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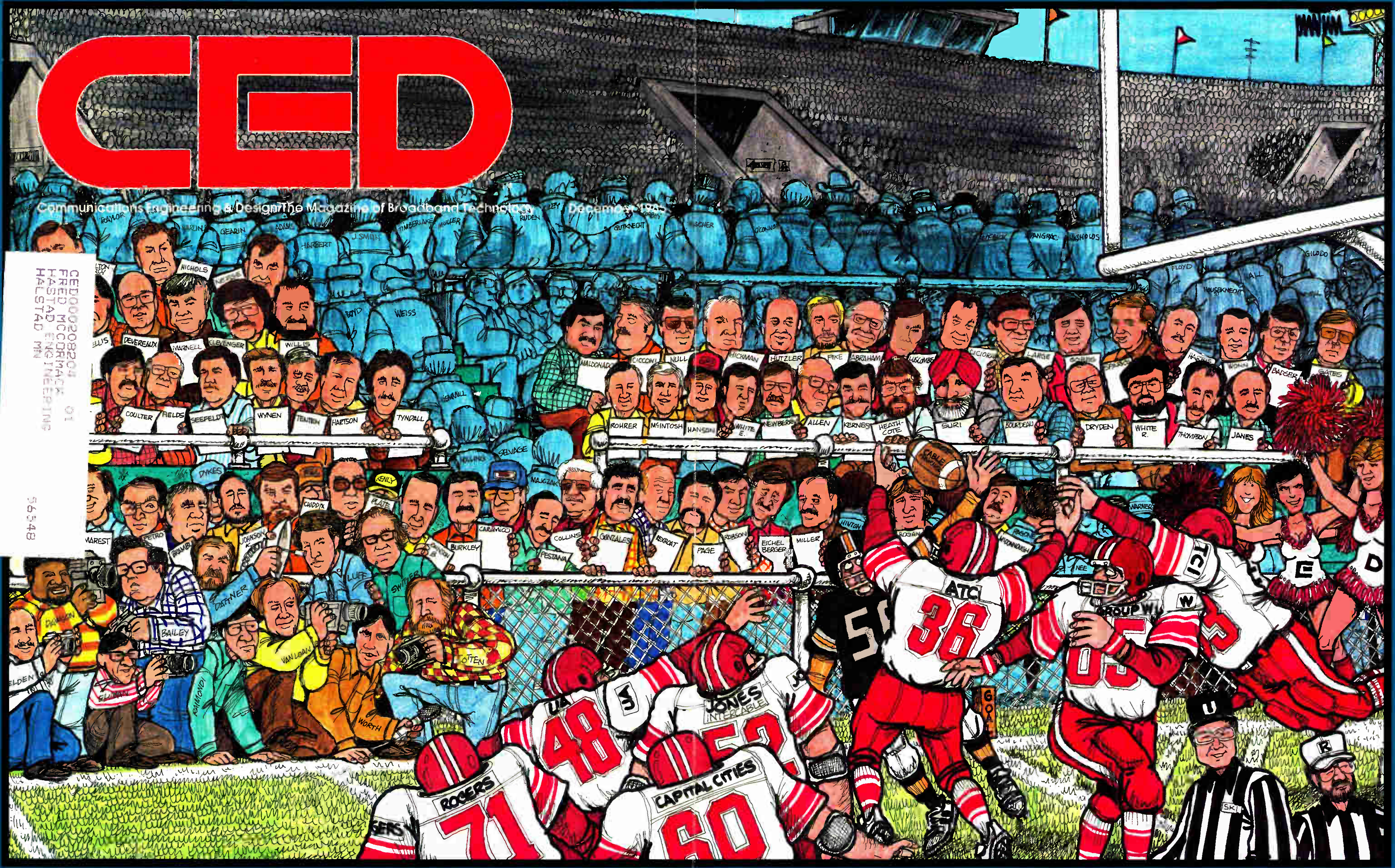
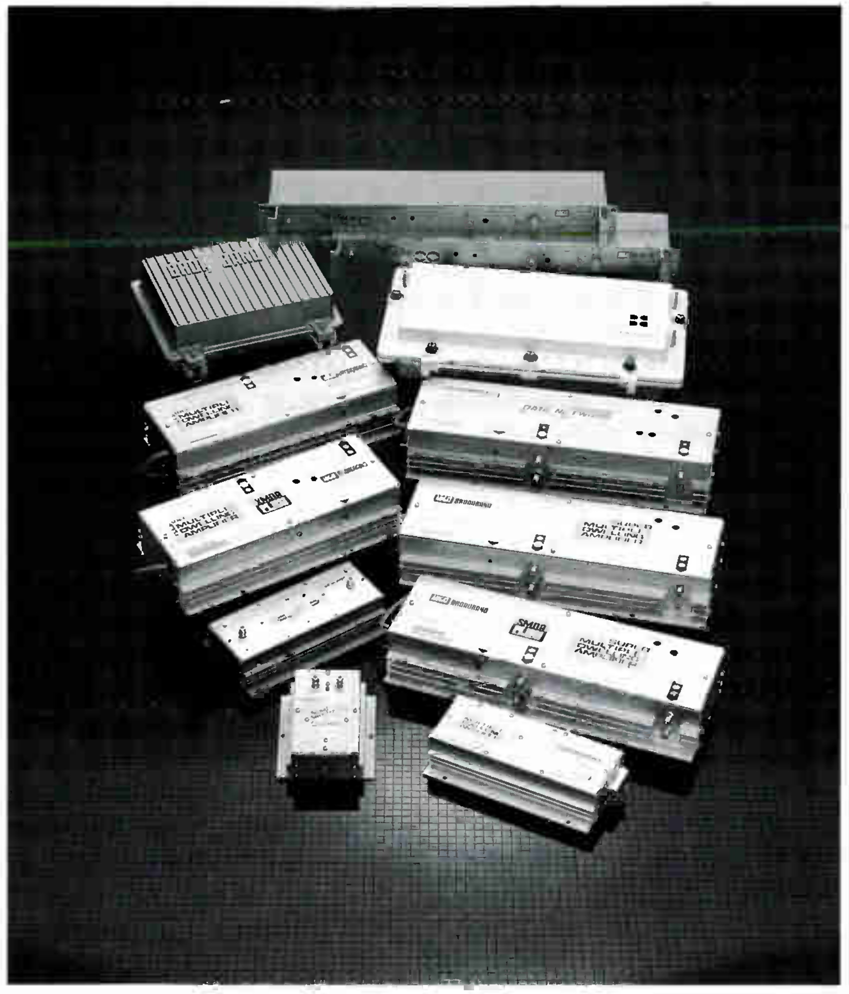
Communications Engineering & Design/The Magazine of Broadband Technology December





