance. There are many office functions against which dollar performance may be difficult, immpossible, or undesireable to measure. Information management can be the management system developed for many of these environments.

Computer conferencing and Viewdata systems will also create new management systems.

With the development of information systems allowing for the management of credibility, "information float" can be a measure of productivity. "Executives are very much aware of the float when they talk about finances," said Dr. George Champine of Sperry Univac. "Float, of course, is the unused cash that is waiting while information is transferred back and forth. I would like to make the point that information float in large organizations is much more damaging than financial." "Since we have been using new technology, I have noticed a significant increase in our pace of activity," he said.

When the office designers can truly address issues such as the increased speed of the office, and at the same time the psychological need of the office, we will see a massive migration towards the automated 'information' office as well as the 'home' office.

A new concept merging with OM will be distributed personnel processing, the activity of working with personnel located a great distances from the physical office. This concept will create enormous demand for use of cable television systems as the delivery of business information services. This can only occur when new approaches in management concepts, like organizational marketing and others, can be implemented.

Automated systems will allow measurement of information efficiency of the task or transaction. Armed with this information system, managers will be able to cross departmental barriers to monitor activities and sell their services more effectively. As departments compete for limited corporate funds, managers must be able to develop strategic plans to win over other departments.

The following are steps leading to an Organizational Marketing approach to managing information systems:

- UNDERSTAND THE COMPANY AND PLAYERS IN THE MARKET
- EVALUATE IMPACTS THAT TELE/INFORMATION SYSTEMS HAVE ON THE COMPANY
- ESTABLISH TELE/INFORMATION HISTORICAL BASEPOINT
- INSTITUTE ZERO-BASED OR PROFIT CENTER FINANCIAL PLANNING
- PERFORM INVENTORY AND ESTABLISH VALUE OF SERVICE
- INSTITUTE MANAGEMENT INFORMATION PROGRAM
- DEVELOP SHORT TERM PLANS
- DEVELOP LONG RANGE STRATEGIC PLANS
- DEVELOPMENT ORGANIZATIONAL MARKET CONCEPTS
- MONITOR IMPACTS WITH CONTINUING STUDIES
- BECOME INVOLVED IN TOP MANAGEMENT
- UNDERSTAND HUMAN RESOURCE MOTIVATION
- MARKET TELE/INFORMATION THROUGHOUT THE COMPANY

The global corporate information community is fast becoming a reality. New management operating systems need to be developed in this arena. With Organizational Marketing systems, we can now begin to address these issues and design in systems which are efficient and humanistic.

AUTHOR

Thomas B. Cross, Director of Communications for the Boulder Communications Company, is a noted planner and designer of automated office systems, digital broadcasting, cable communications, and telecommunications network planning and design. He has conducted product planning research in complex telecommunications issues including Viewdata/Teletext market planning and development, common carrier technologies, cable television, and broadcast public policy.

He received a B.S. in Marketing/Finance and M.S. in Telecommunications engineering from the University of Colorado. He is now an Instructor in telecommunications and office information systems management at CU. He is a member of the Institute of Electrical and Electronic Engineers, Society of Cable Television Engineers, the International Word Processing Association, and the Tele-Communications Association of California.

He was a Program Manager in Telecommunications Market Planning for the Storage Technology Communications Corporation. Prior to this, he was the Director of Telecommunications for the City and County of Boulder where he directed cable television development and telecommunications systems management. He is a founder and faculty member of the Communications Institute of Boulder, an advisor in broadcast and cable television technology to Telecommunications Resource Management, and is a member of the Board of Directors of the Boulder Communications Company, Dove Information Systems Corporation, and Front Range Computing Corporation.

PROGRESS IN FIBER OPTICS TRANSMISSION SYSTEMS
FOR CABLE TELEVISION

A.C. Deichmiller

Times Wire and Cable CATV Division of
Times Fiber Communications, Inc.

This paper reports the continuing progress achieved during the preceding year in fiber optics transmission systems applicable to CATV requirements.

Developments in transmitter/receiver design and signal conditioning are described. Also, included is a discussion of the operating experience and retrofit update of a 12 channel, eight kilometer fiber optic super trunk. A unique feature of the system described is that only one repeater location is employed in contrast with a conventional cable TV system which would require 12 repeaters to cover the same distance.

Specific fiber optic system constraints, including modal noise and carrier distortion, are discussed and the signal conditioning methodology employed to achieve exceptional CATV operational performance is outlined. The impact of these recently developed techniques on fiber optic satellite ground station links, super trunks, and office to head end transmission links is presented.

During the past 12 months, significant improvements have been made in laser transmitter modules, optical receivers, splicing techniques, signal conditioning, and optical reflectometers--all of which have contributed to increased performance, ease in construction, and improved reliability of fiber optic transportation systems. To briefly look at these various improvements, let's examine an existing system and then look at what effect these improvements have had and will have on that system in the near future.

History

The Lompoc system was installed during November and December of 1978 by Teleprompter as an expansion of their pioneering fiber optic experiment in New York City. (See Figure 1)

Figure 1 is a block diagram of the 12 channel, 2 active fiber system as installed at Lompoc. The total length of this fiber optic run is 8.4 km (27,560 ft.) and 3 repeaters were required at approximately 2.1 km intervals. The signals are F.M. modulated at 2.5 MHz deviation and feed to a passive combiner whose output is used to drive the laser module in the optical transmitter. The frequency of the 6 channels in Group A are from 30 to 230 MHz with 40 MHz spacing. Group B signals are from 50 to 250 MHz and the same spacing. These frequencies were selected to allow for the possibility of putting up all 12 channels on a single fiber whenever higher power lasers became available.

The combined F.M. signals are converted to optical signals by the optical transmitter, transported over the fiber and converted back to electrical signals by the optical receiver. A passive divider splits the signals which are then demodulated back to baseband. Transporting the signals by F.M. with 2.5 MHz deviation gives us in practice 13 to 14 dB of F.M. enhancement over received carrier/noise.

The fiber cable used in this system contained 3 fibers and was installed in 8 lengths of approximately 1 km. Fiber optic connectors were used to join the cable and, of course, to interface all electronics.

This system meets the design goal of 50 dB (EIA weighted) signal-to-noise with no visible distortion, but with essentially no margin.

Both Teleprompter and Times have learned a great deal from this experimental system. In fact, many of the developments mentioned in this paper were a direct result of the continuing work being done at Lompoc.

Optical Transmitter

Twelve months ago, the optical transmitters available from Times had a carrier/noise of approximately 42 dB at the laser module output. After approximately 4000 hours of operation in the Lompoc system, a variation of transmitted optical power which did not seem to correlate with temperature nor humidity swings was noticeable. This variation was finally traced to a corrosion forming on the laser itself. The laser drive circuitry was redesigned and the laser module repackaged into a hermetically sealed container. This, along with a general improvement in laser noise levels, has given us an improvement from approximately 42 dB carrier/noise output at the laser to 50 dB. No repetition of the corrosion has occurred in many hours of operation. Incidently, the laser module is expected to have a life expectancy of 100,000 hours which is in excess of 11 years.

Optical Receiver

A new low noise receiver amplifier has been designed, tested, and field-proven which now allows us to work with optical powers as low as 3.5 microwatts, whereas previously 6 microwatts was the lower limit. In addition, we have reduced the noise floor giving us improved signal-to-noise levels.

Fusion Splicing

Prior to 1980 all Times supplied systems used the Deutsch optical connectors for splices. These connectors are field-proven, easy to use, and reliable. Incidently, Times has standarized on Deutsch for all its fiber to electronic interfaces.

Lower loss splicing methods have been available for some time; however, they were difficult to use in the field and many methods tend to show loss variations with temperature swings.

This fusion splicer is now available from Times. It is battery operated and has been field-proven over the last six months. We consistently obtain .4 to .5 dB loss across a splice in the field, without temperature problems. This unit allows us to eliminate the use of connectors for splices with a saving of approximately 1 dB per connection.

Impact on the System

(See Figure 3). During November and December of 1979, the new laser transmitter modules and the new low noise receiver module were installed at Lompoc. The connectors used in connecting the fiber cables together were eliminated by fuse splicing. Two repeaters were eliminated making the run approximately 4.2 km (13,800 ft.) on each side of the remaining repeater. The system performance was essentially the same after this retrofit, however, as you can readily imagine, it would be easier to maintain and reliability would be improved through reduction in parts count.

Based on today's price, the original Lompoc system would have sold for $100,836 complete. The system shown in Figure 3 would have a price tag of $84,984, a 15% reduction.

Signal Conditioning

About the same time as the retrofit F.M. modulator/demodulators which would allow one to adjust the deviation from approximately 2 to 8 MHz became available, we obtained four of these units and used the full 8 MHz deviation with 4 channels up on a fiber. The F.M. enhancement experienced was 20 dB and we were able to measure (EIA weighted) signal/noise of from 54 to 58. Our Engineering Department has been evaluating and testing these new Tomco units and feel that we are ready to start using them in our systems. We have simulated the Lompoc system in our lab and have a similar system here in the hall where, if you like, you can make some signal-to-noise measurements yourself. (See Figure 4)

Our field Engineering Department has scheduled a retrofit for Lompoc the week of June 9. New F.M. modulator/demodulator pairs will be installed with 5 MHz deviation and 20 MHz spacing. Six channels at 20 MHz spacing will be transmitted on each of 2 fibers and our tests indicate we should realize 18 dB of F.M. enhancement which will give us 50 dB signal/noise with ample margin.

Earth Station Links

All the improvements covered, of course, are applicable to Earth Station links except, in some cases, the F.M. signal conditioning equipment. Since many manufacturers of satellite receivers down convert to 70 MHz I.F., we can take advantage of this fact. The 70 MHz I.F. is F.M. with a deviation of 10.75 MHz. Just what a fiber system needs. Typical of systems being quoted lately is the United Cable, Plainville, CT, system which is slated for installation in September of this year. (See Figure 5)

This system will transport 8 channels from the satellite antenna site to the headend - a total distance of 9.5 km (31,168 ft.) One repeater will be used at approximately 4 km. One of the satellite receivers will have its 70 MHz I.F. feed direct to the passive combiner. The other 3 receiver I.F. outputs will be converted by hetrodyning as shown. At the other end of the link, we down convert and feed all four 70 MHz I.F. signals to the satellite receivers demodulator which, of course, had been removed from the satellite receivers at the antenna input end of the link. By doing this, we realize 39 dB F.M. enhancement to received carriers/noise.

It might be of interest to note that if this system had been quoted 12 months ago, the system would cost $80,186 based on present prices. The price today is $60,433, a 25% reduction in 12 months.

Optical Reflectometer

(See Figure 6)

Although not directly connected with the performance of a fiber optic system, the optical reflectometer is a very necessary tool. The unit pictured here has been available for several years and is typical of many others on the market. The OR-1 like the others, for the most part, is a very accurate, reliable and easily used unit in the lab. In the field, it becomes a tremendously frustrating monster. The procedure for using this device is to clean the fiber optic and insert the bare fiber into a capillary tube located in the X-Y positioner.

The problem in the field is the large amount of infrared present in sunlight plus wind. Take this unit plus a scope for readout up in a bucket truck on a windy sunny day and one can take, literally, hours to get good measurements. (See Figure 7)

This is our new field unit which can be battery-powered and comes either as a separate stand alone package or with a Tektronix scope. The big difference is the fact that the positioning device is eliminated and a fiber optic connector is used. In this case, a Deutsch bulkhead connector is mounted. Now one simply installs a connector on the fiber to be measured, plugs it in and proceeds with the readings. There is no infrared leakage and it's not affected by the wind. Measurements are now possible in minutes.

Summary

To illustrate what all of the aforementioned improvements mean, let's look at a system installed in early April of this year at Vision Cable in Fort Lee, NJ. (See Figure 8).

This system is presently in operation. It has 2 active fibers with 5 channels from the studio/microwave site to the headend and 2 channels in the opposite direction. The total distance is 8,800 feet, all of which is aerial except for 1200 feet of ductwork at the headend location. Vision Cable System's own system crew installed the fiber cable in two sections over four working days. Times Field Engineering crew fuse spliced the cable, checked out the system, and ran performance tests in 2 days - a total of 6 working days from start to integration into their CATV system by a crew with no previous construction experience with fiber cable. This system performance measurements came out as follows:

Link	EIA Weighted Signal to Noise
40 MHz	59 dB
110 MHz	55 dB
Optical Power Received	33 microwatts

Link 2	EIA Weighted Signal to Noise
40 MHz	57 dB
110 MHz	53 dB
200 MHz	54 dB
230 MHz	56 dB
250 MHz	55 dB
Optical Power Received	30 microwatts

The F.M. modulators/demodulators in this system used 2.5 MHz deviation.

In closing, continual progress is being made in fiber optic transmission systems as we have related. The improvements of the last 12 months in lasers, laser drive circuitry, laser packaging, low noise receiver amplifiers, fuse splicing, and signal conditioning equipment has allowed us to extend the distance between repeaters in some cases from approximately 6,500 feet to 16,000 feet with, of course, a reduction in system cost and improved reliability by reducing parts count.

Other companies contributing to the results mentioned in this paper are
General Optronics - Injection Laser Diodes
RCA - Avalanche Photo Detectors
Tomco Communications - F.M. Modulators and Demodulators
Power Technology, Inc. - Fuse Splicer
Deutsch - Optical Connectors

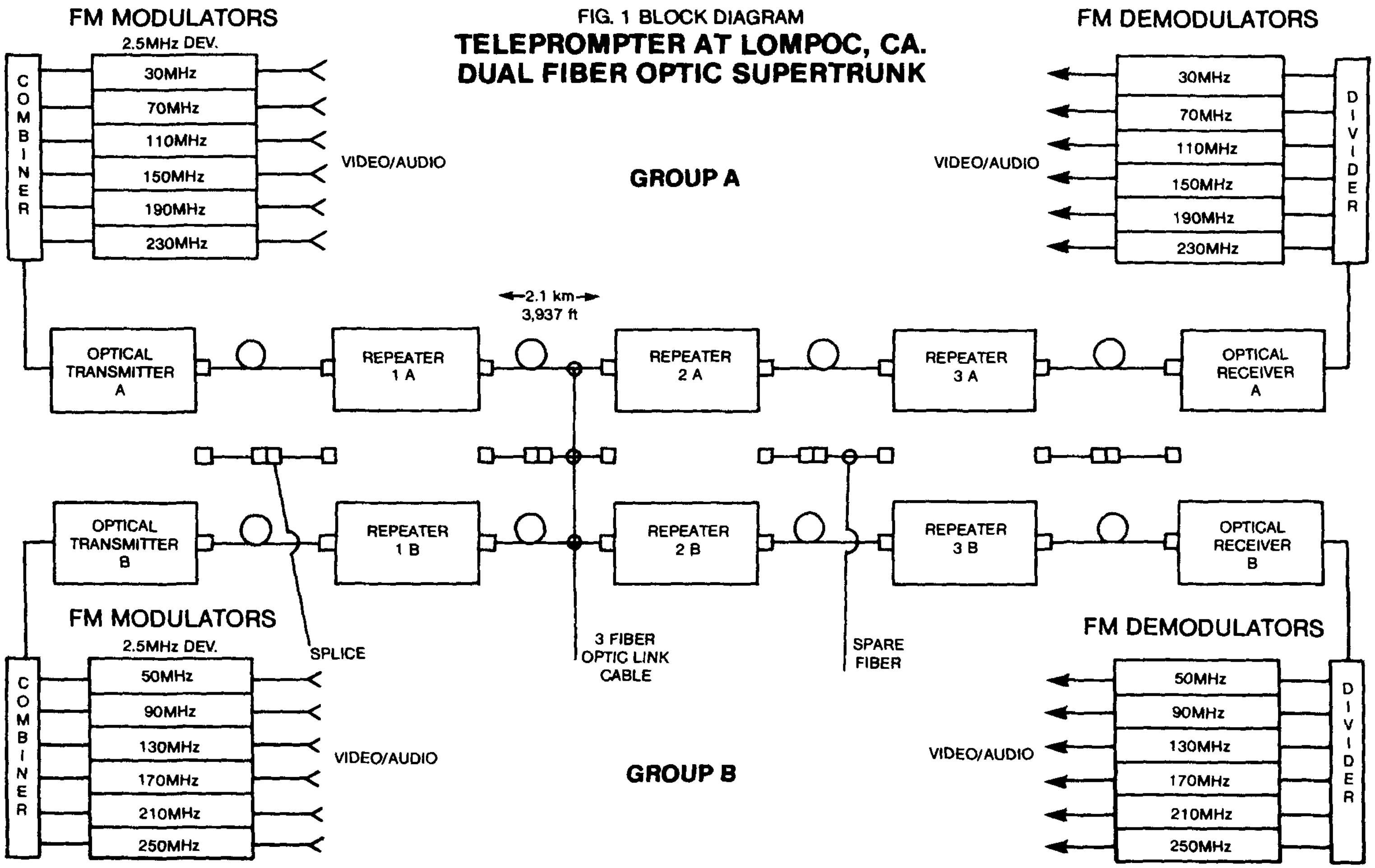


FIG. 1 BLOCK DIAGRAM
TELEPROMPTER AT LOMPOC, CA.
DUAL FIBER OPTIC SUPERTRUNK

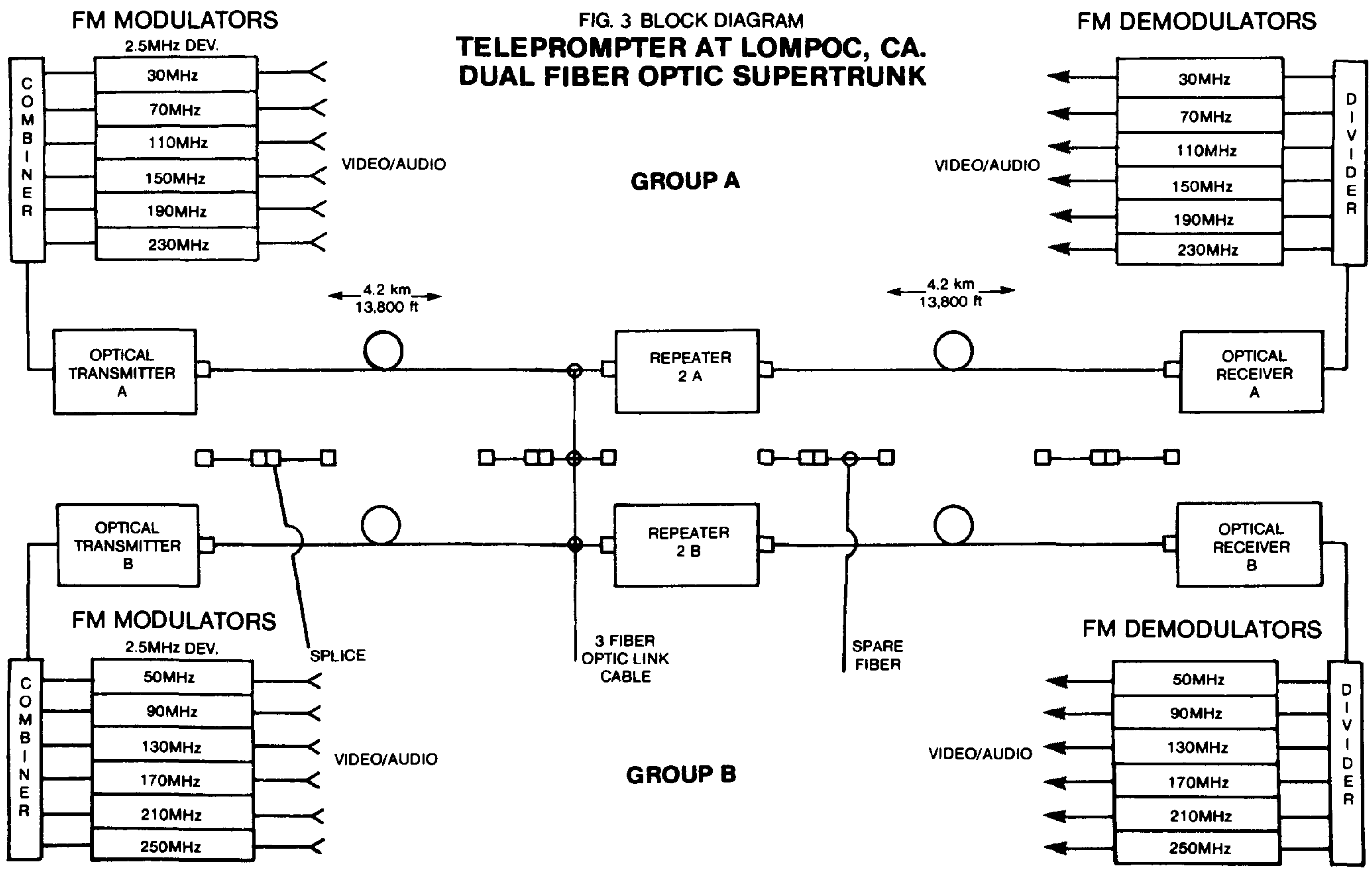


FIG. 3 BLOCK DIAGRAM
TELEPROMPTER AT LOMPOC, CA.
DUAL FIBER OPTIC SUPERTRUNK

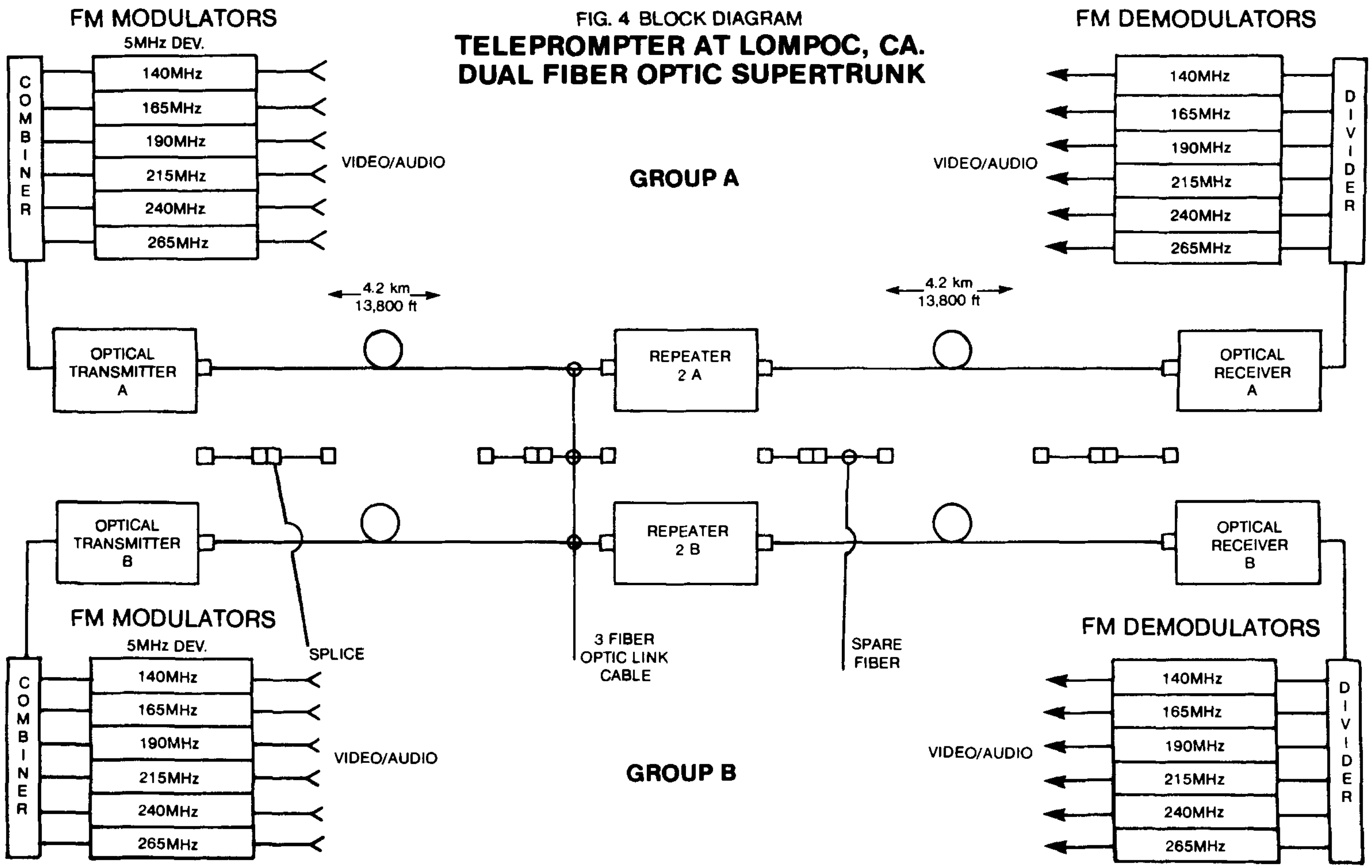


FIG. 4 BLOCK DIAGRAM
TELEPROMPTER AT LOMPOC, CA.
DUAL FIBER OPTIC SUPERTRUNK

FIG. 5 BLOCK DIAGRAM

FIBER OPTIC SYSTEM
UNITED CABLE
PLAINVILLE, CT.

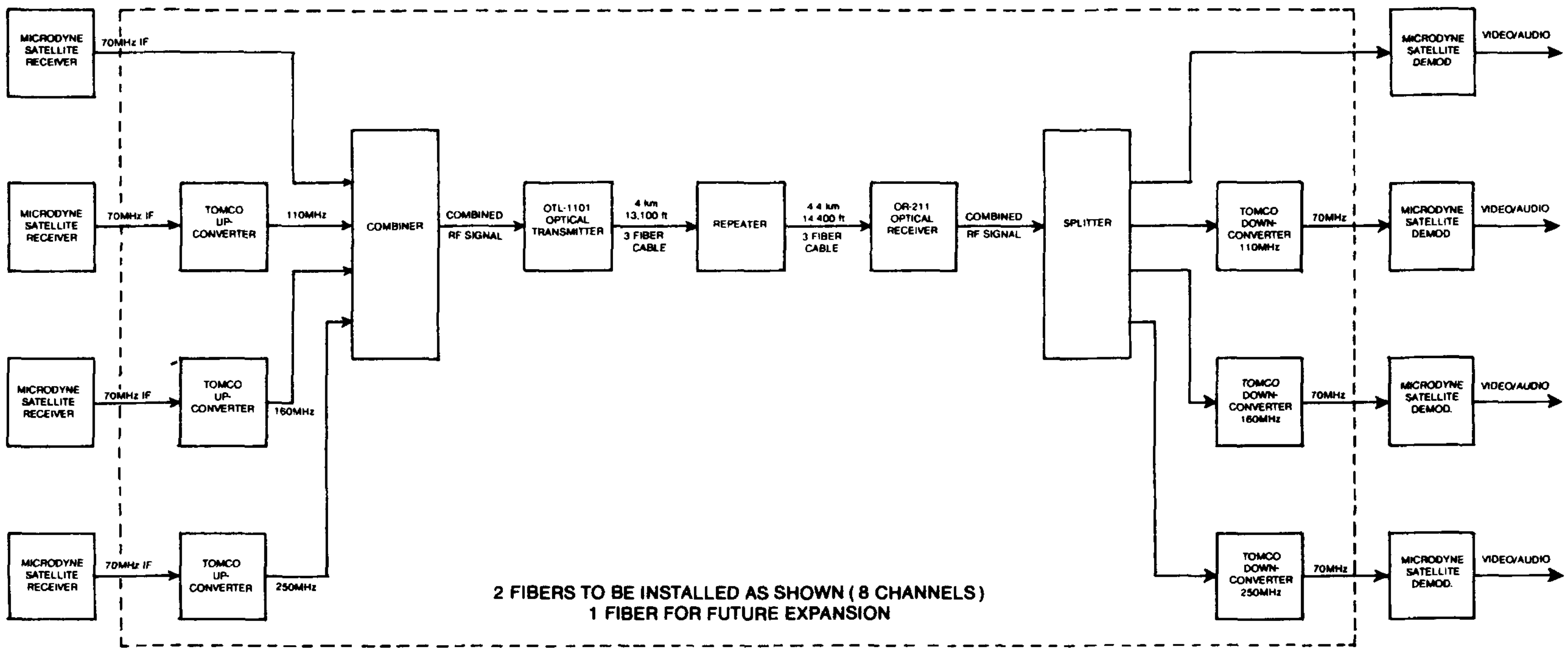


FIG. 6

TIMES FIBER COMMUNICATIONS, INC.

MODEL OR-1
OPTICAL REFLECTOMETER

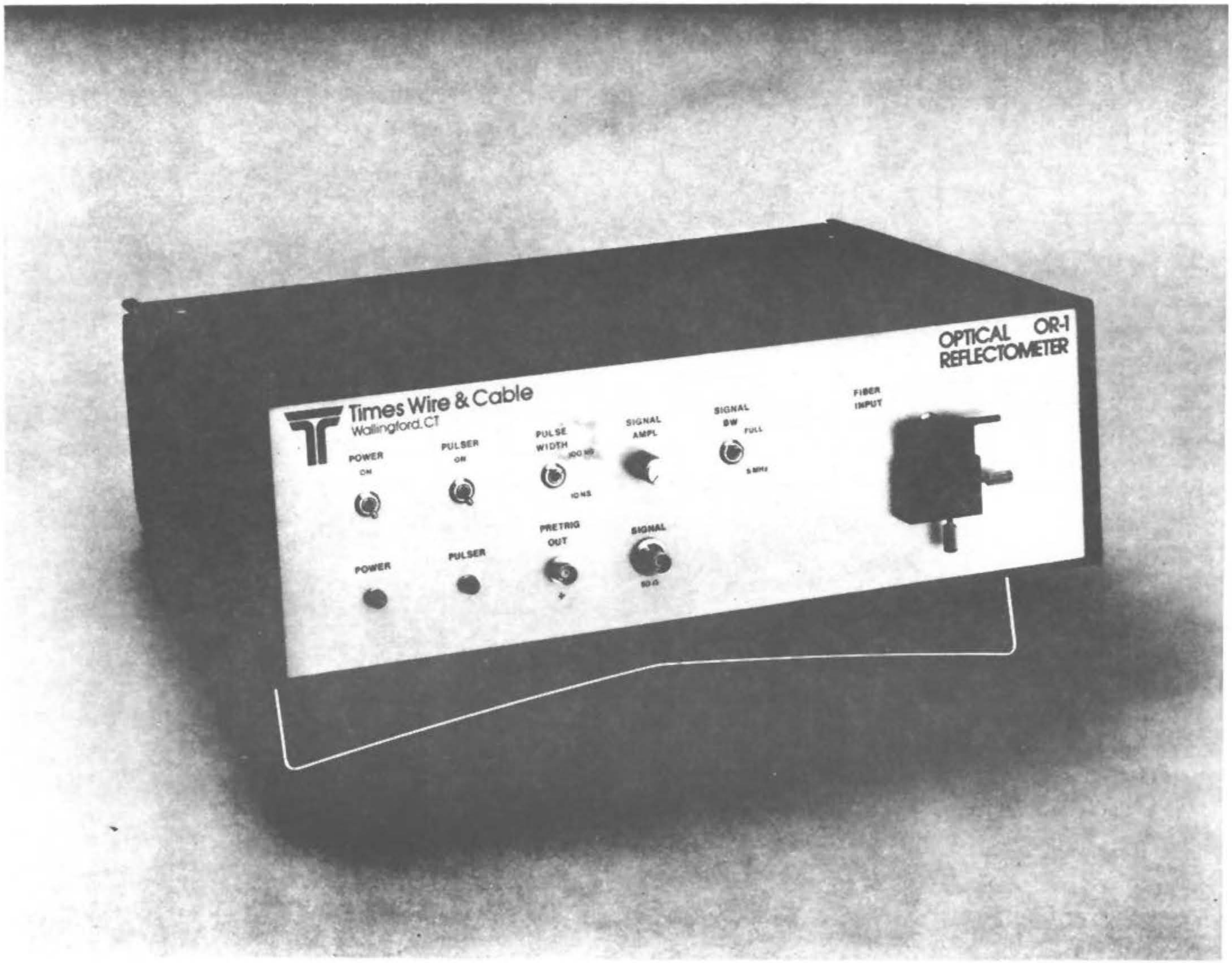
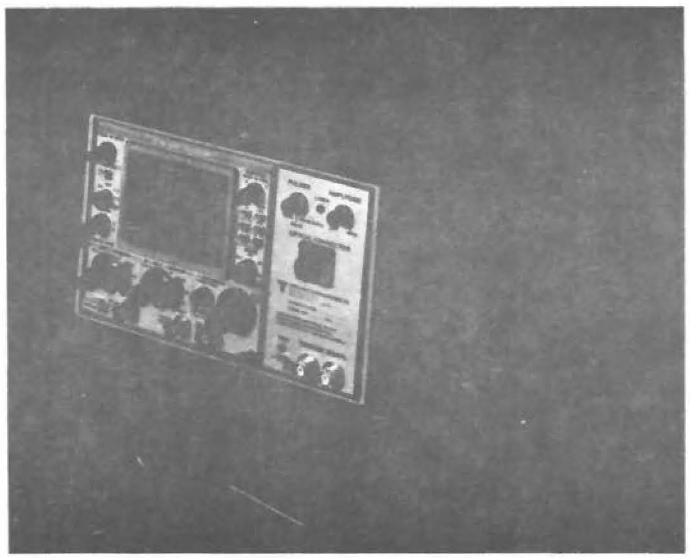


FIG. 7

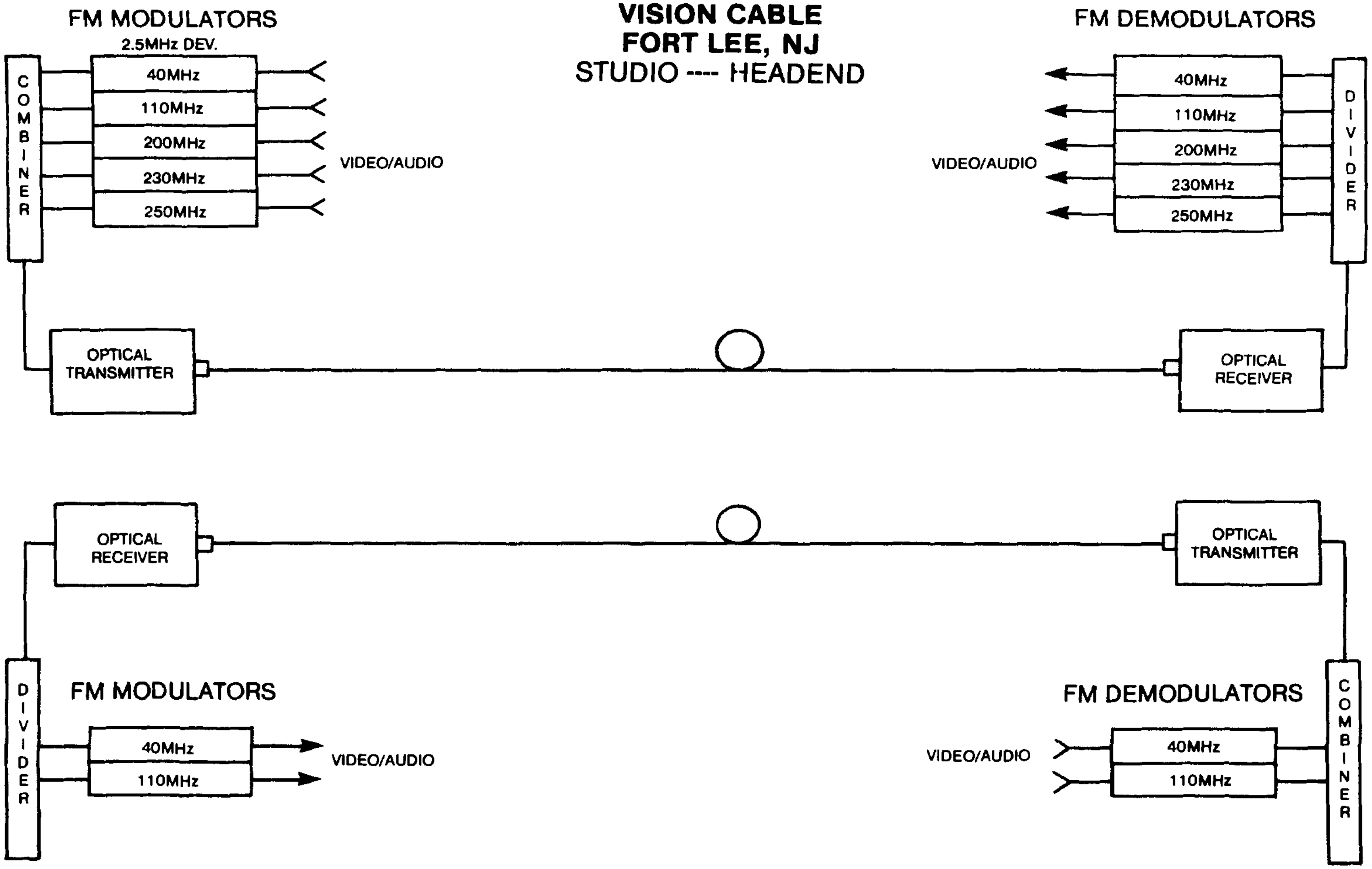
TIMES FIBER COMMUNICATIONS, INC.
OPTICAL REFLECTOMETER



MODEL: SYSTEM 53

MODEL: SYSTEM 51

FIG. 8 BLOCK DIAGRAM
VISION CABLE
FORT LEE, NJ
STUDIO ---- HEADEND



RECEIVING AUXILIARY SERVICES VIA SATELLITE

Thomas M. Keenze

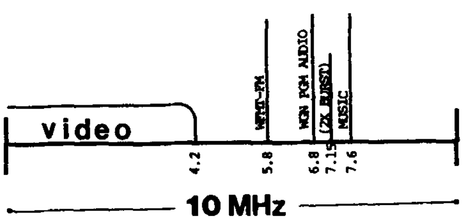
United Video, Inc.
Tulsa, Oklahoma

The number and type of services to be offered along with video on satellite transponders will be large and varied. These will provide financial opportunities for carriers and CATV operators. This report deals with methods of transmission, types of services, and receive station capability requirements.