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CED™

December 1985

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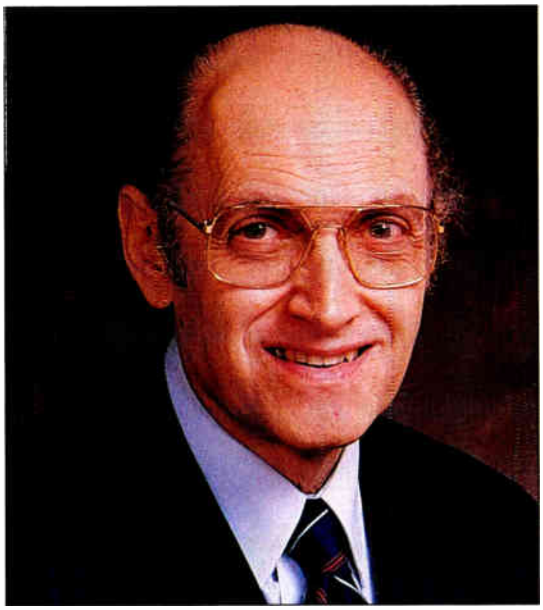

Abe Sonnenshein

Whenever there is something to be said about microwave, or perhaps a question on its regulatory or technical aspects, one person can provide the answer. Abe Sonnenshein, often referred to as "Mr. Microwave," is the person to find. With almost 20 years experience in the CATV industry, the application and usage of microwave is Sonnenshein's second nature.

Sonnenshein began his career with Hughes Aircraft Co. in 1967 as chief scientist for current program development. The job involved investigation of diversification opportunities for Hughes. "Most of the company's work was military, electronics and aerospace," says Sonnenshein. "Applying microwave technology to the CATV industry was one of the diversification activities we investigated. It looked very promising so we implemented it and, almost futuritively, the opportunity for me to become involved was created."

And Sonnenschein's involvement has never stopped. Currently the product manager, AML, for Hughes Aircraft Co., Sonnenschein's job includes engineering, manufacturing and marketing the microwave distribution system for the CATV industry. Cable issues also are important to Sonnenschein, and he stays actively involved with industry affairs. A former director of NCTA as well as of the Society of Cable Television Engineers, he has been chairman of the NCTA Associate Committee and has served on the Convention, Enhanced Services and Award Committees. He has been particularly active on the NCTA Engineering Committee and is a prominent participant in FCC proceedings relating to the commission's rules and regulations affecting the CATV industry.

"I've almost devoted the prime of my life to the industry," said Sonnenschein. "I don't have that many years left, but I'm sure I will maintain a strong presence in it. I'm very satisfied." Apparently, the industry also is satisfied with Sonnenschein's efforts and time. At the conclusion of the last NCTA convention, Sonneschein was awarded the Science and Technology Award for pioneering work performed in the development of microwave and satellite transmission techniques for cable distribution.

"To be honest with you, I'm very proud of the award," says Sonnenschein. "It's probably the highlight ot my professional career to be recognized by my peers and the association as a whole. I suppose, to some extent, it's recognition of the years I put in on the NCTA board, Engineering Committee and other activities."

As for the future of the industry, Sonneschein doesn't see any upset in technology. "I think cable keeps moving towards more maturing and perfecting," he says. "A high priority is building those areas yet to be cabled—before the DBS people have the chance to reach those potential subscribers. Secondly, many of the older systems badly require rebuilding. More emphasis is needed on such things as reliability and better performance—providing a higher standard of service."

Business communications and enhanced services are areas Sonneschein feels hold promise. "The problem I see here is cable operators have not been pursuing those markets aggressively. There are areas in telecommunications where cable companies could provide the service. Enhanced services will be the competition."

Competition in areas such as fiber optics and interactive cable is not a problem, according to Sonnenschein. The application for the markets are good, but they are not economically justified. "Interactive systems are like other inventions in search of a market. The technical feasibility of something like a checkless society is there, but the consumer is not standing in line to do it. What's in it for him? There is just not a great deal of money in it. The application of fiber optics is another example."

What the cable industry needs, says Sonnenschein, is more professional engineers. "Even though the industry is maturing, there is a lot of opportunity for professional engineers," he claims. "As big as our industry is, there are relatively few professional engineers—compared to other branches of engineering. Good, qualified people can shine very easily in the cable industry—it is definitely a good field to be in."

—Kathy Berlin

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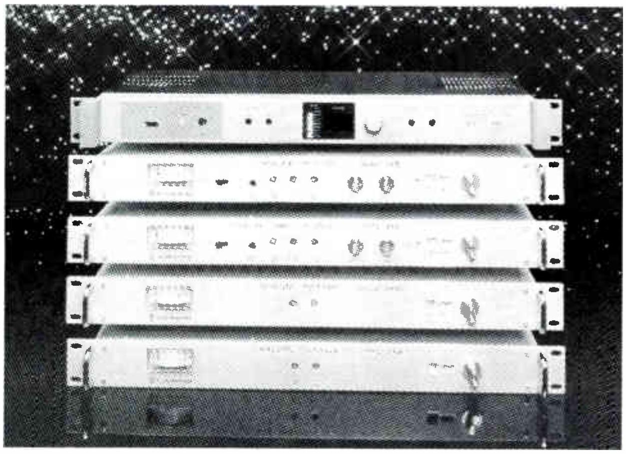

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Reader Service Number 6

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Fiber optics

By Archer Taylor, Malarkey-Taylor Associates

Irving Kahn once said that it was only because of the reluctance of cable television engineers that fiber optics had not been more widely used in the industry. Sruki Switzer pounded the table in Nashville in 1979 as he told the Cable Committee, "Fiber optics is here, today. It is no longer experimental." Two months later, he was telling engineers at the Anaheim convention that "fiber optics is at least 5 to 10 years away," urging 400 MHz, 54 channel coax instead. Sruki is certainly enthusiastic, competent and effective in the pursuit of new technology.

One telephone company engineer after another has talked about providing cable TV service by fiber optics. They contend (correctly) that fiber would solve the signal leakage and theft of service problems; that its small size would be much better for urban installations; that "repeaterless" fiber runs up to 50 km or longer (31 miles) are now feasible; that optical bandwidths of several gigahertz and wavelength division multiplexing (WDM) are now available to permit carriage of 60 digitized channels (at 80 MHz per channel) on a single mono-mode fiber.

We no longer need worry about connectors and splicers, although the loss in each splice is still equivalent to about 100 feet of fiber; and each connector, about 3,500 feet. As engineers, we can learn how to make up fiber splices and connectors efficiently, even though they are more sophisticated and demanding than their coaxial counterparts.

We do not have, to the best of my knowledge, an economical, low-loss optical branching device: an optical tap or splitter. Optical splitters were described, and even demonstrated in the laboratory, more than a decade ago. However, I do not believe anyone would claim that it would be technically feasible now to substitute fiber for conventional coaxial tapped feeders at tolerable cost and without "line extender" repeaters.

Without splitters or taps, the "tree-and-branch" network topology that has served the industry so well for the last

35 years simply is not feasible for a fiber optic system, notwithstanding that repeaterless fiber runs of 30 miles or more are available.

Even if we had optical splitters (taps) at a cost of $15 installed, with no more than 0.5 dB insertion loss (each pair of optical connectors has that much loss!), there is a much more difficult problem.

The cable industry has been forced to adapt to the available terminal display devices—that is, the conventional home TV set. Something like 150 million of these currently are in use in the U.S., representing public investment of at least $40 billion. Virtually all require analog, vestigial sideband AM (VSB/AM) signals. Fiber optical systems are ill-suited for multi-channel FDM/AM transmission, not because of the fiber characteristics, but because of the non-linearity of electro-optic transducers.