Many services other than television signals are now available on the satellites. All of the non-TV signals which are available now and will be made available in the future are being put there to make money for both the CATV companies and the carriers. In order to avail yourselves of the potential revenues sources which are and will be available, a CATV operator will have to have a satellite station capable of proper reception of this additional information.

First, let's look at a typical baseband spectrum from a satellite transponder to see how these additional services might come to you.

(First Overlay)



BASEBAND OF TRANSPONDER THREE, SATCOM I

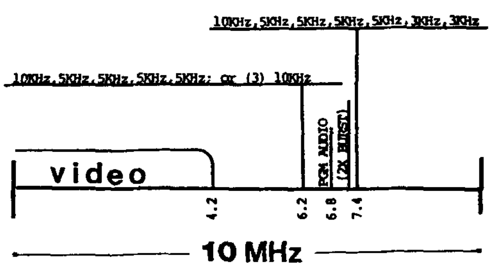
This diagram shows the baseband spectrum of Transponder 3, Satcom I, United Video's WGN signal.

The baseband is 10 MHz wide. Video takes up, for practical purposes, 0-4.2 MHz. The first FM subcarrier is at 5.8 MHz. The space between video and 5.8 MHz is for the skirts of the video low-pass filter in the satellite receiver. This filter requirement will be covered a little later in the presentation. At 5.8 MHz, we have a stereo multiplexed signal. This is WFMT-FM, a radio station in Chicago. Deviation of this FM subcarrier is 300 KHz. It requires 800 KHz spacing to prevent adjacent channel interference. The WGN program audio is at 6.8 MHz. This is the standard slot for program audio on all Satcom I transponders. This FM subcarrier is deviated at 75 KHz. The next thing you see is at 7.15 MHz. This is roughly twice the color subcarrier frequency and is usually avoided because of the possibilities of intermodulation. The last subcarrier is at 7.6 MHz. It is to be used soon for a monaural music service and will be deviated at 75 KHz. Nothing over this subcarrier frequency is used due to the additional technical requirements for receivers and receive system performance.

Remember that these subcarriers above video are FM modulated and are, in turn, used to FM modulate another (main) carrier. Therefore, two processes of demodulation are required. What we have here is known as FM, on FM. This was once described to me as "the carrier goes ape."

The main carrier, approximately 4 GHz, is demodulated by your satellite receiver, and then the output of the composite baseband will be video with FM subcarriers. These must also go through FM demodulation to arrive at baseband information. Most satellite receivers have the 6.8 MHz FM demodulator built in so that baseband audio is available at the output of the receiver along with baseband video.

(Second Overlay)



ANOTHER SCHEME

Another scheme which has been successfully tested is shown here. Again, video takes up 0-4.2 MHz. At 6.2 MHz there is a multiplexed subcarrier capable of one 10KHz and four 5 KHz audio channels or three 10 KHz channels. The 6.8 MHz subcarrier is the standard program audio for the video channel.

7.4 MHz is another multiplexed subcarrier capable of one 10 KHz channel, four 5 KHz channels, and two 3 KHz channels.

For clarification, a 10 KHz channel is the fidelity equivalent of an AM radio station. The 3 KHz channels are the equivalent of standard telephone voice channels. The 5 KHz channels are better than the 3's but not as good as the 10's, and this might be used for such services as background music. These channels are capable of data transmission as well as voice or music. The data may be slow scan video or alphanumeric information. It may also be video-graphic information.

The ways in which this capacity may be used are varied and the transponder operator will select information to be sent in this way in order to maximize his profits and that means he will be providing services that CATV operators can use and sell--either to his subscribers or to another business. This session will not attempt to deal with the specific types of services and the economics involved in each. Rather, we will try to show the volume of traffic capable of being transmitted on the transponder and what you will need to receive all of it.

It should be obvious that proper reception of all of the potential information will require proper receive facilites. In general, you cannot expect the best performance from a receive station with the lowest price.

According to Intelsat, with many years experience in satellite transmission, a G/T of approximately 40 db is desirable. Anything less, according to Intelsat, "remarkably hinders the effective use of a satellite's power." Intelsat satellites have, generally, 10 db less EIRP than our domestic satellites. Therefore, I would recommend a G/T of 30 as a minimum for unhindered performance in a receive station.

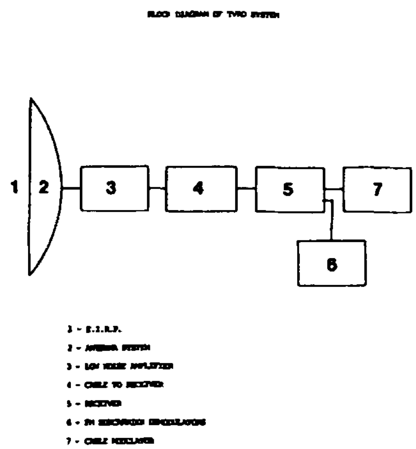
Since the typical video receive-only station is, according to Scientific Atlanta, about 26.8 db, you can see that there is a problem here. The additional 3 db recommended can only be made up, practically, in antenna gain. A 10 meter antenna with 120 degree LNA will move you close to this goal.

To be sure, smaller aperture antennas can be used, but performance of video and the various FM subcarriers will suffer accordingly. This degradation may be something you can live with, or it may not. Whether or not you can live with it will be determined in part by the performance of your cable distribution system. Remember, a 48 db signal to noise at your headend will be degraded further by distribution system noise. You should take this into consideration in your system design.

I would estimate that the additional cost encountered in installing a 10 meter antenna instead of a 5 meter antenna would be about $30,000. But, this will allow you to pursue many new business opportunities which will be afforded by clear reception of this additional information. The additional cost may be recovered very quickly. I recognize that this extra cost may not be practical for small cable systems, but in larger systems, this extra cost should be absorbed very easily. We are talking about a $30,000 additional cost in a multi-million dollar cable television system. It is a small price to pay for the assurance of proper reception. This one piece of equipment, the satellite receive station, is for most systems, the primary source of services that make the system feasible in the first place. You are getting pay television, independent television stations, news services, and in short--everything you do not pick up off air or generate internally. I think that it is the bulk of the key services offered for many systems. Your satellite receive station is not the place to scrimp.

If you already have a station in place let us see what you can do about making it work as good as possible.

(Third Overlay)



The components to consider in the receive system are:

1. EIRP
2. Antenna
3. Low noise amplifier
4. Coaxial or waveguide run from the low noise amplifier to the receiver
5. Receiver
6. FM subcarrier demodulators
7. Cable modulator

Some considerations on each component are:

(Fourth Overlay)

1. EIRP
   a) Actual levels may vary from published figures. An on-site survey is recommended to assure that the actual number is used in performace summaries for the station. All summaries provided by coordination agencies are published numbers. Variations in this may be caused by a local blockage of the signals, reflected signals, etc.
2. Antenna
   The actual gain published may not be achieved because of:
   a) Poor installation. Surface tolerance and feedhorn alignment are of prime consideration as is alignment with the satellite. The antenna should be carefully assembled. No parts should have to be forced. The installation should be done by an experienced

crew. Alignment to the satellite should be done when the satellite is in the center of its box. This information is available from RCA. Pay particular attention to polarization alignment. If you look at the LNA output on a particular polariztion, you will see carriers spaced 40 MHz apart. Interspersed between these halfway (20 MHz) are the carriers of the transponders from the other polarization. These should be 20 to 30 db down or more from the peaks of the carriers for the polarization you are looking at. If they are not you have a problem with alignment of the feedhorn. Misalignment will result in poor polarization discrimination. You will have noisy pictures due to adjacent channel interference. This looks much like impluse noise. If you see any carriers 10 MHz away then you have terrestrial carrier interference. Terrestrial frequencies plans are offset from satellite frequency plans by 10 MHz.

Make sure that you have a clear path over the horizon at the proper elevation to the satellite.

3. Low noise amplifier
   These are generally reliable as to noise and gain figures. However, they may be adversely affected in these respects by an extremely hostile environment (extreme heat or cold). Remember, the noise figure is specified at ambient temperatures. Check what they are. Perhaps an enclosure for the low noise amplifier would be appropriate.
4. Coaxial cable
   a) N-type connectors with RG214 cable is commonly used to jumper the low noise amplifier to the coaxial cable. This is not an outdoor cable and the connectors, especially, should be protected from intrusion of moisture. Degradation of performance will be severe if even small amounts of moisture are allowed to penetrate the connectors.
   b) The connectors on the heliax should be installed as per manufacturer's specifications. Inproper installation will result in VSWR, causing unwanted and unnecessary losses.
   c) Half-inch cable may be used in installations up to 200 feet. Above this 7/8 inch heliax should be used.
5. Receiver performance
   Critical areas:
   a) Sensitivity. A low noise figure and threshold will be desirable. Manufacturer's specifications vary. Check for the best and test to see if they meet specifications.
   b) Bandwidth of satellite transmission is 36 MHz, of which 34 MHz is considered usuable for practical purposes. Anything less than this is cheating on the bandwidth to improve noise performance. This would be tolerable if the only information on the transponder is video and program audio. If a transponder is fully loaded, bandwidth limiting to achieve lower noise figures actually lowers the carrier to noise of the receiver, causing noisy video to result, as well as non-linear distortions in the demodulation process.
   c) Filtering on the video output to your modulator should be provided. Proper performance demands a 4.25 MHz equalized video low-pass filter. Check with your manufacturer to see what you have. Many are not providing this. If required, these filters may be bought and added externally. The price range is $145-220, depending on where you get them. Improper filtering will cause noisy waveforms, noisy pictures, and perhaps beats in the pictures on the cable systems.
6. FM demods
   These are used to demodulate the FM subcarriers above video which are present at the receiver composite output.
   a) As with basic receivers, sensitivity should be checked.
   b) Bandwidth should be the same as that of the subcarrier being demodulated.
   c) Proper filtering should be provided in the equipment to reject adjacent subcarriers.
7. Modulators are not really part of the receive system but should be considered because that output is the one the television customer sees.
   a) The noise figure should be as specified by the manufacturer.
   b) The modulation linearity should also meet specifications.

Now if you are receiving the signal as well as possible, you will be ready to take on additional services.

United Video added the first stereo signal to satellites on its transponder. This was done not long after Southern Satellite Systems pioneered slow scan video with the introduction of UPI Newstime on Transponder 6.

In our case, we wanted to provide a high quality stereo transmission channel to accomodate the signals of WFMT-FM of Chicago.

We investigated equipment manufactured by several different companies. Our primary considerations in the equipment selection were economics and spectrum usage on the transponder. The first consideration was to keep the cost of customer owned equipment at the receive sites as low as possible. The second consideration was that we wanted to transmit the signal on a single subcarrier over the satellite in order to save room for other new services.

Our previous terrestrial experience with delivering WFMT had proved that any audible degradation of the signal transmitted would be unacceptable to cable company customers purchasing FM service. We chose the Leaming transmission system because it met all of the criteria. This equipment allows high quality transmission on a single subcarrier with low cost upconverters. The system transmits the signal over the satellite in a composite stereo format. This allows accurate reproduction of the WFMT signals without necessitating regeneration of the 19 KHz pilot signal. That factor cuts the cost of the equipment at the receive end virtually in half, when compared with dual subcarrier systems which regenerate the 19 KHz pilot signal. The equipment used at the customer site to demodulate the FM signal from the composite baseband of the satellite receiver is the Leaming FMU-201C. This device employs a technique called deviation enhancement which encreases the frequency deviation of the subcarrier from a standard 75 KHz to 300 KHz. This is coupled with a special filter for removing unwanted intermod products that may occur as a result of non-linearities in transmission and demodulation systems, and a unique pre- and de-emphasis curve which improves signal-to-noise in the upper portion of the baseband.

Actual testing of this system proved that the results were worth the effort. One Sunday night at midnight, WFMT engineers generated test signals in the studio, which were transmitted over the air in Chicago, received by the Leaming downconverter, transmitted through microwave to Lake Geneva, uplinked to Satcom I Transponder 3, received at Tulsa Cable, upconverted by a Leaming FMU-201C, and there were tested for signal-to-noise, frequency response, stereo separation, and distortion. Signal-to-noise on the channel was recorded at 67 db. This is 7 db better than FCC requirements for an over-the-air broadcaster. That proves not only the quality of WFMT's broadcast in Chicago, but also the quality of the transmission system through the microwave and the satellite. Stereo separation was around 35 db. Frequency response was essential flat from 50 Hz to 15 KHz. Distortion was well within FCC limits, ranging across the frequency band from one percent to two percent.

The next item on United Video's agenda will be activation of the 7.6 MHz subcarrier on Transponder 3. This subcarrier will be used to transmit monaural music for use as background on cable TV channels and in stores. The 7.6 MHz subcarrier has already been tested and its performance is satisfactory. This subcarrier will be transmitted with a standard 75 KHz deviation. Its bandwidth will be 5 KHz.

United Video also plans to replace the 6.8 MHz program audio subcarrier on Transponder 3 with a multiplexed 6.8 MHz subcarrier. The 6.8 MHz demodulators built into most satellite receivers will still receive the same monaural audio signal, but those systems wanting to put WGN audio in the FM dial in stereo, will be able to use a Leaming FMU-201C similar to the one used for WFMT for this purpose. United Video will not charge cable systems for this service.

A great deal of additional information may be transmitted on a satellite transponder through the use of vertical interval transmission. It would take another session to discuss that, so I will not cover it here.

In conclusion, I would say that during the next two years, many additional audio and data services will be activated on various transponders carrying video information. The smart cable operator will be the one who will be prepared to receive these serivces and recognize them for the money-making opportunities they are.

REVIEW OF PRESENT STATE OF THE ART OF RESIDENTIAL FIRE AND BURGLAR ALARM HARDWARE

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ABSTRACT

The present residential alarm hardware and system configuration is described for cable management and technical personnel who are interested in providing this ancillary service over a two-way cable system. The advantages and disadvantages of wired and wireless systems, perimeter and volumetric intrusion sensors, as well as heat and smoke protection, are described. Important features of the alarm control panel and various methods of communicating to the central security station are discussed. Pictures of current hardware are included. The conclusion identifies unique advantages of a cable television company offering alarm services.

BACKGROUND ON THE ALARM MARKET

For many cable industry people, the recent interest in monitoring fire and burglar alarms over cable communication systems is a return to the late 60's and early 70's when several manufacturers offered interactive cable terminals. It is interesting to note that Scientific-Atlanta designed and demonstrated interactive two-way cable terminals in 1969 to monitor residential fire and burglar alarms before it developed a line of distribution equipment.[1] (See Figure 1.)

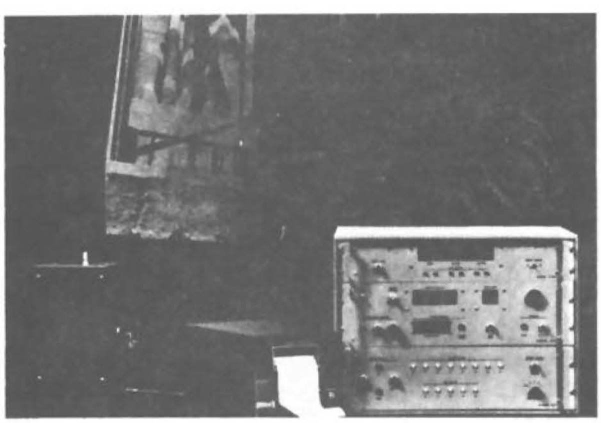


FIGURE 1. 1969 Alarm monitoring system for cable television

Although the two-way cable market didn't develop in the 70's, this early involvement with residential alarm systems resulted in a major contract for Scientific-Atlanta to supply residential fire and burglar alarm systems to Rollins Protective Services Company in 1971. Through this arrangement Scientific-Atlanta has become a leading supplier of residential alarm systems, having well over 40,000 installed systems.

Until recently most alarm service companies have concentrated in the commercial and industrial market. The residential market has presented unique and expensive marketing problems. Fewer than 2% of U.S. homes are now outfitted with security systems. Thus, the potential market includes almost all the nation's 75,000,000 existing residences. Creative Strategies, a marketing research firm in San Jose, California, estimates that installed sales will total $395,000,000 by 1985. Gallup Polls estimates that one in every four houses was hit by crime within the last year, and that 20% of the U.S. population doesn't feel safe, even at home. The time seems right for an effective, affordable protection system.

The cable communications system and the cable door-to-door marketing offers a unique opportunity to provide a needed service to the consumer and a profitable ancillary service to the cable industry.

A security system consists of three major elements: sensors, a control unit, and an alarm. The sensors detect an intrusion or fire. The fire sensor is usually a smoke detector, that is a device which detects the presence of smoke or other products of combustion. The intrusion sensor, however, can take many forms. The most commonly used is a special switch that opens when windows and doors are opened or broken into. The control unit turns the system on or off and monitors the sensors. When a sensor is tripped, that is, a set of contacts is either opened or closed in the sensors, the control unit will sound the alarm, which is normally a siren or bell. Most control units also contain an automatic communicator which signals over telephone lines or a cable television system to a central monitoring station. This signal identifies the customer, the location, and the nature of the emergency. The answering service then notifies the proper authorities. A block diagram of the system is shown in Figure 2.

Alarm systems can be further subdivided into wired systems, where all sensors are wired to the control unit, or wireless systems, where the sensors are connected to the control unit via radio or some other nonwired communication channel. Most

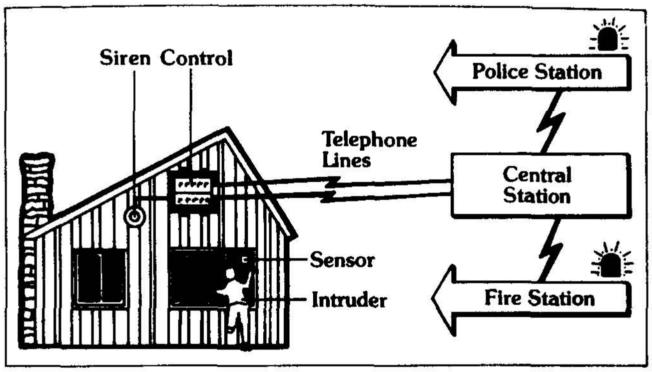


FIGURE 2. Block diagram of security system answering service

wireless systems use a radio link between the sensors and the control unit. The sensor's transmitter frequency, power output and transmission duration are controlled by the Federal Communications Commission Regulation Part 15. Compliance to these Rules constrains the equipment designer in providing an effective alarm system. The FCC has proposed new Rules (Docket 20990, dated November 1, 1976) which may improve the equipment design options. But until these new Rules become effective, the radio equipment must comply with the present Rules and be certified by the FCC. The advantages and disadvantages of a hardwired and a wireless system are outlined in Figures 3A and 3B.

Advantages of a Wired System

1. Sensors are supervised, systems cannot be turned on with doors and windows open
2. System hardware cost is less than a wireless system
3. Sensor powered from master control unit
4. Zoning is possible
5. Equipment doesn't require FCC approval and neighboring system cannot interfere

Disadvantages of a Wired System

1. Requires considerable on-site labor running wire from control unit to sensors
2. Exposed wires are often objected to by homeowner
3. Installed cost is usually more than a wireless system

FIGURE 3A

Advantages of a Wireless System

1. Requires less on-site labor running wires
2. Installation less conspicuous
3. Portable or hand-held sensors possible
4. Easy installation for homes already constructed

Disadvantages of a Wireless System

1. Range of transmitter limited
2. Batteries must be replaced periodically
3. Zoning is usually not possible
4. Equipment must comply with FCC Rules Part 15
5. Supervision of sensors not possible
6. System can be turned on without detecting open doors and windows
7. Subject to interference from neighboring systems

FIGURE 3B

INTRUSION PROTECTION

Intrusion protection sensors are divided into a perimeter sensor and a space or volumetric sensor. A perimeter sensor detects an intrusion through the perimeter of a building or area, such as the opening of a door, a window, or gate. The volumetric sensor protects a defined volume and senses whenever there is an intruder in this volume.

The most popular perimeter sensor is a magnetic switch. (See Figure 4.) This sensor consists of a permanent magnet and a magnetically activated switch. When the switch is in close proximity to the permanent magnet, the switch is closed. When the two units are separated, the switch opens, indicating an intrusion. This type of sensor is usually installed on doors and movable windows.

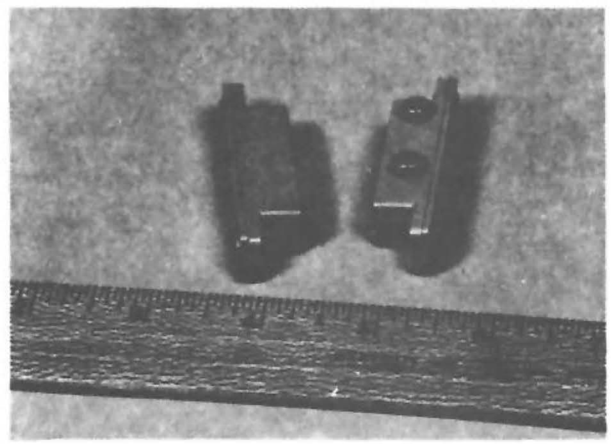


FIGURE 4. Magnetic switch

Pressure type switches can also be used to detect window and door openings, by arranging the switch so that when the window or door moves the circuit is open. (See Figure 5.)

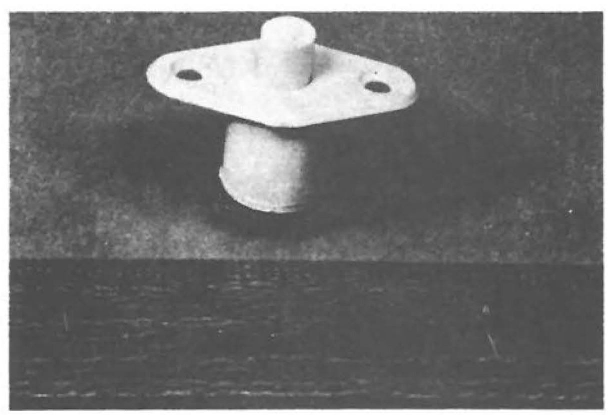


FIGURE 5. Pressure switch for windows and doors

Large plate glass windows can be protected by a thin foil circuit taped to the perimeter of the window. This foil circuit will open should the window be broken. Another technique for protecting large plate glass windows is the so-called glass break detector. This unit consists of a small transducer mounted on the glass window. (See Figure 6.)

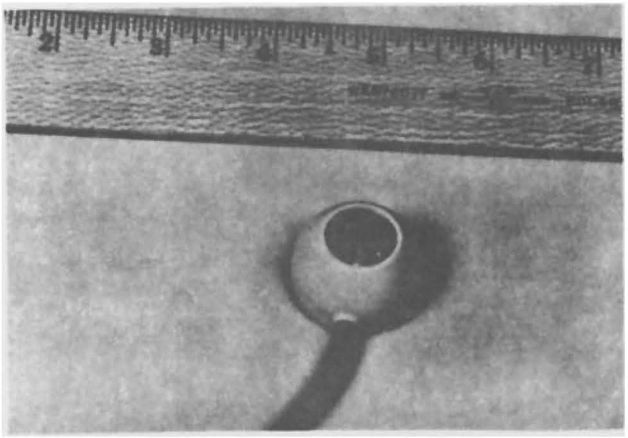
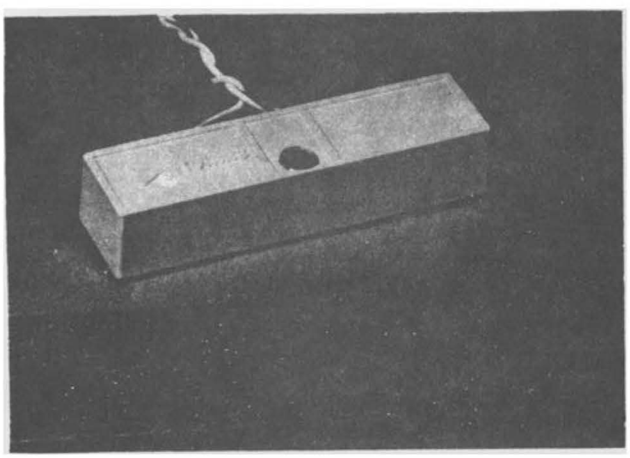


FIGURE 6. Glass break detector

This transducer is tuned to the frequency of breaking glass and opens a switch when the glass breaks. This has the advantage of minimizing the labor involved in taping the perimeter of large plate glass areas. Another type of window protection is a vibration detector. (See Figure 7.) This device consists of a weighted switch, which momentarily opens with the shock of breaking glass. This device can also be used to detect vibrations caused by penetration of walls.



FIBURE 7. Vibration Detector

Another type of perimeter detector is the photoelectric eye. The photoelectric eye consists of an optical or infrared light source and a receiver. The transmitter and receiver are placed so that an intruder entering a perimeter will break the light beam. When the light beam is broken, an alarm is sounded. The light source is usually pulsed in a coded manner in order to avoid jamming by external light sources.

Initial perimeter protection can be backed up by additional perimeter protection, such as mat switches, which are placed under rugs or carpets to detect intruders. The basic security systems are often backed up with panic buttons or manually activated switches to start an alarm sequence.

A volumetric sensor, as the name implies, is designed to detect the presence of an intruder in a specified volume of space. The most popular form of volumetric sensors is the ultrasonic motion detector. This motion detector works similar to a police radar. An alarm is sounded any time the sensor detects motion in the area covered by the detector. A microwave motion detector works on the same principle as the ultrasonic detector, except microwave frequencies are used to detect motion rather than ultrasonic sound waves. The microwave motion detectors are somewhat more expensive than the ultrasonic detectors and they also provide better control of the space to be protected. Another volumetric sensor that is gaining acceptance is the passive infrared detector. This device senses the heat radiated by an intruder. Balancing circuitry inside the infrared heat detector keeps it from being sensitive to ambient temperature changes and constant light sources.

Volumetric sensors tend to find their application in protecting areas in which the occupancy can readily be predicted, such as commercial and industrial buildings. The problem with volumetric sensors in homes is that any movement by the homeowner or house pets, even air movement caused by the heating and air conditioning fan, can sometimes cause an alarm.

FIRE DETECTORS

Thermal detectors, or heat sensors (See Figure 8) are activated when the detector element exceeds a predetermined temperature. While heat detectors are useful in minimizing the damage to a protected residence, they may not offer much life protection.

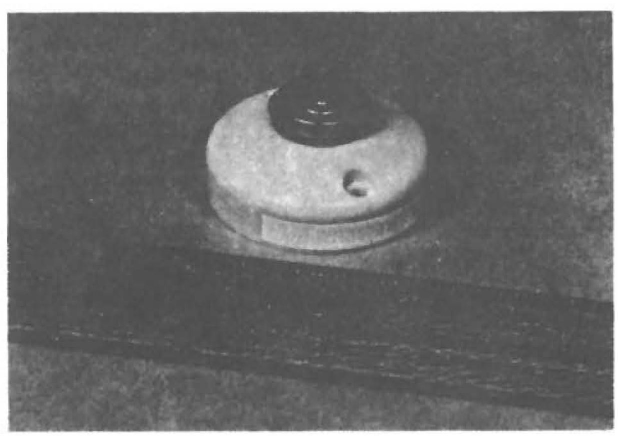


FIGURE 8. Thermal detector

Most fire casualties are caused by smoke inhalation, as opposed to heat. Unless the thermal detector happens to be in close proximity to the origin of the fire, it is not likely to detect the fire in time to ensure the safety of the occupants. Therefore, most residences are now being outfitted with smoke detectors. These smoke detectors can give a much earlier warning of conditions that are likely to be unsafe for humans. Smoke detectors work either on a photoelectric principle or an ionization principle, or a combination of the two.

Photoelectric smoke detectors operate on a light principle, reacting when smoke obscures the beams path or reflects light into the photocell located inside the detector. With an ionization detector, the air within a small chamber is electrically conducted (ionized) by the emission of alpha rays. Combustion particles entering the chamber cause a change in the current flow, which results in an alarm. Some smoke detectors use a combination of both principles to improve the detection of all types of fires. A typical smoke detector is shown in Figure 9.

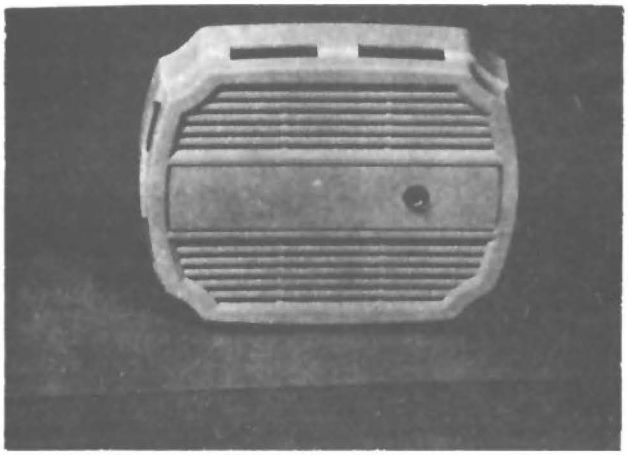


FIGURE 9. Smoke detector

CONTROL SYSTEM

The control unit is the heart of the alarm system. (See Figure 10.) It allows the customer to select the security mode or level. It also provides housing for the alarm processing electronics, batteries for emergency power, and the communication device to relay the alarm to the central station. If the system is a wired system, the wires from the sensors located throughout the protected premises are brought to the control unit. If the system is a wireless system, the control panel generally will also house the radio receiver which receives the messages transmitted by the wireless sensors.

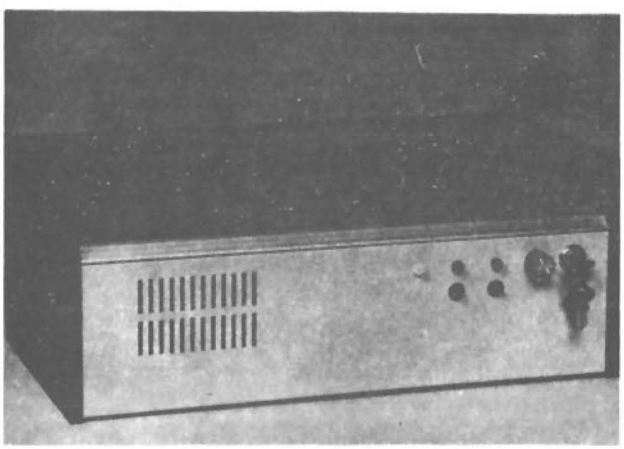


FIGURE 10. Control unit

The customer can turn on the intrusion alarm either with a key with is removable, or a keyboard entry which consists of a customer secret code followed by a command to indicate system on or off. The fire alarm is usually on regardless of whether the intrusion alarm is on or off. Some sophisticated control panels have a zoning feature, i.e., a portion of the system can be on while another portion of the system can be turned off. For example, if people are at home and confined to the main living space, that portion of the system can be turned off. The normal going and coming through the main living space would not set off the alarm, while the intrusion alarm in the basement and the upstairs can be left on to detect any would-be intruder. Most alarm control units have an entrance and an exit delay built into the system. This delay allows the homeowner to turn the system "on" and leave the house without setting off the alarm. Conversely, the entrance delay allows the owner to enter the house and turn the system "off" before the alarm goes off. The control unit allows these delays to be adjusted from 10 seconds to 45 seconds. U.L. Specification No. 1023 specifies that the maximum delay shall not exceed 45 seconds. Most alarm controls sound a low volume beat, while in the entrance delay mode, indicating that within a short period of time the alarm will sound if the system is not turned off. This warning also helps to reduce false alarms caused by accidental setting off of the alarm.

Sometimes entrance and exit delays are not convenient. In this case, a shunt lock can be wired in series with a sensor, which will allow the homeowner to open a specified door to enter and exit the home without setting off the alarm. The shunt lock is usually mounted outside the door that is commonly used to enter and exit the home without setting off the alarm.

Most residential alarm systems will provide for a loud local alarm, such as an electronic siren or an outside bell. This local alarm serves several purposes: (1) it alerts the neighbors that an intrusion or fire has taken place; (2) it alerts the occupants of a fire or intrusion; and (3) in the case of an intrusion, hopefully it will frighten the would-be intruder away. The control unit must provide two distinct alarms: one sound for intrusion, the other sound for fire. U.L. 1023 requires that minimum sound levels should be 85 dB at 10 feet. A reset timing circuit is desirable so that at the end of a 4-10 minute alarm the system automatically resets, thus eliminating the necessity of someone entering the home to turn the alarm off. U.L. 1023 requires a minimum of four hour emergency stand-by power. This is normally supplied by one or more batteries which are continuously being charged while primary power is available.

COMMUNICATION TO THE CENTRAL STATION

Many alarm systems depend on the local alarm only. The local alarm theory is that the would-be intruder would be frightened away and neighbors or passers-by, on hearing the alarm, would report the alarm. The next step up in system sophistication is the automatic telephone dialer. This communication device is usually located inside the control unit, and when the outside alarm sounds, it seizes the telephone line and dials the central station and reports either an intrusion or a fire message. The central station then sends the appropriate authorities to the identified residence.

Many early automatic telephone dialers dialed the police department directly, but because of the number of false alarms received and because some of the telephone dialers had a tendency to jam the switchboard at the police or fire station, most city authorities enacted ordinances which forbade dialers from directly phoning the emergency and fire numbers. Most alarm service companies therefore provide a central station to intercept these messages. They in turn follow the emergency procedures that the customer has provided. The central station not only will call the appropriate authorities, but many times will notify neighbors and friends, and will call the owner at work if the emergency occurs during working hours.

One of the main deficiencies of the automatic telephone dialer is the possibility of a would-be intruder cutting the telephone wires prior to break-in. This will revert the system to local alarm only. The cutting of the telephone lines with an automatic telephone dialer cannot be detected at the central station. In order to overcome this difficulty, dedicated telephone lines can be provided from the protected residence to the central answering station. This type of protection has been quite popular with commercial and industrial installations but is expensive for homeowners. Also, the availability of these circuits has become very scarce. The telephone company with its multiplexing system can get twenty or more voice channels out of a single copper pair, but if the copper pair is used to provide security protection to the central answering service, it can serve only one customer. Therefore, the telephone company has little economic incentive to provide these circuits.

Interactive two-way cable systems revolutionize the economics in remotely monitoring residential fire and burglar alarms. A central computer can periodically interrogate the security terminal located in customers' homes, and determine if the system is working and if there is an alarm. Because of the broadband "party line" nature of the cable system, interrogation can be done rapidly. The telephone system cannot approach this performance, because its system requires switching from one customer to the next before interrogation can begin. The cable system can tell when a line is cut, because a lack of response from a terminal is treated as an alarm. If a would-be intruder cut the cable drop before attempting to enter a protected home, it would be communicated immediately to the central station. Should a sector of the cable system go out, this interrogation process would also automatically identify and pinpoint for the cable operator where to dispatch a repair crew, without having to wait for phone calls from complaining customers.

Obviously, the approach can easily be extended to increase customer service and system reliability by incorporating a cable performance monitoring alarm into the interrogation system. These monitors could detect signal level out of specifications as well as outages.

UNIQUE ADVANTAGES OFFERED BY ALARM SERVICES OVER CABLE TELEVISION SYSTEMS

Cable operators possess several unique advantages in providing residential alarm services. The cable companies' high integrity and visibility in the community provide a unique marketing advantage. The residential security market has been plagued by fly-by-night, unethical companies. There are presently more than 15,000 local and regional fire alarm companies who install and maintain systems. An estimated 35% to 40% of these companies go out of business each year, according to a recent study by a New York based market research group, Frost and Sullivan.

Small local suppliers have neither the resources nor the interest to attack the residential market. No national company with a recognized brand name has emerged in the residential market. Cable companies already have the expertise that will be demanded to penetrate this market. The same in-the-home sales effort, the same marketing savvy, the same expertise in operating local offices, and the substantial capital to cover the front end expenses used to make the cable entertainment services successful will be necessary to make the residential alarm service successful. Few traditional alarm service companies could match these resources.