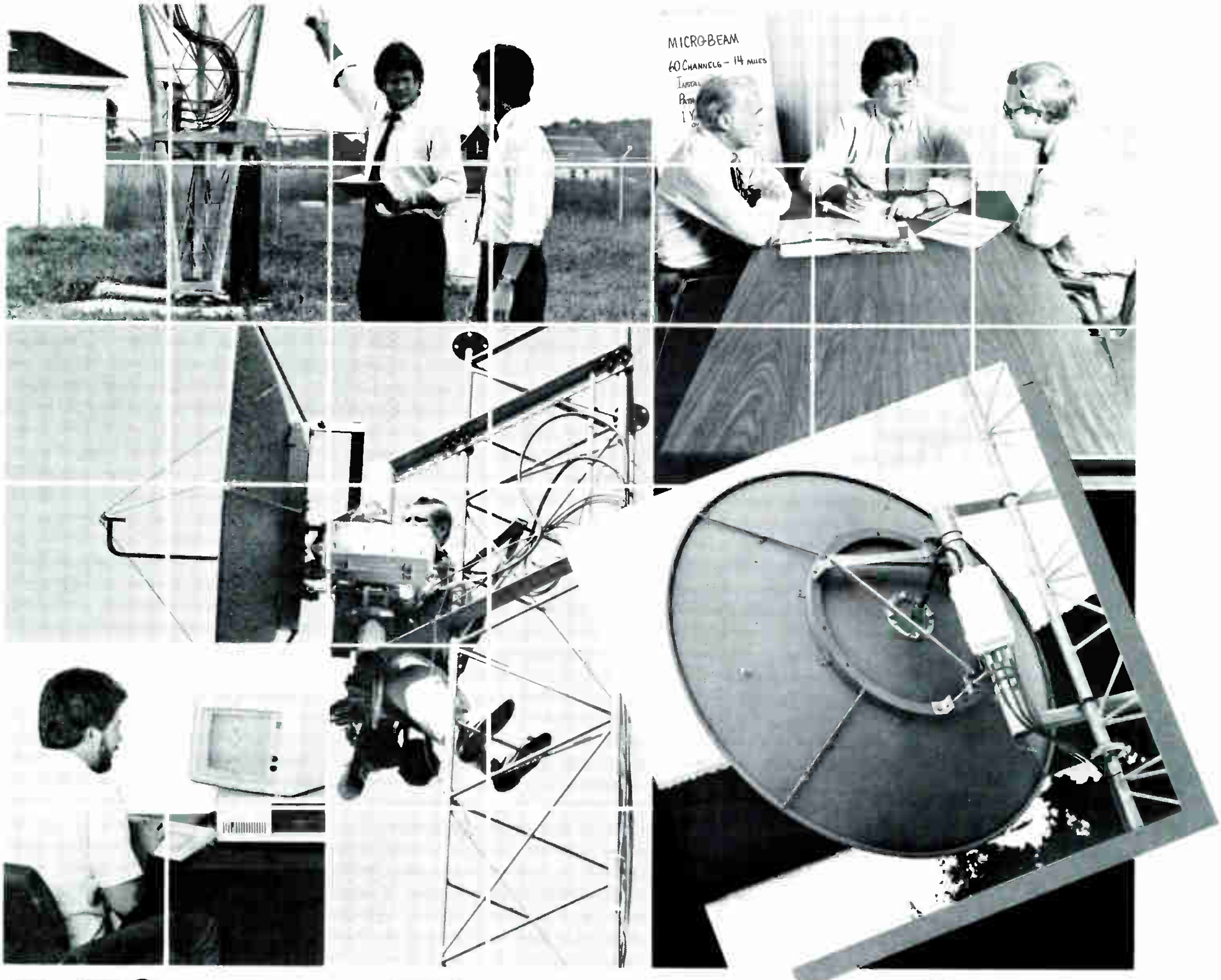
Few proponents of fiber would disagree that FM, or preferably PCM (digital), signals are far more suitable for optical transmission. But that requires some means to convert FM or PCM to VSB/AM to be compatible with the user terminal. The interface could be in the home (like a set-top converter) or in the public ways (like off-premises converters such as TRACS, SCAT or Mini-Hub). In either case, the interface would be able to deliver only one VSB/AM TV channel at a time to the TV set.

These considerations lead me to two important inescapable conclusions regarding fiber optics for TV distribution to subscribers:

1. The switched star, with electronic or optical switches, appears to be the only suitable network topology for distributing television or data on optical fibers to residential subscribers.
2. The advantages of fiber optics are most fully realized with FM, or PCM, but the television (and VCR) sets that will be available to the public for the forseeable future are not at all suitable for service as terminals in an FM or PCM television fiber distribution network.

It is not the backwardness of cable TV engineers, nor cost, nor even the technology of fiber optics that restrains its use for television distribution. Telcos provide modems, for a fee, for data services distributed by fiber optics, but they are not likely soon to distribute TV to residential subscribers on fiber. The cable industry should be just as capable as telcos of finding a way to provide television terminals *compatible* with an FM or PCM fiber optics distribution network. But to do so, either industry would have to overcome the momentum and market power of the consumer electronics industry and the public investment in terminals that are simply not compatible with effective television distribution on fiber optic networks. This situation may change, but it is not yet clear when that might happen.

Very frankly, I would like to see the day when cable TV could assume responsibility for delivering *pictures* on a TV screen, not just electronic signals which become pictures only by means of a TV set that is not compatible with the distribution system without an adapter interface. There are almost twice as many cable TV subscribers today as the total number of TV sets produced and marketed in 1984. Why shouldn't a part of this $6 billion annual market be designed for cable, SMATV, MDS, VCR, DBS and backyard dishes, with converters to adapt to off-air reception? Maybe then fiber optics could become suitable for TV distribution. Unfortunately, there is still the chicken and egg problem. The cable industry will not build fiber systems until there is a suitable terminal. Consumer electronics will not built a suitable terminal until there is a market for it. How do we get there from here? **CED**



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Reader Service Number 7

Volume 11, No. 12

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In Perspective

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Reader Service Number 42

RF/BTSC interaction

By James O. Farmer, Technical Manager, Broadband Communications Division, Scientific-Atlanta Inc.

Interaction between RF subscriber equipment and stereo primarily is a result of scrambling. The interaction breaks into two problems: what they do to us and what we do to them. The first problem comes about as a result of the wider deviation and bandwidth of the audio subcarrier. The latter is a result of the amplitude pulses placed on the sound carrier by RF scrambling techniques. These are converted to phase modulation and detected by the discriminator.

This article does not address the unique problems of baseband converters, which generally are less compatible with BTSC audio than are RF converters.

Much has been written concerning how bad the problem of stereo on CATV will be. Based on calculations and experience to date, the author's reaction is that BTSC stereo on cable (and over the air, for that matter) certainly will not represent a new high in high fidelity, but it will offer a reasonable quality service for the average viewer. David Large has compared the signal to noise ratios of various audio delivery means.[1] He concludes that cable-delivered BTSC stereo will be of about the same quality as CATV FM stereo.