Until recently, the homeowner had two basic choices in residential alarm systems: a $2000-3000 stripped down version of a commercial system installed and maintained through a central station alarm business or various gimmicks that were low cost, self-installed and largely ineffective. Cable companies can provide the homeowner with a variety of security systems at affordable prices.

Given the unpleasant connotation of residential fire and burglaries, the home security system will require a hard, in-the-home sell strategy, like life insurance and cemetery lots. Only a very small percentage of the consumers can be convinced to voluntarily seek out and buy such products. Marketing is the name of the game in the residential alarm business, and marketing is where the cable companies have the edge.

NOTES:

[1]Marvin Roth, "Security Alert, a Two-way Digital Communications System," The 20th Annual NCTA Convention Official Transcript, National Cable Television Association, 1971.

SATELLITE SECURITY

ALLEN DAVIS

HOME BOX OFFICE
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I doubt very much if any of us really want to see satellite security ever become a requirement, with the possible exception of the manufacturers presently engaged in developing such a system. I have spent several months of time and travelled thousands of miles talking to various companies and individuals who are interested in providing equipment to secure satellite feeds. It is not surprising that while many people are engaged in research and development in this field that they are all following one of perhaps three or four paths. We'll discuss some of these systems a little later.

There are, of course, problems created with having to secure satellite transmissions, such as the logistics of supplying decoders fast enough, (remembering that earth stations are being installed every day), so that the network can pick a date for commencement of scrambling without someone being unable to receive the transmission due to the lack of a much needed decoder. This decoder which is placed right after the earth station receiver, places another link in the transmission and reception chain. In other words, it's something else to go wrong. Recognizing this problem we must now find a way of overcoming it. If we have to have a redundant decoder the price doubles, if we don't and a CATV system, for whatever reason, has a decoder failure, then either the affiliate will lose their pay service until the problem is rectified or the only other choice would be to unscramble the entire network. As you can see this would be more or less self-defeating.

While all the problems could be troublesome they can be overcome by careful planning and emergency procedures adopted. Unfortunately, these questions cannot be answered right now.

1. <u>Economics</u>:

When the costs of providing satellite security are considered it is very easy to see the reluctance to commit yourself to such a project. Costs for decoders have been estimated anywhere from $150.00 to $15,000.00, depending upon the degree of security being offered. One must consider the time frame involved even if a decision were to be made today to scramble it would be anywhere from 18 to 24 months before the equipment could be manufactured and delivered. At this date in time we could be talking about having to supply perhaps as many as four to five thousand decoders. With a little math you can see the amount of money that has to be considered.

2. <u>Technical Requirements</u>:

There are a few basic technical requirements that are a must in choosing a scrambling system. There must be no apparent degradation to either the sound or picture. This is important as subscribers have been used to viewing a certain standard of quality before satellite security began and I believe they would not be tolerant of any change in those standards. Another important consideration is that whatever system is selected, it must not touch the vertical interval. As you are aware, this is where the vertical interval test signals are placed and these must remain in their original form if they are to be of any use in determining the performance of a given transmission path. Also located in the vertical interval, in the future, will be teletext information and this must be left intact. The question arises if audio security is necessary. Some approaches to audio range from ignoring it to digitizing it, depending on what scheme the video scrambling has taken. Certainly if teleconferencing is to be considered, it would be absolutely necessary that both audio and video be secured as no firm would want their competition even listening to what future plans were being made.

The system must be capable of changing the decoder control codes when required. Some approaches to this problem have been to provide thumbwheel switches on the decoder so that at a specified date and time the affiliate can change the switches to a new code. Another system is a code credit card, good for the next month, which is mailed to each affiliate to be inserted in their decoder. These systems are too prone to problems such as our U.S. Mail not getting through in time, if ever. I believe the best method of controlling codes is to place the required data on a line in the vertical interval at the encoder. In this way codes could be changed at random without bothering the affiliate at all or taking a chance of a "folded and mutilated" card arriving by mail. Lastly, it is important that the manufacturer provide circuit cards that cannot be copied, should a decoder fall into the hands of an enterprising individual. This would require that either key circuits be potted or special components be provided that would be available to only the one manufacturer. Of course, the last system is also the most expensive one.

3. Scrambling Systems:

Various companies and individuals are either developing a scrambling scheme or have modified existing equipment they already produce in order to provide satellite security hardware. I tend to place the various systems into three categories:

a. Soft security
b. Medium security
c. Hard security

Soft Security:

Soft security implies that it can be easily defeated. This is not necessarily true; it could be by certain individuals but not to the same extent that some cable scrambling systems can. Some of the STV security methods fall within this category, all of them being strictly analog designs. While suppressed sync, inverted polarity are used, some are more advanced, using the vertical interval for code control changes.

These systems are, naturally, the least expensive being offered, with costs running between $150.00 to $300.00.

Medium Security:

As in the previous category all the medium security systems are analog in design. Here they, however, begin to depart from the soft security approach in that each line is attacked instead of complete fields of video. Most of the companies are doing line by line random polarity reversals with the control data being placed in the vertical interval or on a separate subcarrier. The approach to securing the audio is either to cut it off completely without the proper codes or to use a different form of modulation.

Costs for this type of equipment range between $1,000.00 to $2,000.00, with quantity playing an important role.

Hard Security:

Hard security is exactly what it implies, it would be nearly impossible to defeat due to the method and to the fact that, in some cases, millions of different codes are readily available. All these systems utilize analog-to-digital converters, scrambling in the digitized form and reconverting back to analog for transmission. Naturally, the reverse takes place in the decoders.

Some firms are utilizing their frame synchronizer design and interchange complete lines on a random basis. With the sequence constantly changing, it is almost impossible to break the code.

Another firm has developed a system that not only digitizes the video line by line and interchanges them on a random basis, but dissects each line at different points and reverses each line front to back. The audio is also digitized and placed on lines in the video. I think it's safe to say that it would be totally impossible to defeat this system.

Cost for hard security seems to run between $7,000.00 to $15,000.00 and up.

SUMMARY:

As you can see you get what you pay for. The question is -- how much security, if any, do we really need? Would a simple solution be enough or do we have to go to the other extreme and spend millions upon millions of dollars for hard security? There are still a lot of questions to be answered; this is why HBO will continue to work with those doing the designing work and follow the progress very carefully and with much interest.

"Status Report on EIA Broadband Modem Standards"

Harold W. Katz

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In May 1978, the Broadband Communications Section of the EIA Communications Division authorized the formation of sub-committee TR 40.1 to develop industrial standards for data modems that would be used on broadband cable networks. A sub-committee comprising industrial end-user representatives and modem manufacturers was formed in late 1978. Three smaller groups were established to provide the initial recommendations on 1) channel allocation, 2) cable system parameters, and 3) modem parameters. The paper presents the current status of the committee's work which used, as a guideline, present CATV technical standards.

Introduction

Interest in the distribution of data via two-way CATV cable networks has been a topic at NCTA conventions for over ten years. However, only a very limited amount of hardware and associated application software has actually been implemented on CATV systems over this period of time. The technology has, nevertheless, undergone extensive development and practical utilization. This activity has taken place primarily in the industrial environment rather than within the CATV industry which originally developed the broadband cable technology. Large scale production plants (in the order of one to two million square feet) recognized the need for an economical medium which would permit the distribution of high speed data throughout the plant without the need for running individual twisted pairs in conduit. There was also a need for audio and television distribution but to a lesser degree. Various manufacturers responded to this requirement by developing and marketing data modems to the industrial and commercial world. In this process each modem vendor and user was utilizing the cable bandwidth in a different manner. The potential conflicts and incompatibilities were becoming evident to the growing number of users and modem vendors. As a result, the Broadband Committee of the EIA (Electronic Industry Association) established in May 1978 a technical committee TR 40.1 to develop standard for industrial and commerical modems which interface to the broadband CATV coax.

The objective of this paper is to outline the tentative results of the committee's activity. It is hoped that this would provide a vehicle for disseminating this information to the CATV technical community at an early date, and thus obtain critical feedback prior to final stages of the developement of the standard.

Committee Scope:

A committee was drawn together which consisted primarily of cable modem suppliers,and industrial users of in-house broadband cable networks. A broader spectrum of interested groups included representatives from goverment agencies, manufacturer of related hardware, etc. The initial scope was rather broad to include "engineering matters related to the transmission of digital data on broadband coaxial cable systems typically used in industrial and institutional applications". However, the initial focus was directed toward data modems as used in industry. The committee tentatively excluded the class of modems which may be used in the conventional city-wide CATV systems, because it felt that the transmission environment was so different from the industrial that separate standards would have to be developed. It was decided not to attempt both standards simultaneously.

After considerable discussion on the possible approaches to the standard, the committee was divided into three sub-committees to work on separate but related portions of the problem. One committee was assigned the area of channel allocation, the second to modem terminal parameters, and the third to the cable system interface. A basic assumption for each committee was that the cable system to which the modem would be connected was designed in accordance with the standard TV signal and noise specification provided by the FCC and other organizations such as NCTA.

The following sections are a summary of the surrently proposed parameters which, as noted above, have not yet received official approval of EIA.

Sub-Committee #1 - Channel Allocation

a. Band Allocation
The designation of the conventional 6 MHz channels would be the same as that currently used in the CATV industry. For industrial use the cable system most commonly uses a mid-split configuration. An assignment of paired channels was made to provide full duplex operation, and where possible the standard TV channels 2-13 were not used for data as follows:

T-7/H
T-8/I
T-9/7
T-10/J
T-11/K
T-12/L
T-13/M
T-14/N

This assignment is also compatible with low-split networks.

b. Sub-Channel Designation
Since data channels normally occupy less than 6 MHz of bandwidth, each TV channel is sub-divided in 1 KHz increments with sub-channel zero at the lower baud edge and succeeding channels numbered one, two, etc.

c. Modem Spectral Designator
This is a numerical code assigned by the modem manufacturer to describe the frequency region over which the modem operates. The designator will have the following format:

TX - Channel Boundary - Sub Channel Displacement - Modem Channel Spacing - Modem Channel Bandwidth

RX - (same corresponding parameters)

Channel Boundary: The lower frequency edge of a channel expressed in MHz.

Sub-Channel Displacement: The number of sub-channels from the channel boundary to the center frequency of the modem.

Modem Channel Spacing: The number of sub-channels between the center frequencies of adjacent modems.

Modem Channel Bandwidth: The number of sub-channels occupied by the modem. (See sub-committee #2 summary)

The approach given above permits the vendor and/or user to assign the center frequency of the modem anywhere in the 6 MHz channel, and also allows a comparison between vendor modems to determine spectrum compatibility. Since each vendor uses a different modulation technique, it did not appear feasible to standardize on specific sub-channel center frequencies and bandwidth for different modem data rates.

Sub-Committee #2 - Modem Parameters

This group concerned itself with the possible standards which would apply to the RF and digital terminals of the modem, i.e., the external characteristics of the modem. It did not appear either feasible or desirable to attempt to standardize the internal modulation and demodulation techniques for each class of modem. One factor influencing the decision was the wide range in costs associated with the more sophisticated approaches which could be employed to reduce the amount of cable bandwidth for a given data rate. Furthermore, the availability of cable bandwidth has not been to date a limiting factor in the use of broadband coax by industry.

The following sections list the modem parameters deemed to be most important.

a. Nominal Transmit Power and Adjustment Range.

The nominal modem transmitter power output should not be a parameter for standardization but shall be specified by the manufacturer. The adjustability range shall be a minimum of 30 dB below the specified nominal maximum power output of the modem. Any specific level within this range should be settable within ± 0.5 dB.

Bulletin Note: It is not clear at this date what the optimum criteria is for establishing levels of data channels relative to video or nominal video levels in a given system. Constant power density has been used however there is some question as to whether this loading is acceptable particularly in conditions where the modem transmissions include coherent products. The technical bulletin to be published in addition to the standard will contain a discussion of power levels normally encountered and criteria for cable system loading.

b. Transmitter Bandwidth

The bandwidth is tentatively to be described at the 3 dB and 40 dB points. Further consideration has to be given to this measurement, particularly with respect to the affects of the carrier turn on and turn off as well as modulation products.

c. Out-of-Channel Spurious Output - 5-500 MHz

The manufacturer shall specify the output of the modem by assigning frequencies to the following envelope. These frequencies shall be stated in integral multiples of the subchannel increments (1 KHz) and measured from the channel center frequency assignment. Full power is allowable from center frequency to $\pm f_1$; -40 dB maximum is allowable from $\pm$ (f_1 to f_2); -65 or -5 dBmV whichever is greater at frequencies more than f_2 from the channel center frequency. These conditions shall be met at any possible output level including "Carrier Off". Spurious outputs from the receiver portion of the modem shall be governed by the transmitter output spurious envelope (based upon the <u>transmit</u> channel assignment).

<u>Bulletin Note</u>: The technical bulletin should discuss what are considered good operating numbers for the above.

d. Off Condition Output

The manufacturer shall specify the in-channel output of the modem under "Carrier Off" conditions in addition to the requirements of item c. It is the manufacturer's responsibility to assess the effects of Off Condition output in conditions of shared channel operation. The manufacturer shall specify any limitations brought about by in-band, off condition transmitter output.

<u>Bulletin Note</u>: A more complete discussion of the above, particularly as related to polled operation will be contained in the bulletin.

e. Minimum Receive Level and Operating Range

The minimum receive level shall be specified by the manufacturer and must be defined in terms of achieving rated bit error rate (BER) as a function of S/N. The resultant is an absolute level stated in dBmV. Performance equal to or better than the above specification shall be guaranteed through a range of at least 30 dB in excess of the minimum receive level without manual adjustment of the modem.

<u>Bulletin Note</u>: The technical bulletin will discuss performance degradation caused by decreased S/N. The discussion should also include information to alert the user to the effects of impulse noise on data transmission performance.

f. Receive Carrier Detect Level and Adjustability

We do not feel that this value should be standardized, however, statement of this value should be standardized when the feature is present. A range relative to minimum operating level of -10 dB to +20 dB is suggested.

g. Channel Spacing of Similar Modems and Allowable Level Differences

The channel spacing has been previously considered. The allowable level difference we feel should not be standardized, however, this requirement shall be clearly stated by each modem manufacturer. This specification shall include:

a) Adjacent channel operation with a like modem, and
b) An envelope of acceptable adjacent CW carrier levels versus frequency displacement from the carrier frequency or band edge.

<u>Bulletin Note</u>: The technical bulletin will discuss problems arising from data signals operating adjacent to video channels. Of specific concern is the problem of TV interference from adjacent channel data signals where the cause of the problem is the TV set's inability to reject relatively high signal levels in the adjacent channel.

h. Receiver Frequency Tolerance

Modem vendors shall specify the receiver frequency tolerance including the ability of the modem to accommodate changes within the envelope specified.

Bulletin Note: The bulletin will discuss the possible problems arising from translator frequency error or drift and other frequency errors or drifts might be encountered in microwave transportation. Incidental FM introduced at power or other frequencies should also be considered.

i. Maximum RTS/CTS Delay and Adjustability

This is not a matter of standarization however it is recommeded that this be part of the manufacturer's statement of specification.

j. Carrier Turn Off Delay

Modem manufacturers shall specify the actual time required after the removal of the carrier control signal for the modem output to decay to the levels specified in Item 16.

Bulletin Note: Technical bulletin will discuss turn off delays relative to bandwidth restrictions, polling delays, and shared channel operation.

k. Modulation Type

The manufacturer shall specify the following items relative to the modulation of the modem transmitter. These parameters are requested to aid the system designer is assessing the effects of distortion, etc. upon total coax system performance.

1. General Modulation Type (AM, FM, FSK, etc.)
2. Number of modulation levels
3. Percentage modulation (for AM)
4. Maximum modulation index (for PM and FM type signals)
5. Does modulation contain coherent products?

l. Digital Interface

The manufacturer shall supply a complete digital interface specification including mechanical factors such as the connector. Reference to standard specs such as RS-232C, etc. is acceptable however, further definition of options such as controls used, leads used, etc. must be included. Other factors such as sync or async, half or full duplex, etc. should be included.

Bulletin Note: The discussion of various factors to be considered in establishing digital interfaces have many options. There may be installation problems arising from incomplete interface specification by the user or the modem manufacturer.

m. Operating Environment

Manufacturer should specify temperature and humidity limits. It might be possible to standardize on several ranges of temperature and associated humidity conditions perhaps called Classes A, B, C, and D or the like. These would move from room temperature to extreme outdoor environment and have a category for special environments. Further investigation of applicable specifications is in order.

n. Single or Dual Cable

Part of manufacturers normal specification

Sub-Committee #3 - Cable System

The objective of this committee was to specify the parameters of the cable system which could influence the performance of the model described by the manufacturer in the items discussed by Sub-Committee #2. The group delineated the following categories:

a. Mechanical Interface

The cable system shall present a type F male connector to mate with the corresponding F female connector on the modem.

Where the coaxial cable or device center conductor is used to enter the F connector, the diameter shall be limited to that of a standard RG-6 cable. It is recommended that the female F connector should accommodate RG-6 or RG-59 coax.

b. Electric Interface - ohmic

1. The coaxial cable shield shall present a low resistance earth ground to the modem terminal. (A numerical value is required for the final standard).

2. The coaxial cable center

conductor impedance is undefined and may range from a low resistance to an open circuit. The center conductor nominally carries signal potential only but may be exposed to system cable powering voltages and/or potentials induced by incidental ground fault currents. This lack of definition suggest that modem manufacturers should consider DC isolation of the center conductor with a minimum breakdown value of 500V.

3. The problem of receiving modem power from the coax system will be discussed in a separate bulletin.

c. Electric Interface - RF

1. Impedance

The impedance of the system shall be nominally 75 ohms, unbalanced, over the specified operating range of frequencies.

2. Match

The system match shall be specified in dB return loss across the specified cable system operating frequency range. The recommended minimum match at the modem interface is -16 dB.

A bulletin will be added to discuss the mismatch in the reverse direction for low value taps and the impedance of the modems outside of its operating range.

d. Signal Level

The cable system shall be designed to provide a nominal level of 0 to +10 dBmV at all taps outlets for forward direction TV channel operation across the band of operating frequencies.