Frequency response probably will not be quite FM radio quality because of the lower pilot frequency of BTSC stereo, but 12 kHz should be possible with good receiving equipment. Good encoding equipment can encode to 15 kHz, but the author doubts that receiving equipment will work too well above 12 kHz because of the proximity of the pilot to the program material.

Does stereo work with scrambling? Our experience to date indicates that it does. While the degradations discussed below do take place, we find that the problems are measurable but not of sufficient magnitude to render the BTSC service incompatible with scrambling. One caveat though: The author's experience is limited to one RF system and may or may not apply to other systems. The manufacturer of any other equipment used should be contacted concerning equipment compatibility.

The CATV industry should embrace stereo with as much enthusiasm as possible. It gives us another feature to offer our subscribers in the race to stay ahead of the competition from other delivery media, such as VCRs and private earth stations. They can offer stereo, but so can CATV. Enjoyment of certain types of programming is greatly enhanced by stereo. For example, sports events heard in stereo give the viewer a sense of "being there."

BTSC format

Figure 1 shows the baseband spectrum of the BTSC stereo audio format. As in the FM stereo format, a sum (L + R) signal is transmitted at its normal baseband frequency. This is the only part of the composite audio signal utilized by monaural equipment. Above this, the difference (L − R) signal is transmitted. It is double sideband suppressed carrier (DSB-SC) modulated onto a carrier at twice the horizontal rate (2fh). Suppressed carrier modulation is used to eliminate any unnecessary energy from the difference signal. (The BTSC format differs from the EIAJ format used in Japan, which uses a frequency modulated carrier in the difference channel.) In order to recover the L—R signal, the suppressed carrier first must be recovered. To do so, a pilot signal phase-

Figure 1 BTSC stereo format

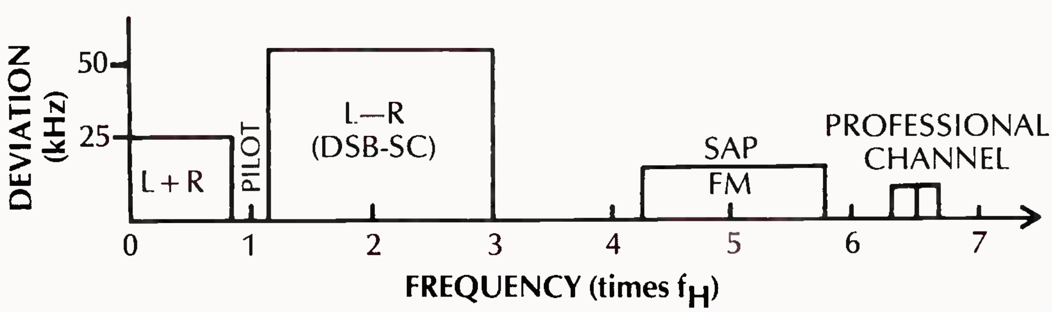

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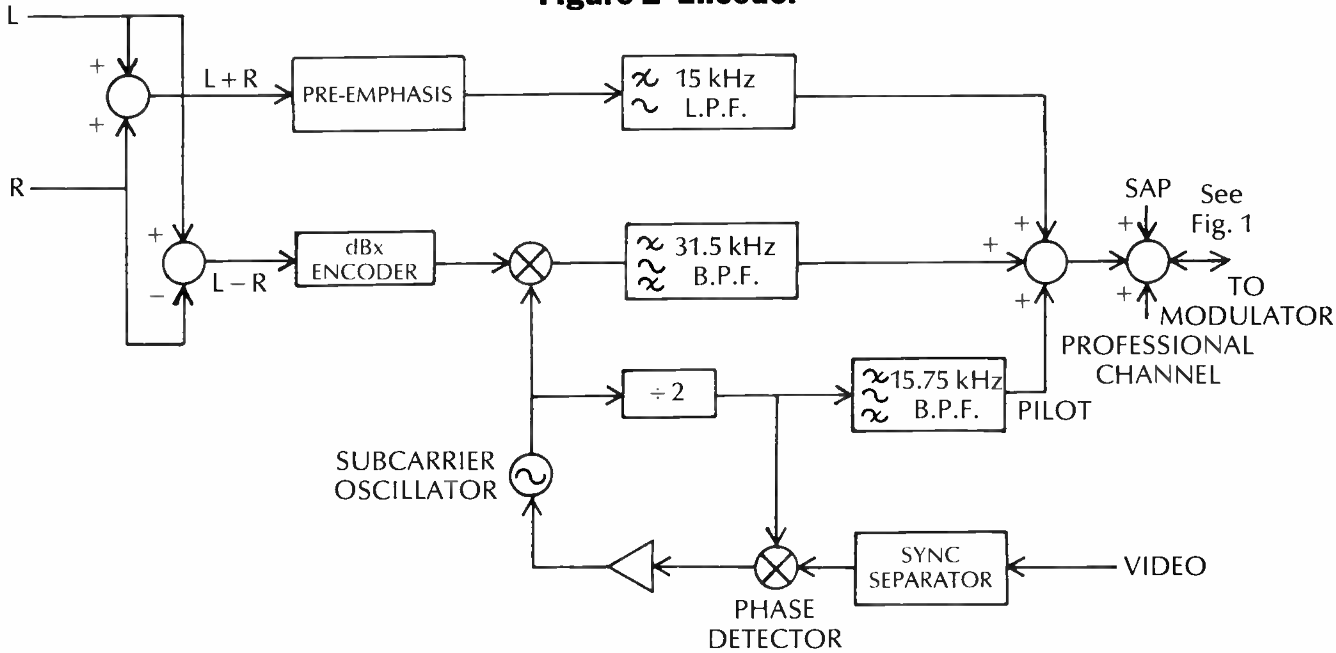
Figure 2 Encoder



locked to the video horizontal line rate is transmitted. This pilot is doubled (usually in a phaselocked loop) and synchronously detects the L—R signal. As shown in the appendix, phase errors in the pilot result in amplitude errors in the recovered L—R signal. This, in turn, causes loss of separation.

Next higher in frequency is the supplementary (or second) audio program, the SAP channel. This normally is an independent audio track such as a second language broadcast. The SAP is frequency modulated onto a carrier locked to the fifth harmonic of the horizontal line frequency.

Finally, we have the professional channel, which is intended as a utility communications link for station personnel. Uses planned are for telemetry, allowing transmitter parameters to be monitored at the studio and for voice coordination of field news crews. Both the SAP and professional channels are optional.

Figure 2 shows a block diagram of one type of stereo encoder. The left and right channel audio signals are designated L and R. They are applied to a summing circuit to produce the L+R signal, which is pre-emphasized as would be the sound for a monaural broadcast. The sum signal is low pass filtered to remove any components above 15 kHz, as they would interfere with recovery of the difference signal.

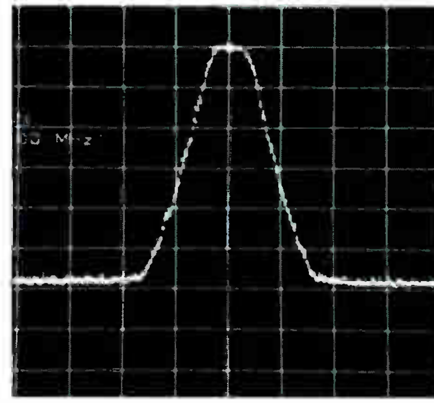
The L and R signals also are applied to a subtractor which develops the L—R signal. This subtractor is nothing more than an inverting amplifier for the right audio, and a resistive network to add the left and inverted right signals. Prior to modulation, the L+R signal is supplied to a frequency selective compressor used for noise reduction. Noise reduction proved necessary for adequate signal to noise performance in CATV and weak signal situations. The L—R signal at baseband is amplitude modulated onto a subcarrier at 31.5 kHz, twice the horizontal frequency. This subcarrier is divided by 2 and applied to a phaselocked loop, which locks the oscillator to twice the horizontal sync rate. The divided output is filtered to remove harmonics and is added to the composite baseband signal as the pilot.

The sum, pilot, difference and (if used) SAP and professional channel signals are added at the output of the encoder. The output of the encoder is supplied to the sound modulator, which must have been modified to accept the wideband input. This modification consists of increasing the frequency response, increasing the deviation capability and removing the pre-emphasis. Alternatively, the modulator might be included in the encoder. The reason is that the deviation of the sound carrier must be calibrated very accurately in order to prevent loss of separation.

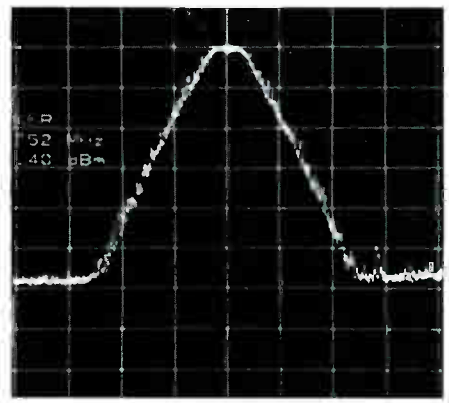
Having finished this digression, we return to the interaction between scrambling and stereo.

What they do to us

Figure 3 shows the spectrum of a monaural and stereo signal. The photographs this figure was based on were made by programming a digital spectrum analyzer to hold the peak amplitude of a spectrum sweep. A 20 minute section of a tape of Dixieland music was played through a monaural modulator. The photograph of Figure 3(a) was taken. The tape was rewound and played through a stereo encoder and modulator. Thus, the spectra shown are