No recommendation was reached for return signal level requirements. It was tentatively stated that difference between the transmit and receive modem levels should be no greater than 50 dB.

e. Other System Considerations

The following topics have not yet been fully resolved:

1. Intermodulation distortion products and their effect on on system performance with high channel loading.

2. Specification of cable signal/noise

3. Interface to standard TV channels

The brief review of the statues of standard Committee TR 40.1 presented above represents the efforts to-date of many members of the Committee. In particular I would like to extend my appreciation for the work of the chairman of each of the Sub-Committees:

Mr. Carl Schoenberger - ToCom
Mr. Robert Dickinson - E-Com
Mr. Allan Pawlowski - Jerrold

SYSTEM DESIGN CRITERIA OF ADDRESSABLE TERMINALS OPTIMIZED FOR THE CATV OPERATOR

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JERROLD DIVISION
GENERAL INSTRUMENT CORPORATION

Pay TV has now emerged as a primary driving force for the rapid expansion of CATV subscriber growth. Effective control of subscriber access to premium programs can be realized through the availability of low cost subscriber terminals, capable of remote authorization of multi-tier subscription and eventually pay per view services. Providing reliable terminal equipment with increased capability at low cost, represents both a challenge and an opportunity for CATV manufacturers. The limitations of the traditional approach to data distribution are examined and compared to the emerging trends in newer system designs. The trade-offs and specific solutions to the problems of authorization speed and data format are presented. A headend distributed computer architecture is also discussed which results in lower initial cost and overhead while permitting the multiple system operator to exploit the advantages of simplified on-site upgradability and reduced spare part inventory. Technqiues which permit simplified, cost effective solutions to the problems associated with cable system growth, are also discussd.

INTRODUCTION

Sync suppression has long been recognized as an effective method of limiting subscriber access to premium programs. A key factor in the viability of this technique is the proliferation of new pay services and the ever increasing cost of service changes.

Advanced system design strategies are required in order for manufacturers to meet the demand for increased capability while avoiding product obsolescence and higher cost.

Remote authorization subscriber terminals requires the transmission of data to control the re-insertion of timing which was deleted from the video signal, identify the tier or pay level of premium programs, and address, authorize and connect (or disconnect) the terminal. Addressability is based on transmission of the required data in two ways: timing and level information is present on an additional modulation component contained within the normal 6 MHz TV signal, while authorization and connection data is sent on a separate narrow band FM carrier.

TIMING TRANSMISSION

While the limiting action of the TV receiver rejects the added timing signal, it is present at the channel converter output for use by a timing signal receiver. The receiver identifies the channel by detecting a set of pulses called a "tag". Note that the tag does not identify the TV channel number, rather the tier or pay level of the transmission on that channel. The tag pulses are binary coded to specify 1 of 128 possible levels.

DATA TRANSMISSION

Preliminary results of experiments with multi-level addressable descramblers, have generated concern with respect to update rate, error performance, bandwidth requirements, and cost of both terminals and headend equipment. Of secondary importance, is the lack of standardization and compatibility between systems designed for the same or similar purposes.

The traditional method of distributing authorization codes is to simply send the configuration of address, authorization data, and control bits as one data word as shown in Figure 1. In this example, 35 bits are

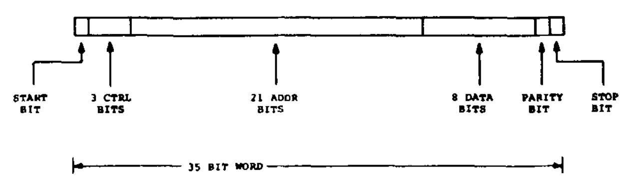

Figure 1

Traditional Word Format

necessary to completely define the transmission to each individual terminal. This method has the advantage that all of the information intended for a given terminal is contained within the space of one transmitted word. Some disadvantages are: the check (parity) and sync bits occupy only 8% of the word, resulting in reduced detection capability; system update rate is slow because most of the information is repeated from one word to the next, and both the terminal and headend require expensive dedicated hardware because of the non-standard nature of the word format.

The disadvantages may be overcome by a unique collection of techniques oriented toward the standard EIA word format shown in Figure 2. The address, control and

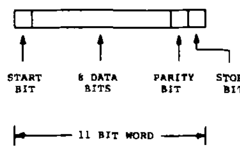

Figure 2 EIA Word Format

authorization data are partitioned into groups, and transmitted sequentially. The terminal receives each word in sequence, compares its logical address to the designated group, and stores the result for subsequent use. No action will occur until all groups have been validated. The control bits would be used to command all terminals to perform the same action; therefore, the command word need be sent only once during a sequence.

This concept offers the ultimate in flexibility, yet maintains compatibility with all industry accepted data communication protocols. The logic required to identify, interpret and respond correctly to so complex a transmission sequence would not be cost effective were it not for the availability of microcomputer and LSI circuits. Designing an addressable converter/descrambler using microcomputer technology represents both an opportunity and a challenge due to the complex nature of these devices.

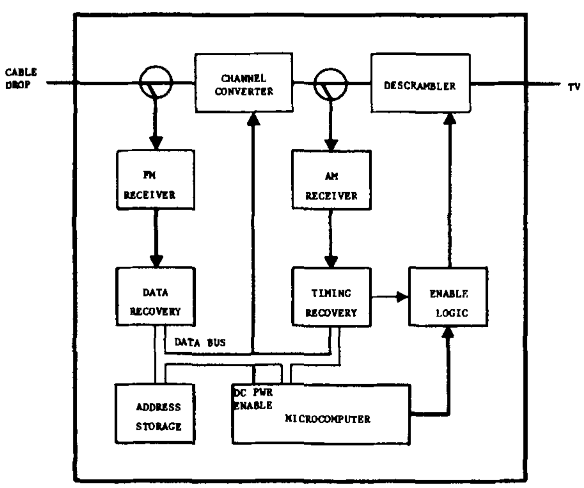

Figure 3
Addressable Converter/Descrambler Block Diagram

The diagram in Figure 3 illustrates a typical design. The FM receiver demodulates the data and converts it to a serial bit stream. The data recovery circuit synchronizes and decodes the bit stream, presenting 8 bit parallel data to the microcomputer for analysis. The AM receiver demodulates the timing signal which is decoded by the timing recovery circuit to generate the composite sync signal. The address, authorization, connect and level data is analyzed by the microcomputer which responds by controlling the converter and descrambler circuits.

The requirement to uniquely identify each terminal is of special importance when viewed in the light that hundreds of thousands of terminals may exist on a single cable system. This problem may be solved by using a programmable read only memory to store the terminal's logical address. Terminals may be shipped from stock and inventoried as identical units because addresses are assigned at the time of installation.

Figure 4 typifies the performance possible in this type of addressable converter/descrambler design.

• Address range	:	2 million subscriber terminals
Geography code	:	8 cable systems
Terminals	:	256K per system
• Update rate	:	128K subscribers
8 Levels	:	4 minutes
• Timing transmission	:	Embedded in TV signal
Program levels	:	128
• Data transmission	:	Narrowband FM
Frequency	:	107.3 MHz
Level	:	-15 dB below picture carriers
Guard band	:	±200 KHz
• Features		
Microcomputer architecture		
EIA compatible data format		
High performance/cost ratio		

Figure 4
Addressable Converter/Descrambler Performance Summary

HEADEND

Improved utilization of headend resources is also possible through exploitation of microcomputer devices in the form of distributed computer architecture. Within this concept, a microcomputer is used to store, format and transmit the address, control, and authorization data to the RF data modulator. Because of its small physical size and dedication of purpose, the microcomputer can be designed to fit within the main frame of a controller computer as shown in Figure 5. The microcomputer module is purposely limited to servicing a reasonably small number of terminals and levels to keep initial cost low. As system penetration increases or it becomes advantageous to increase the number of levels (or both), additional modules may be added. This technique more closely relates headend cost to generated revenue and permits growth through upgradability instead of replacement, while lowering maintenance cost due to reduced spares inventory.

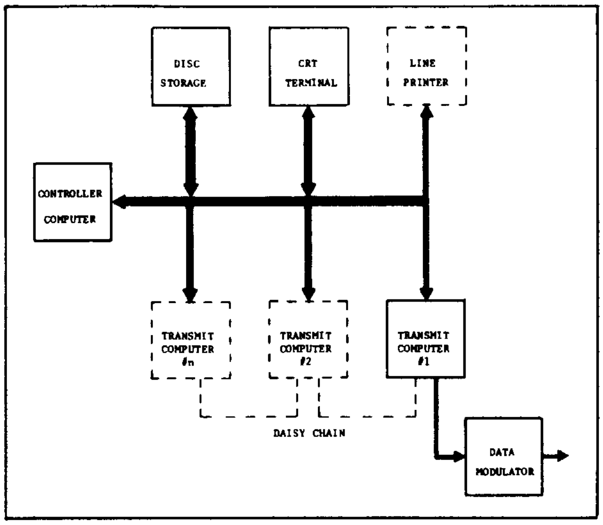

Figure 5
Controller Computer Architecture

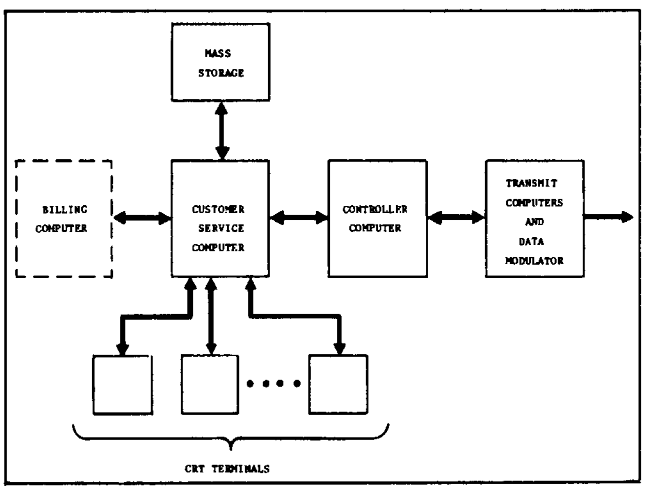

Figure 6
Distributed Computer Architecture

The controller computer, freed from the task of transmitting data, is more effective in other system activities such as authorization file maintenance, terminal logistics management and auditing, and the creation, deletion and execution of authorization schedules. When the level of system activity warrants additional processing power, the distributed computer concept easily extends to customer service functions as shown in Figure 6. The customer service computer carries out the activities associated with cable system management and administration while directing control functions to the control computer as before. Transactions are acquired on line and recorded for subsequent use by a billing computer. The physical location of the billing computer may vary according to system requirements, however, the extension of the multiple computer complex to the inclusion of billing represents the final realization of distributed computer architecture, applied to the operation and management of the cable system.

SUMMARY

It has been demonstrated that the strategy necessary to produce higher cost effectivity in newer designs hinges on being able to exploit the advantages of low cost integrated circuit devices, in particular, those originally intended to serve the microcomputer industry, and that these devices hold the potential for performance improvement and lower cost in both headend and terminal equipment. Finally, the system design concepts presented should lead to products with the capacity to serve the needs of today and remain viable through upgradability in the future.

TECHNICAL CONSIDERATIONS FOR OPERATING SYSTEMS EXPANDED TO FIFTY OR MORE TELEVISION CHANNELS

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Phase Lock and Sync Lock are tools that can be used to reduce distortion and favorably change the subjective appearance of the interference seen in the background of a television channel. The use of these tools allows systems carrying fifty or more channels to serve the same geographical area formerly limited to thirty-five channel distribution. Effects of Cross Modulation and Composite Triple Beat will be discussed, and it will be proven that the Triple Beat mechanism is the predominant source of distortion. The phase-lock technique will be explained analytically showing the mechanism which causes the subjective transition of distortion from low frequency beats to sliding video frames. The report will also discuss further additional improvements in system tolerance using sync-lock and sync suppression.

INTRODUCTION

Many CATV systems built in the last six or seven years took advantage of the 300 MHz equipment available from suppliers to the industry, and operators planned their layouts to allow for the ultimate carriage of thirty-five television channels. The improved signal handling capability of hybrid IC's and the "quad" circuit, together with larger and more efficient coaxial cables, kept pace with this increased channel loading. Improved system layout approaches, such as hubbing - in conjunction with the use of AML for hub interconnect - were tools used by the CATV operator to deliver quality pictures to their subscribers. Few took advantage of the subjective performance benefits available from phase lock.

Now that CATV is expanding rapidly into systems that will cover significantly larger geographical areas with the increased demand for additional services - thus more channels - the need for techniques to maintain quality performance is evident. Phase lock is such a technique. The incremental cost is low; it is the best performance improvement bargain available today. However, it is evident that the benefits of a phase-locked carrier system are not fully understood by many.

Without phase lock, the major non-linear distortions from system amplifiers that are first apparent on the television screen (assuming well balanced push-pull amplifiers) are the carrier beats from the composite grouping of all the triple beat distortions which fall into the sideband of a desired channel close to its carrier. Even in the older twelve-channel systems it can be shown that the predominant distortion is triple beat, not cross modulation. Now, before I get into trouble with you readers, let me establish a few definitions that I will use throughout this article. I will first state that all the distortions discussed can be derived mathematically from the Power Series expansion of the non-linear transfer characteristics of a typical CATV amplifier. The expression "Cross-Modulation Mechanism" will be used to refer to the 3rd order term in the Power Series expansion, which results in sideband components (and a small carrier component) from one TV channel in the system transferring its signal information symmetrically onto another channel in the system. The small carrier component involved, falls precisely onto the later carrier. The expression "Triple Beat mechanism" will be used to refer to the third order term in the Power Series expansion which results in three separate sideband components and a carrier component from three TV channels transferring their signal information assymmetrically onto a channel in the system. For distortion to occur via the Cross Modulation mechanism, both the distorting and the distorted channels must be in the system. For distortion to occur via the Triple Beat mechanism, at the frequency slot of the channel being distorted, the distorted channel need not be in the system.

The mathematical expressions shown in Figure 1 represent four TV channels (A, B, C, & D) which are 100% amplitude modulated carriers (f_A, f_B, f_C, f_D) by a sine wave signal (f_{sa}, f_{sb}, f_{sc}, f_{sd}). Figure 2 gives the formula for the Cross Modulation mechanism as derived from the third order component of the Power Series.

Unmodulated Carrier = $A \sin 2\pi f_A t$

let $A = A_1 (1 + m \sin 2\pi f_{sa} t)$

Modulated Carrier $= A_1 (1 + m \sin 2\pi f_{sa} t) \sin 2\pi f_A t$

$A_1 = \frac{A}{1+m}$

A is the peak level for all values of m

A_1 is the carrier level

m is the modulation index (m = 1 for 100%)

f_{sa} is the modulation signal frequency

f_a is the carrier frequency

Channel $A = A_1 (1 + m_a \sin 2\pi f_{sa} t) \sin 2\pi f_A t$

$B = B_1 (1 + m_b \sin 2\pi f_{sb} t) \sin 2\pi f_B t$

$C = C_1 (1 + m_c \sin 2\pi f_{sc} t) \sin 2\pi f_C t$

$D = D_1 (1 + m_d \sin 2\pi f_{sd} t) \sin 2\pi f_D t$

Figure 1

ONE CROSS MODULATION COMPONENT

$9/4\ k_3 A_1 B_1^2 \sin 2\pi f_A t$

CARRIER COMPONENT

$3/2\ k_3 A_1 B_1^2 m_b \sin 2\pi (f_A \pm f_{sb}) t$

SIDEBAND COMPONENT

Figure 2

It shows the distortion from channel B, (whose carrier frequency is f_B and whose signal is f_{sb}) onto Channel A. Note that the small carrier component from this distortion falls precisely at the frequency of A (f_A) and that the sidebands fall symmetrically around the carrier of Channel A. Also, note that Channel A is an integral part of the distortion component and must be in the distorting system (the CATV amplifier system) for this mechanism to occur. Figure 3 graphically represents the result.

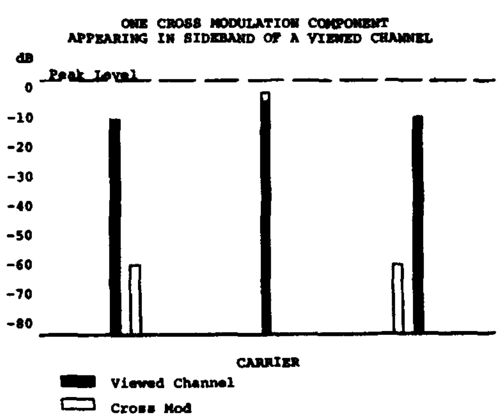

Figure 3

The Triple Beat mechanism is defined by the formula in Figure 4 which also derives from the third order component of the Power Series. You can see that there is a carrier component falling at the frequency $f_X = f_B \pm f_C \pm f_D$ and

$3/2\ k_3 B_1 C_1 D_1 \sin 2\pi (f_B \pm f_C \pm f_D) t$

CARRIER COMPONENT

substitute f_x for $(f_B \pm f_C \pm f_D)$ t

$3/4\ k_3 B_1 C_1 D_1 [m_b \sin 2\pi (f_x \pm f_{sb}) t \pm m_c \sin 2\pi (f_x \pm f_{sc}) t$
$\pm m_d \sin 2\pi (f_x \pm f_{sd}) t]$

SIDEBAND COMPONENTS

Figure 4

three sideband components (one set from each offending channel) are symmetrically centered around the above distortion carrier component, f_x. An example is given in Figure 5.

LET

f_A = Channel 10 = 193.250 MHz

f_B = Channel 12 (-10KC offset) = 205.240 MHz

f_C = Channel 9 = 187.250 MHz

f_D = Channel 11 = 199.250 MHz

$f_x = f_B + f_C - f_D$

205.240 + 187.250 - 199.250 = 193.240

$f_x = f_A$ - 10 KHz

Figure 5

The carrier beat from $f_B + f_C - f_D$, given in the example, falls in the sideband of Channel A at 10 KHz below the carrier f_A and the three sideband components from this Triple Beat mechanism fall symmetrically around the distortion carrier, f_x - not around f_A. Also, note that Channel A was not involved in the formation of this triple beat component. Figure 6 represents this mechanism graphically.

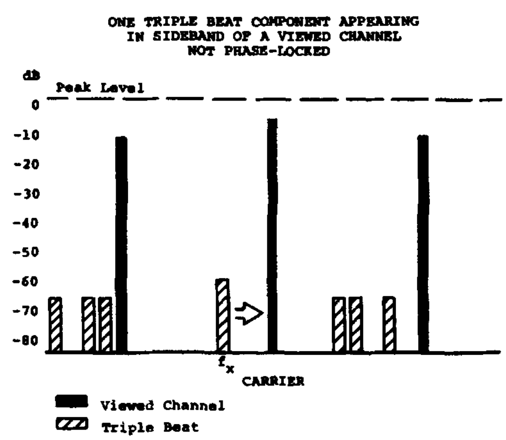

Figure 6

Extensive subjective evaluations of distortion in cable systems have been made at the Jerrold engineering laboratory. These studies have included systems carrying twelve, thirty-five and fifty-two television channels. Tests were conducted using both the phase lock and non-phase locked modes. A reference of a "not perceptible" distortion was established. This is typically one dB of system output level below the point where distortion is first seen by a group of trained observers. Results establish that a test system of either thirty-five or fifty-two channels can be driven five dB higher in level when phase-lock techniques are applied to a non-locked system. Similarly, a 52-channel system using phase-lock has the same (or a slightly higher) "not perceptible" reference as the identical system carrying 35 channels non-phase locked. In each case, the specific channel showing most distortion was used as the reference.

It is evident from these studies that the form of the interference changes. In the non-coherent system, the distortion appears as massive low frequency beats in the sideband of the viewed channel. Rarely can a videoframe be identified in the background. In the phase-locked mode, these carrier beats disappear and, at the 5 dB increased level, slowly sliding video frames are apparent. Figure 7 shows that the carrier

ONE TRIPLE BEAT COMPONENT APPEARING IN THE SIDEBAND OF A VIEWED CHANNEL PHASE-LOCKED

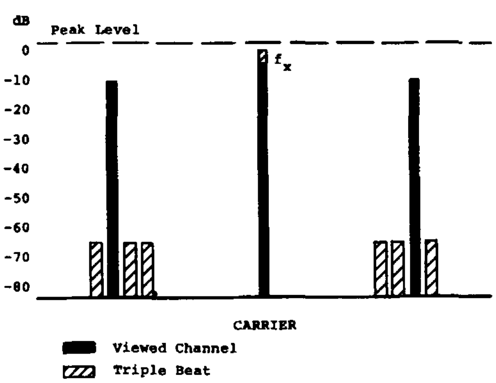

Figure 7

component of triple beat distortion depicted in Figure 6 has been shifted in frequency until it coincides with the carrier of the channel being viewed; thus, eliminating the subjective effect of the carrier beats and disclosing the sideband components of this distortion. Note that with phase lock these sideband components are also shifted to become symmetrical about the carrier of the viewed channel. The remaining distortion appears in the same form as pure cross-modulation and deceives some engineers into thinking that triple beat is eliminated and cross-modulation is predominent. Figure 8 is a table showing the number and source of distortions appearing in the worst channel of the three systems.

NUMBER OF DISTORTION COMPONENTS

No. Of Channels	12	35	52
Channel with Most Distortion	10	11	0
Triple Beats $f_A \pm f_B \pm f_C$	23	347	917
3rd Order Intermod $2f_A \pm f_B$	3	17	28
Second Order	0	6	17
Video Sources Triple Beat	85	1126	2613
Video Sources Cross Mod	11	34	51

Figure 8

Once the subjective impact of the carrier components of the triple beat is removed by phase-lock, there remains the video components. A single video component from the Triple Beat mechanism is 6 dB lower in level than a single component from the Cross Modulation mechanism. The coefficients shown in Figure 9 indicate this 6 dB relationship.

SIDEBAND COMPONENTS

$$\text{Xmod} = \tfrac{3}{2} k_3 \, m \, A_1 \, B_1^2$$

$$\text{Triple} - \tfrac{3}{4} k_3 \, m \, A_1 \, B_1 \, C_1$$

Assumes the carrier level and modulation index are the same for all channels.

Figure 9

Referring again to Figure 8, you can see that in a 52-channel system the ratio of video components from triple beat compared to the video components from cross modulation is 2613/51 or 51.2. Similarly, in 35-channel systems the ratio is 1126/34 or 31.1. Converting 51.2 to a power ratio, we get 17.1 dB. Subtracting 6 dB from this to allow for the stronger individual cross modulation components we get an 11.1 dB power ratio or approximately 13 times as much distortion power in the video sidebands from triple beat than from cross modulation. Adding two powers 11.1 dB different in level increases the predominant source by 0.3 dB or impacts the operating level of the system by 0.15 dB. Cross Modulation distortion is clearly incidental.

I mentioned early in this paper that the predominance of triple beat over cross-modulation was easily proven. The test set-up shown in Figure 10 shows 51 channels of a 52-channel system coupled directly to an amplifier cascade. The reference channel being viewed can be switched "THRU" the cascade or can bypass it. In the THRU position, the viewed channel has both cross modulation and triple beat components. In the PASS position, the viewed channel has only triple beat components.

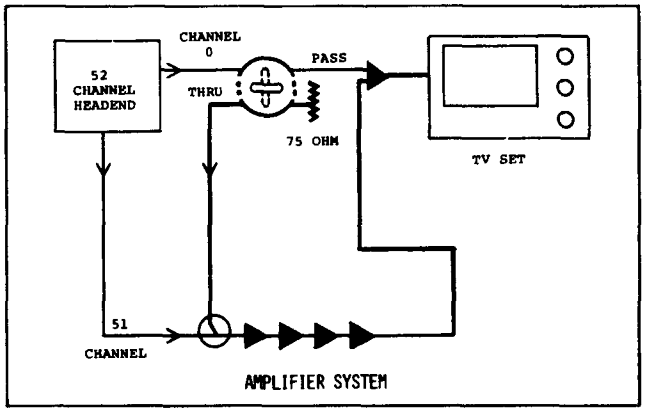

Figure 10

Recall that for cross modulation to occur, the viewed channel must be in the distorting system. Subjective tests conducted at Jerrold laboratory show that removal of cross modulation components has no impact on the picture quality, indicating that the real source of distortion is from the Triple Beat mechanism. This proved true even for 12-channel systems.

Another tool that has great promise for reducing distortion and its subjective effect, is a technique I call Sync-Lock. By use of a product called a Frame Synchronizer, a video source can be delayed to have all synchronizing pulses, including the vertical, align precisely with a reference television channel. The simplest way to view the concept is to assume there are N number of channels - then there are N-1 Frame Synchronizers required - each being locked to the same reference. All signals must be at video baseband to create this condition. This entails demodulation of all headend channels received off-air. Headend sources received from satellites and microwave links, plus signals locally generated, are already at baseband. Once sync-locked, all signals are then individually modulated onto the appropriate r.f. carrier. It was brought to my attention that many locally generated video sources can first be gen-locked, reducing the number of Frame Synchronizers required. The major distortion energy in the amplifying system occurs when the television set is blanked vertically and horizontally off-screen. As long as the distortion at the sync pulse period is not sufficient to cause a TV set to roll or tear, the distortion during the viewed portion is reduced with the increased advantage that no sliding interference exists.

The major deterent to this technique is not technical, it is cost. Frame Synchronizers currently sell at $12,000 each. Since these have additional features not required for Sync Lock, it is anticipated that a significant price reduction is possible. A demodulator/modulator combination must substitute for a processor for off-air signal reception.

SUMMARY

For those large CATV systems which require fifty or more channels, the proven technique of carrier phase-lock is an important tool to maintain quality pictures. In measuring distortion on such systems, the Triple Beat mechanism is of prime importance - cross modulation is incidental. On systems with thirty-five channels and less, phase-lock can be used effectively to significantly improve carrier-to-noise ratio and/or improve system tolerance. In systems so large that the benefits of phase lock are not sufficient, the technique of Sync-Lock holds additional improvement.

THE HIDDEN COSTS OF 400 MHZ

Archer S. Taylor, P.E.

Malarkey, Taylor & Associates, Inc.

ABSTRACT

Cable television (CATV) has already suffered through too many premature technological developments. We do not need any more fiascos like the early transistor amplifiers, or strip-braid and styrafoam cable. Expanded bandwidth is now being promised in fanciful franchise proposals before it is ready, with unrealistic system design and gross lack of awareness of either the costs or the difficulties. The crash program to provide more channels appears to be a repetition of the automobile industry's horsepower race, now seem as disastrous. The effort is diverting our attention from the scandalous inefficiency of use of the channels we already have, such as spreading the information content of a 4 kHz news wire over 24 MHz of cable spectrum. We need to improve our product; we need to recognize that more is not necessarily better.

- -

I have long maintained that engineers can do anything, given proper motivation, and enough money. We can fly to the moon; and believe it or not, we can board an airplane in Paris after sunset and deplane in New York before sunset the same day. But even though we can do these things, we need to consider whether doing them is a good idea. I doubt that regular flights to the moon will soon be scheduled, just because we can do it; and the reports are that the supersonic airplane has been a commercial disaster. I have no doubt whatsoever that we can build 400 MHz or 500 MHz systems, or whatever and make them work. I am concerned about the costs, in dollars as well as less tangible assets, and whether the true costs are really justified.

My concerns fall in two categories: the short term; and the long term.

For the short term, I would remind you of the disastrous use of the first available transistor amplifier in Great Falls, Montana. The entire manufacturer's engineering department was unable to make them function properly with cascades of more than 8 or 10 stations. After a great deal of promotional ballyhoo, Teleprompter had to admit failure, and rebuild with tube equipment, at considerable expense and embarrassment.

Then there was that great, wonderful, new kind of cable, called "strip braid." The only way you could keep the high band going was to beat it with a baseball bat to break up the corrosion at the crossovers.

And then we had the Starline One transistor problem, which may still be in litigation against RCA for all I know. The laboratory models were great, but a weld in the output transistor kept failing in the field.

Do I dare mention styrafoam cable; or fuse blowing in the first edition of the Channel Commander II; or 45 MHz IF converters; or a host of other major and minor technological disasters?

Our industry has had a terrible habit of field testing new equipment on unsuspecting, and often unhappy customers. We don't need any more strip braid fiascos, but I am afraid we may be headed in that direction by promising the cities to deliver 54 channels with equipment that has not yet even been produced, let alone subjected to operational experience in the field.

Not only that; but now we are trampling all over each other to offer dual 54 channel cables, after first arguing that the expanded band single cable is more cost effective than dual 300 MHz cables. Who will be first to offer a triple 440 MHz system with 180 channels?

As a matter of fact, the short range problems I have worried about may not even happen. I rather suspect that most of the 400 MHz series of amplifiers may never actually carry 51 or 52 or 53 or 54 channels. The fancy proposals proclaiming the desparate need for 50 or 90 or 120 channels call for 15 or 20 access channels, most of which will be dark most of the time; 10 or a dozen channels for "future use"; several channels for proposed satellite services that have not yet started, or are available for only a few hours a week. When the system is actually constructed, it will likely be required to carry only 30-35 channels at the most. With HRC and conservative spacing, the systems will probably work well.

When a real need develops for 50 or more channels, however, it may be necessary to drop the levels and degrade the carrier-to-noise ratio by a few dB to get rid of cross-mod; or redesign the hub interconnect; or a lot of other costly changes.

In the long run, I am more concerned about a lot of hidden costs that are not being taken into consideration.

The Dallases, Houstons, Cincinnatis, Pittsburghs, in fact all major markets require a quality of performance and reliability of service which we have mostly only talked about in our self-serving advertising in conventional underserved markets: "studio quality pictures"; "perfect TV"; "snow-free reception"; "ghost free television"; and so on. In my opinion, we are going to have to produce and maintain 45 or 46 dB carrier-to-noise ratio and the equivalent of 53 dB carrier-to-composite-triple beat ratio (non phase-locked C.W.) at the end of the line, including satellite and microwave relay, hub interconnect, and upstream carriage from the most remote origination source; and all this at any temperature between the normal maximum and normal minimum for the area.

This is tough, even with 30 channels. I am afraid that few systems, present or proposed, could honestly comply with such standards today. With 40 channels, it will be twice as tough; with 50 channels, probably four times as tough; and with 70 channels, it could be eight times as tough, or even more. This is merely because of the enormous build-up of triple beat products.

In their seminar several weeks ago, Jerrold used a goal of 45 dB CNR for a comparison of the cost of hypothetical 400 MHz and 300 MHz plants. The best we can expect of a hub interconnect system is that it reduce CNR by no more than 1 dB. So, in order to achieve my goal of 46 dB overall, the hub distribution system would have to be designed for 47 dB, not 45 dB. Jerrold based its analysis on the assumption that noise figure is only 1 dB greater at 400 MHz than at 300 MHz; but their SJS spec sheet shows a 2 dB degradation. Jerrold assumed 6 dB improvement for ICC phase-lock. Published data suggests that with 27 channels cross-modulation can be reduced at least 6 dB by optimum phase adjustment (phase phiddling) of the HRC carriers. I know of no published work on the subjective improvement due to HRC without phase adjustment. The unpublished information is that the improvement is 4 to 6 dB. Since only half as many offending beats are coherent with ICC, as with HRC, it would appear safer to count on only 4 dB improvement with ICC. As far as I know, no one, including Switzer, has proposed to take advantage of "phase phiddling."

If all these adjustments are made, the maximum trunk cascade allowable reduces from 25 down to 14. Switzer is probably on the right track to limit the maximum 400 MHz cascade to 12 amplifiers.

I am very much concerned that so many people, in the cities and in the industry, are being led to believe that cascades can be even longer with the 400 MHz amplifiers than with 300 MHz. We will either face a rude awakening one day, or we will not be able to fullfill our promise to carry 50 plus channels. I call this a costly hidden danger.

How many hubs do you need for a 1500 mile plant with maximum cascade of 12 distribution trunk amplifiers? How long will the hub interconnect routes be? I don't know, but I suspect that there will be some 10-15 mile routes, or longer. To achieve 46 dB CNR overall, with 47 dB distribution, the interconnect CNR would have to be at least 53 dB. A 54-channel cable, 15 miles long, would require losses of only 0.14 dB per 100 feet at 400 MHz. You could almost make it with 5-inch air dielectric Heliax at $25 a foot; $2 million for 15 miles! Forget it.

AML seems to be the most popular answer. It works; it will achieve 53 dB C/N; and the price is reasonable. But do your customers take kindly to rainfall fades during a premium movie, or a critical game? Multi-path fading outages increase roughly according to the cube of the path length, for paths longer than about 6 or 7 miles. In regions where atmospheric inversions are rare, and the climate is never very hot or humid, a 10-15 mile AML path is probably no problem. But I have been places where the customers were so angry about microwave fading they were ready to do violence. This is a hidden cost which can't be expressed in dollars alone.

AML is a one-way facility. In order to accomplish all the wonderful two-way services promised in most proposals, you will probably have to construct a return cable between the hubs anyway. The CNR on this cable figures in the overall picture delivered, for example, from a school studio in one hub area to subscribers at the extremity of another.

Since you will need a cable for return anyway, and since AML has some undesirable characteristics, the best answer may be FM cable, or perhaps a combination of AML and FM cable. But remember that each FM channel requires 14 MHz, so that at least two cables will be required for 50 channels downstream; and a third for upstream. The modulator/demodulator pair for each channel costs about $3250 for one line. Another set of demodulators is required for each additional hub, at $1800 per channel. This is a hidden cost, if in fact, Catel and Tomco can produce them fast enough to supply the demand.

It is probably fair to note that not all of the hub interconnect expense should be allocated to the 54-channel design; and, in any case, the hub interconnect probably represents no more than 5% to 10% of the total capital cost. Nevertheless, a lot of small increases can add up to a fairly substantial overall increase.

And there are other hidden costs that cannot be measured in dollars alone.

The beats due to ingress from strong local TV stations are at least 15 dB worse with HRC than they would be if the cable carriers were phase-locked to the TV stations. Unfortunately, it also just happens that 1.25 MHz is the very portion of the video band in which beats are most visible. Customer complaints are probably the most sensitive detectors of such ingress. Much more careful maintenance is required with HRC in strong local fields. This is a hidden cost.

The amount of subjective improvement in triple beat interference possible with phase-locked carriers is limited by cross-modulation. It is a curious situation that a proposal to reduce the composite triple beat standard to 43 dB, when the carriers are phase-locked, should be made at the same time as the announcement that cross-modulation would no longer be specified in data sheets. Since a phase-locked system is actually cross-modulation limited, it would seem important not to ignore cross-modulation.

Switzer proposes to use a $20,000 synchronizer on off-air channels, and gen-lock on locally originated channels, so that all sync pulses will occur during sweep blanking. This is a good idea, but it is another substantial addition to the cost of 54-channel carriage.

And then, what happens to captioning data, the VIRS color control signal, and encoded teletext data when we dump all the worst cross-modulation into the blanking interval? Is this another hidden penalty we will have to accept? And besides, Switzer is promoting the Tektronix ANSWER system to monitor VITS waveform. So what happens to that when the blanking interval is messed up with cross-mod?

I think of HRC as analagous to sweeping the dirt under a rug. As long as there is only a little dirt, it will never be noticed. But, if there is a lot of dirt, some nails, blocks of wood, and other junk, there could be quite a disturbance under the rug.

At 30 channels, we have a maximum of about 315 zero beat intermodulation products in the worst channel. At 54 channels, we have nearly 1000; at 70 channels, I suspect we may have several thousand. With harmonic carriers, these zero beats will be coherent, and their voltages will be additive. If single amplifier 3-tone triple beat is down 108 dB, the zero-beat voltage with 54 tones will be down only 48 dB (108-60=48 dB). If we cascade 25 of these amplifiers, with 54 harmonic carriers, the pile of dirt under the rug will be only 20 dB below the desired carrier (48-20 log 25 = 20 dB). If the coherent pile of dirt is steady, it will simply add 10% to the carrier voltage relative to the sidebands. That is to say, the modulation level and consequently the picture luminance will be reduced by 10%.

What if we find out, next year in Atlanta, or Dallas or Pittsburgh that cable TV pictures are slightly washed out, not quite as brilliant as they are when received directly? Moreover, since these zero beats are all constantly varying in magnitude with picture content, isn't the sum likely to fluctuate? Will we actually have pictures with fluttering luminance? Will AGC take care of this on all TV sets, or only some, depending on the time constant? Is this a tolerable hidden cost?

TV receiver designers have told me they are considerably dismayed by our non-standard HRC allocation plan. They have finally come around to the idea of marketing cable-ready TV sets so that a converter interface would not be necessary. But they have problems of compatability between standard and HRC channelling, and are disturbed that we keep changing our plan. Although manual fine tuning is generally broad enough to encompass HRC channels, AFT will probably not have (and should not have) sufficient capture range. In fact, considering the Channels 5 and 6 anomaly, and the extra HRC channel between 4 and 5, the AFT design appears to be rather difficult. Moreover, the practice of including a special trap ahead of the mixer to keep the low end of the FM band from interfering with Channel 6 will actually knock out the sound on HRC-6 which falls at 88.5 MHz. It appears that widespread use of HRC may very well put an end to the development of cable-ready TV sets. I consider this a hidden cost of the 54-channel development.

I believe the desperate scramble for franchises has seriously diverted our innovative technological attention away from areas that could be more profitable and more meaningful in the long run than a crash program to expand amplifier carriage capacity to 50 or 70 or more channels.

For example, the extravagantly wasteful way in which we are presently proposing to use the information carrying capacity of our cable systems is simply scandalous. For example, many applications actually propose to use at least 4 channels, 24 MHz, to display on customer TV sets the infinitessimal information carrying capacity of a single 4 kHz news wire. All of the information contained in a 6 MHz alpha/numeric channel could be transmitted "piggy-back" during the vertical interval of a single TV channel without requiring any cable spectrum at all.