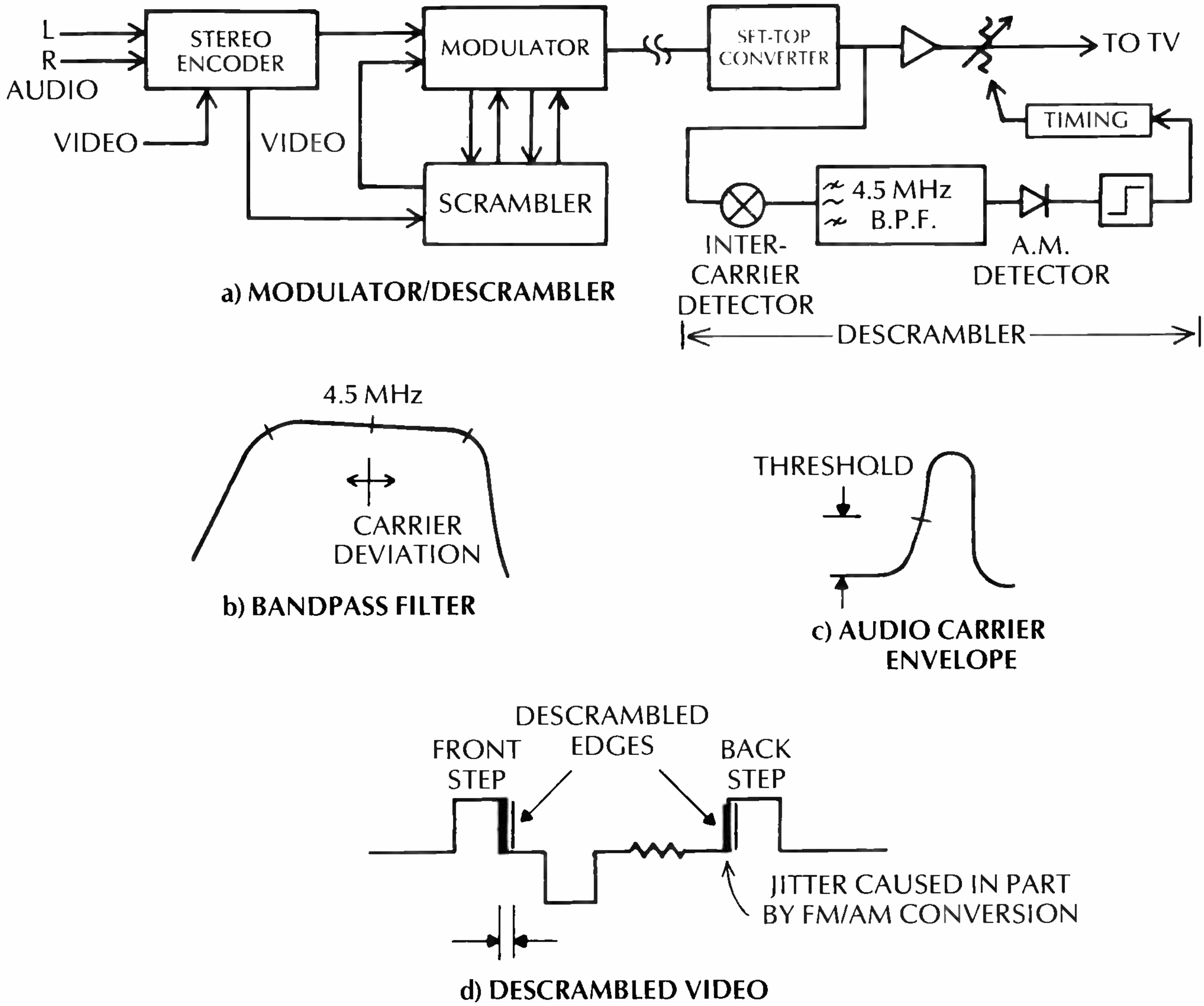
(a)



(b)

Figure 3 Peak spectra of monaural (a) and stereo (b) signals.

Figure 4 Descrambler susceptibility to stereo



of the same real program material in both monaural and stereo. The vertical scale is 10 dB per division, and the horizontal scale is 100 kHz per division. Notice that the occupied spectrum of the monaural signal is just over 100 kHz at the -20 dB points, while the spectrum of the stereo signal occupies 200 kHz. SAP and professional channels were not used in making these photographs. The amount of spectrum spreading is a function of the high frequency content and the separation of the material.

If a frequency modulated signal is passed through a bandpass filter too narrow to pass all significant sidebands, an amplitude modulated component will be added. The process is called FM to AM conversion. The AM thus created can cause distortion of the timing pulses frequently employed in scrambling systems.

The problem with scrambling is that we have been putting amplitude modulation on a signal that has been FM'd with a deviation of 25 kHz, and now we find ourselves facing a much wider deviation. Figure 4(a) shows the signal path that illustrates the point. A modulator accepts an input from a stereo encoder and a video source, and is interfaced with a scrambler. The signal is transmitted to a descrambler. As is commonly the practice today, synchronizing information is transmitted to the descrambler as amplitude modulation of the sound carrier. In the decoder, the sound carrier is amplitude demodulated to recover timing pulses. The sound carrier receiver shown uses intercarrier detection to permit better filtering and greater immunity to frequency error.[2] These same arguments would hold true for the older TRF receivers. Figure 4(b) shows the typical bandpass response of the 4.5 MHz filter. When the deviation is increased, the signal may begin to "fall off" the flat portion of the filter response. This will cause additional and undesired amplitude modulation of the sound carrier. (This spurious modulation is particularly dangerous in the case of sine-wave scrambling because it will be transferred to the picture carrier and will show up in the picture.)

In a switched sync suppression system as shown, the spurious AM is not directly transferred to the picture. However, it does distort the amplitude of the leading edge of the timing pulse, causing the apparent pulse position to change. Figure 4(c) shows the desired envelope of the audio carrier. Risetime of the timing pulse is constrained to follow a waveform which maximizes the transition rate near the 50% point, where the pulse is detected, while minimizing the bandwidth occupied by the modulation. However, should any spurious AM be introduced, the time of occurence of the 50% point will be in error.

Figure 4(d) shows a horizontal blanking interval for a descrambled signal.

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Front and back steps are added by the scrambling and descrambling process. This is absolutely necessary in order to prevent the process from adding a false sync by amplifying (in descrambling) before attenuating (in scrambling). Extraneous noise on the sound carrier, from FM/AM conversion or any other cause, will create uncertainty in the time of the synchronizing pulse, causing jitter on the descrambling edges of the front and back steps. Because of these steps, some safety margin exists, but if too much jitter is present, the sync tip will apparently change in time, causing the picture to exhibit horizontal jitter.