We should be developing improved premium channel security methods to more effectively keep ahead of the rip-off entrepreneurs.

Subscribers need a better way of sorting out even 35 channels, many of which are seldom if ever viewed. We need a better way to provide return transmissions. We need to develop and market information retrieval systems such as teletext. We need a multi-bird TVRO antenna.

If the new Motorola and TRW hybrids, either this year or in the near future, offer increased dynamic range for non-phase-locked carriers, the 400 MHz program will have valuable consequences almost incidental to the expanded bandwidth.

But to my way of thinking, the real and hidden costs of expanding to 54 channels on a single cable are hard to justify when compared with other methods of expanding channel capacity as needed.

As Pat Hawken of the British Independent Broadcasting Authority recently said in commentary on the IBA decision to use terrestrial microwave rather than satellite relay:

> "This is one illustration to show the danger of 'futurology' based solely on engineering and technology. Even if, in end, the best engineering solutions have a habit of winning through, it takes time to tango."

Back off, fellows. Let's be sensible.

The Concorde is an engineering triumph, but a commercial disaster.

The automobile industry is in a tailspin because they had their heads in the sand reading signs that said "big is better." Cable television had better take heed. More channels, like more horsepower, could lead us to disaster unless we have first maximized the quality of our service and the efficiency with which we can offer information and entertainment to our customers.

TWO WAY CABLE TV COMMUNICATIONS FOR CENTRALIZED TRAFFIC CONTROL SYSTEMS

Charles Farell

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ABSTRACT

Two-way cable TV networks can provide the communications requirements for centralized traffic control systems, and offer both performance and cost advantages. Wide-area cable plant coverage makes practical the extension of centralized control beyond central business districts. Existing types of traffic controller equipment can be utilized in central control systems by means of adapter interface assemblies built into Remote Communications units connected to the cable system. A combination of Time Division Multiplex and Frequency Division Multiplex techniques are used for efficient utilization of available bandwidth.

Centralized computer-based traffic control systems have good potential for improving the efficiency and traffic-handling capability of existing streets and freeways. Experience gained from existing prototype systems has shown that reductions of 20% to 30% are possible for average travel time and number of required stops[1]

While rapid advances in minicomputer and microprocessor technology have increased the performance and lowered the price of central and remote processing equipment, high interconnection cost has been a major obstacle to the widespread application of centralized traffic control systems. To date, such systems have typically been confined to central business districts, where high traffic densities and limited geographic area have helped to justify the high interconnection costs.

In most present systems, communications between the traffic control center and remote terminals has been provided by dedicated telephone circuits. Such circuits may be leased or private lines. Either way, costs tend to become prohibitive with expansion of the control area and the number of remote terminals. With leased lines, rising tariff rates result in open-ended and increasing operating costs. If a city installs its own lines, installation and maintenance costs are high for wide-area systems. Many such circuits are required. Unconditioned voice-grade circuits are limited to about 2400 bit/second data rates for reliable communications. This sets a practical limit of about eight remote terminals per wire-pair, requiring at least 125 wire-pairs for a system of 1000 controlled intersections.

Two-way cable TV systems provide an attractive alternative for traffic control communications. They offer several significant advantages:

1. Performance

   Individual data carrier channels can transfer data in either direction at rates of 28000 to 56000 bits/second. Seven to fourteen such data channels can be provided within the 6 MHz bandwidth of one standard TV channel. Space is also available for additional narrow-band channels,

(1) Traffic Control Systens Handbook
Federal Highway Administration
Washington, D.C. 1976

useful for system support functions such as point-to-point voice communications and full-duplex RS-232 data links. With cable communications, more remote terminals can be accommodated, and each terminal can be polled more often.

2. Availability and Coverage

By necessity, the cable plant of a TV system must follow all city streets, or at least along nearby alleyways. This universal coverage makes possible the inclusion of virtually all city street intersections within a control area, regardless of its size.

3. Cost

The cost of a wide-spectrum two-way cable TV system can be shared and amortized by all services using it. Considering the large number of TV channels available on modern cable systems, it is possible that the spectrum space required by even the largest traffic control systems may otherwise go unused.

4. Special Capabilities

Wide bandwidth traffic control functions, such as real-time video surveillance of potential trouble spots, are easily provided by cable communications. This feature is impossible with narrow-band telephone circuits.

Centralized Traffic Control Systems

Centralized traffic control systems are designed to maximize traffic flow, reduce delays, and provide aid or information for motorists. Two major categories of such systems have evolved:

1. Urban Street Surveillance and Control.
2. Freeway Surveillance and Control.

In either of these two major traffic control applications, traffic data is collected by the Central Processing Unit (CPU) from many roadway vehicle detectors throughout the system. In an urban street control system, the CPU uses this traffic data to determine optimum timing plans for each individual intersection controller in the system. For freeway control, data collected from detectors in each traffic lane and entrance ramp are used by the CPU to determine metering rates for each individual ramp controller. Timing plans or metering rates are updated as required, and implemented at each local controller by addressed control commands transmitted from the CPU. These control commands are updated frequently, usually at intervals of one second or less. Each remote terminal receives an updated control command at the same time that it is polled for vehicle detector data.

The most common type of vehicle detector consists of a multi-turn loop of wire embedded in the road surface. The loop is connected to an interface unit that generates one logic level when a vehicle is over the loop, and the opposite logic level when a vehicle is absent. Several detectors may be installed in the vicinity of an intersection. They may be placed on one or more intersection approaches, and in one or more lanes of each approach. On a freeway system, detectors may be placed at approximately one-half mile intervals in each lane, and also at selected locations on each entrance ramp. A single remote terminal has multiple input ports to receive the output lines from several detectors, which can be at locations up to one mile away.

In TOCOM traffic control technology, the remote terminal is called the Remote Communications Unit (RCU). Included in the RCU is an RF transceiver for communication with the traffic control center, processing and control logic, an adaptor assembly for local controller interface, and detector input signal-processing/logic circuits. An RCU may be designed to take as many as 16 detector inputs and provide up to 16 control outputs.

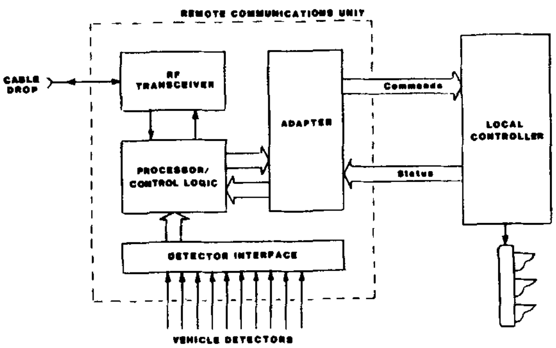

Figure 1. Remote Communications Unit

From each detector input signal, the RCU processes two basic traffic parameters - volume and occupancy, which are updated every second. Volume is a measure of traffic flow, in vehicles per minute. Occupancy is a measure of traffic density, and indicates the percentage of time that a vehicle is over a detector loop. These two parameters are formatted (two bits for volume, five bits for occupancy) and stored in registers to await transmission to the CPU, in response to an interrogation request from the traffic control center.

The adaptor assembly of an RCU is designed to be compatible with the type of local controller to be used. Relay contacts are provided for electromechanical types of controllers. Appropriate logic levels are provided for solid-state controllers. In addition to providing vaious control lines, the adaptor unit also receives status inputs from the local controller. As many as 16 status bits are stored in a status register, to await transmission to the control center in response to an appropriate interrogation request.

Urban Street Traffic Control Systems

In an urban street traffic control system, the central CPU analyzes the raw volume and occupancy data received from all points in the system. Using this data, timing plans are selected for each individual intersection. In most present systems, as many as 25 standardized timing plans are stored in memory and selected according to pre-determined criteria for volume/occupancy conditions. With more sophisticated software being developed for future systems, the volume/occupancy data will be used to directly compute unique timing plans on a real-time basis for additional flexibility.

A timing plan is defined by three basic intersection controller parameters:

1. Cycle Time
2. Split
3. Offset

Cycle time is the time required for a controller to go through a complete sequence of all possible phases. (Phases are the individual states during which no signal changes are made, such as major street green, minor street green, left turn, etc.).

Split is the proportion of green time alloted to competing phases.

Offset is a time difference between a zero reference time and a defined point on the time cycle of individual traffic signals in a co-ordinated sub-system. Such sub-systems may consist of a progressive series of traffic signals along a major thoroughfare. In non-centralized systems, the individual signals in such a sub-system are controlled by slave controllers, hard-wired to a master controller. The master controller determines the zero reference time and offset for each individual traffic signal. Offset does not apply to controllers used for isolated intersections.

Two basic types of intersection controllers are commonly used in non-centralized traffic control systems:

1. Pre-timed Controllers
2. Traffic-actuated Controllers.

Pre-timed controllers are often used in co-ordinated subsystems along major arterial streets. Their timing plans are established by settings on an electro-mechanical dial unit or an electronic timing module. Once set, the timing plan is inflexible and unresponsive to traffic conditions. Some pre-timed controllers have more than one timing unit. With a three-dial controller, three preset timing plans can be scheduled for different times of the day, corresponding to AM-peak, PM-peak, and off-peak conditions.

Traffic-actuated controllers are often used at isolated intersections. They do not have preset timing plans. The green time assigned to a phase is dependent on "calls" from detectors actuated by traffic. One phase may receive a green light indefinitely if no calls are received from an opposing phase. Such controllers can be co-ordinated with controllers at nearby intersections by the addition of a special co-ordinating dial unit. A new version of traffic-actuated controllers is the micro-processor controller, which is useful for complex intersections. It has memory storage capability for holding actuator data, and can compute appropriate timing plans on a real-time basis.

Most modern pre-timed and traffic-actuated controllers are equipped with means to suspend normal operations and operate under direct control of external signals from a control adaptor. One of the control lines from the TOCOM RCU adaptor assembly is a master control called "Hold On-Line". When active, the timing plan of the interconnected controller will be established by the other control lines. One of those other control lines is an "Advance" control. When pulsed, the advance control causes the controller to advance to the next phase. The controller remains in that phase until it receives another advance pulse. The frequency and timing of the advance pulses therefore establishes the timing plan of the controller when "Hold On-Line" is active. The other control lines serve various other purposes, such as to place the controller in a red/yellow flashing mode, turn on school zone signs, and to pre-empt the controller for special accommodation of emergency vehicles, railroad crossings, etc.

When the "Hold On-Line" control from the RCU becomes inactive, the interconnected controller reverts back to its normal "off-line" mode of operation. This fail-safe feature of the system provides a standby mode of operation, which is actually a normal non-centralized control mode. As long as the "Hold On-Line" control is active, all intersection controllers operate in the same mode, under the direct control of the CPU in the traffic control center. When the "Hold On-Line" control becomes inactive, all controllers return to the specific mode of operation for which they were designed - pre-timed, traffic-actuated, etc.

Most controllers are designed with auxiliary contacts, providing status signals for confirmation of proper controller operation. Up to 16 status input ports are provided on TOCOM RCU's. Signals appearing on these ports are transmitted as status flags back to the control center.

Freeway Traffic Control Systems

In freeway control systems, the traffic detector and communications equipment is similar to that used for urban street systems. The traffic detectors are typically spaced at regular intervals in each traffic lane, and also in the entrance ramps. Reduction of freeway congestion is the basic goal of such systems, which include one or more of the following functions:

1. Entrance Ramp Control
2. Frontage Road or Corridor Control
3. Variable Sign Control
4. TV Surveillance.

Entrance ramp control is the most common function of present freeway systems. The CPU at the control center uses volume and occupancy data to determine metering rates of entrance ramp traffic signals. Ramp controllers are interfaced with RCU's similar to those used for urban street systems. The ramp metering rates are determined by comparing current traffic flow and density to the capacity of the freeway. When a freeway is near its capacity, metering rates are kept low, forcing traffic to alternate routes.

With frontage road control, timing is adjusted on intersection signals along frontage or service roads alongside the freeway. Under normal freeway conditions, the timing of such signals may favor cross-street traffic. However, when freeway traffic becomes congested, timing may be adjusted to a more progressive pattern, to allow frontage roads to carry part of the freeway traffic more efficiently. Signal timing on so-called "corridor" streets paralleling a freeway may also be adjusted in the same way.

Motorist advisory information may be provided by variable signs placed along the freeway, carrying messages related to traffic conditions ahead, accidents, variable speed limits, etc. Each sign would be interfaced to a remote terminal that receives appropriate data from the CPU, addressed to the specific location.

TV camera surveillance may be used at selected high-density, trouble-prone locations. Remote cameras can be panned right and left, tilted up and down, zoomed, focused, and adjusted in various other ways by console controls in the traffic control center. Real-time high resolution video signals require a full 6 MHz TV channel. If several camera locations are required, the 5-30 MHz return bandwidth available on a conventional CATV Cable System may be inadequate. An alternative solution would be time-sharing of one or more channels by several cameras, whose transmissions could be controlled by selective commands on a separate control channel.

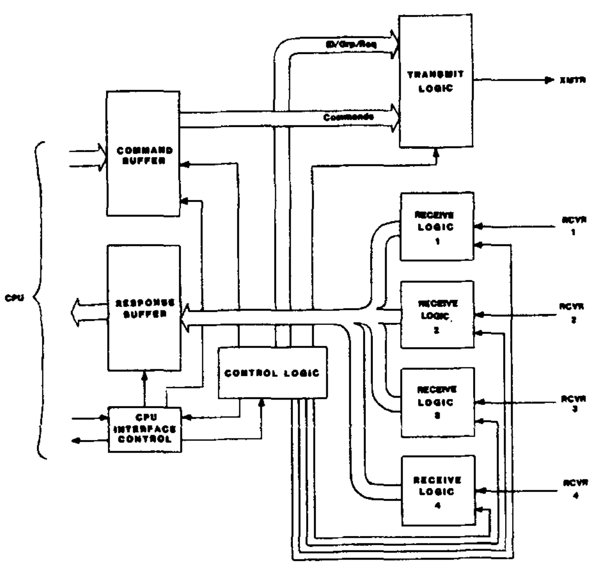

Figure 2. Communications Control Unit

<u>System Organization & Communication Format</u>

In a recent TOCOM system design, 400 Remote Communication Units are interrogated and commanded every second. Update commands are transmitted from the control center to each RCU within the same message structure used to interrogate for detector and controller status data. In the Control Center, a Communications Control Unit (CCU) handles data transfers to/from the CPU. It contains the buffer memories and control logic required to scan 400 RCU's. The memories are double-buffered, so that command and response data can be block-transferred to/from the CPU by means of one set of buffers while data from the other set is being distributed and received to/from all the RCU's. The CCU is illustrated by Figure 2.

A combination of Frequency Domain Multiplex (FDM) and Time Domain Multiplex (TDM) is used to scan all RCU's. In the above-mentioned system, the 400 RCU's were divided into four groups of 100 RCU's each. Unique identification (ID) codes are assigned to each RCU in a group. All RCU's receive transmissions from the control center on one common data channel. They respond on separate data channel frequencies, each common only to the RCU's within one group. Transmissions from the control center include the ID code and a group code, along with a command code. Following each control center transmisssion, four RCU's sharing a common ID code respond simultaneously on four separate group channels. The ID and group codes in each transmission identify a unique RCU, whose logic circuits will latch the transmitted command code into a command register. The 16-bit RCU response following the control center interrogation is sufficient to transfer one 16-bit controller status word, or to transfer volume/occupancy data from two vehicle detectors. To transfer a complete set of RCU data (with ten vehicle detectors connected to one RCU), six separate interrogation sequences are required for each ID/group code combination. To distinguish between these six separate parts of the RCU response data, a request code is added to the interrogation transmission from the control center, along with the ID and group codes. For each ID code, the request code is incremented six times. Then the ID code is incremented to interrogate four more RCU's. Every second, this sequence continues through 100 ID code combinations, with a different set of four RCU's responding (on four separate frequencies) for each ID combination. In this way, command and response data can be transferred to/from 400 RCU's every second, with volume/response data coming from ten vehicle detectors per RCU.

The interrogation sequence is illustrated by Figure 3, which shows the four-byte interrogation transmission format from the control center, followed by two-byte responses from the four RCU's sharing a common ID code; one RCU from each group.

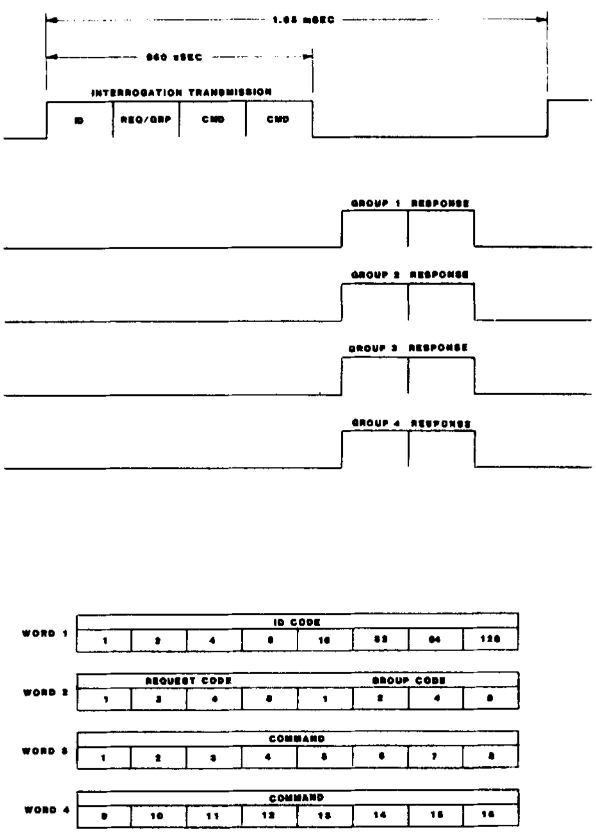

Figure 3. Interrogation Sequence

By expanding the number of data channels and/or modifying the message format, the number of RCU's can be increased. A system size up to at least 1500 RCU's (intersections) can be accommodated within the bandwidth of one standard TV channel in each direction.

Ancillary functions, such as point-to-point voice communications and RS-232 data links, are required in a practical system for maintenance and support activities. Three additional narrow-band channels in each direction are added for these functions. One set of these channels is reserved for voice communications and the other two are for a full-duplex RS-232, 9600 baud data transfer link. All remote units, whether voice or data-modems, transmit on a low-band upstream data channel. By means of a block up-converter at the traffic control center, these narrow-band upstream channels are translated to equivalent down-stream channels, to which receiver sections of the voice of data units are tuned. In this way, any remote voice communications unit or data modem can communicate with any similar unit at any other point in the system, including the traffic control center.

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