What we do to them

Just as FM can be converted to AM, AM can be converted to FM.[3] After the FM is generated, it is indistinguishable from the desired audio signal and will be detected along with it. Since the scrambling and descrambling processes both place AM on the sound carrier at a TV line rate, the pulses are locked to the horizontal rate of the video. Look back to Figure 1 and notice the stereo pilot signal, also locked to the horizontal rate and having a deviation of only 5 kHz. This pilot is used to detect the presence of a stereo telecast, switching on the stereo decoder. It also is used to reconstruct the difference signal carrier to allow detection of the L—R signal.

When this FM sound carrier (now contaminated with spurious modulation due to AM/FM conversion) is detected, the resultant signal will have excess energy at the horizontal frequency, fh. If enough energy is present, the stereo pilot detector may false trigger on a monaural signal. This would cause the audio to be very noisy. Also, the horizontal rate artifact generated by the scrambling process is at a random phase with respect to the pilot during a stereo broadcast. This causes a phase shift in the pilot carrier which, in turn, causes a phase shift in the reinstated 2fh carrier. The end result is loss of separation (see appendix).

The table below shows the separation loss that results from various amounts of phase shift on the pilot. The equations used in the calculation are derived in the appendix. Since the pilot is doubled to obtain the difference subcarrier, pilot phase error is doubled in subcarrier generation. This table shows that pilot phase deviation of more than 10 degrees begins to cause unacceptable degradation of the separation. A little trigonometry shows that this can happen when the amplitude of the spurious energy is 15 dB below that of the pilot. This corresponds to a resultant deviation of 0.87 kHz.

Figure 5(a) shows the baseband spectrum of the audio output of a television demodulator with the de-emphasis removed, when the carrier is modulated by a 1 kHz tone deviated 70 kHz. This tone is for calibration purposes. Video modulation also was applied to the incoming signal. Since it has such a

Pilot Phase Error (Degrees)	Subcarrier Phase Error (Degrees)	Separation (dB)
1	2	70
5	10	42
10	20	30
15	30	23
20	40	18
25	50	13

Separation versus pilot phase shift

strong 15.734 kHz component, this component may be seen in the output —but at a level 60 dB below the 1 kHz tone. Figure 5(b) is the same as Figure 5(a) except that pulses were added to the sound carrier to represent scrambling and descrambling of an offset timed RF scrambling system. The pilot amplitude is shown, though no pilot was actually transmitted for this test. Note that the amplitude of the 15.734 kHz component is 5 dB higher than in Figure 5(a). The difference is caused by the AM timing pulses on the sound carrier being converted to FM and detected by the discriminator in the demodulator. In this case the spurious energy is some 32 dB below the pilot amplitude, so we would not expect a problem with stereo separation. Neither would we expect a problem of falsely keying on the stereo decoder on a monaural signal. However, the amount of contamination at the pilot carrier frequency is very much a function of the receiver circuits, so the amplitude shown here does not indicate the amplitude of contamination in a TV receiver.

It is essential that AM/FM conversion be minimized to permit high quality audio on a scrambled stereo telecast. Much of that responsibility rests within the TV receiver, but some things may be done within the scrambling system, too. Obviously the higher the amplitude of the AM placed on the sound carrier, the more severe the problem. The greater the scrambling depth, the greater the AM imposed.[4] When on-time scrambling is employed, the pulse amplitude is greater because of scrambling and descrambling pulse overlap.

This is not the only source of separation loss. One of the most severe errors, not related to scrambling, is amplitude error in the recovered difference signal caused by errors in modulation level. These errors exist because of the effect of amplitude companding in the difference channel. If an error exists in setting the modulation level of the composite stereo signal, the expander in the television set will return the difference signal to the incorrect amplitude so that when the stereo composite signal is demultiplexed, the separation will be degraded.

This is why the setting of modulation level at the modulator is so important, causing some manufacturers of encoders for the CATV industry to include 4.5 MHz modulators in their encoders—so the amplitude setting can be done in the factory where calibration is better controlled. One encoder which will be introduced soon has a built-in calibration oscillator to allow the deviation of a modulator to be set in the field. Even this procedure will not yield acceptable results unless the deviation of the sound modulator can be measured precisely.

Appendix

This appendix is intended to illustrate the basic mathematics of stereo transmission and will show the sensitivity of the separation of phase errors in the pilot. We begin by assuming that at the headend we have an audio signal of amplitude A and frequency ω_m on the left channel and no signal on the right channel. Our equations for the right and left channels are, therefore:

$L = A\sin\omega_m t$
$R = 0$ eq. 1-1

These signals are passed through the sum and difference matrices to yield:

$L + R = A\sin\omega_m t$
$L - R = A\sin\omega_m t$ Eq. 1-2

The sum signal, L + R, is transmitted in the form given, while the difference signal is modulated onto a subcarrier at frequency ω_s.

$V_{sc} = A(\sin\omega_m t)(\sin\omega_s t)$ eq. 1-3

Straight multiplication is the correct representation for amplitude modulation, double sideband suppressed carrier. The difference signal of eq. 1-3 is added to the sum signal of eq. 1-2, and the pilot, of frequency $\omega_s/2$. This com-

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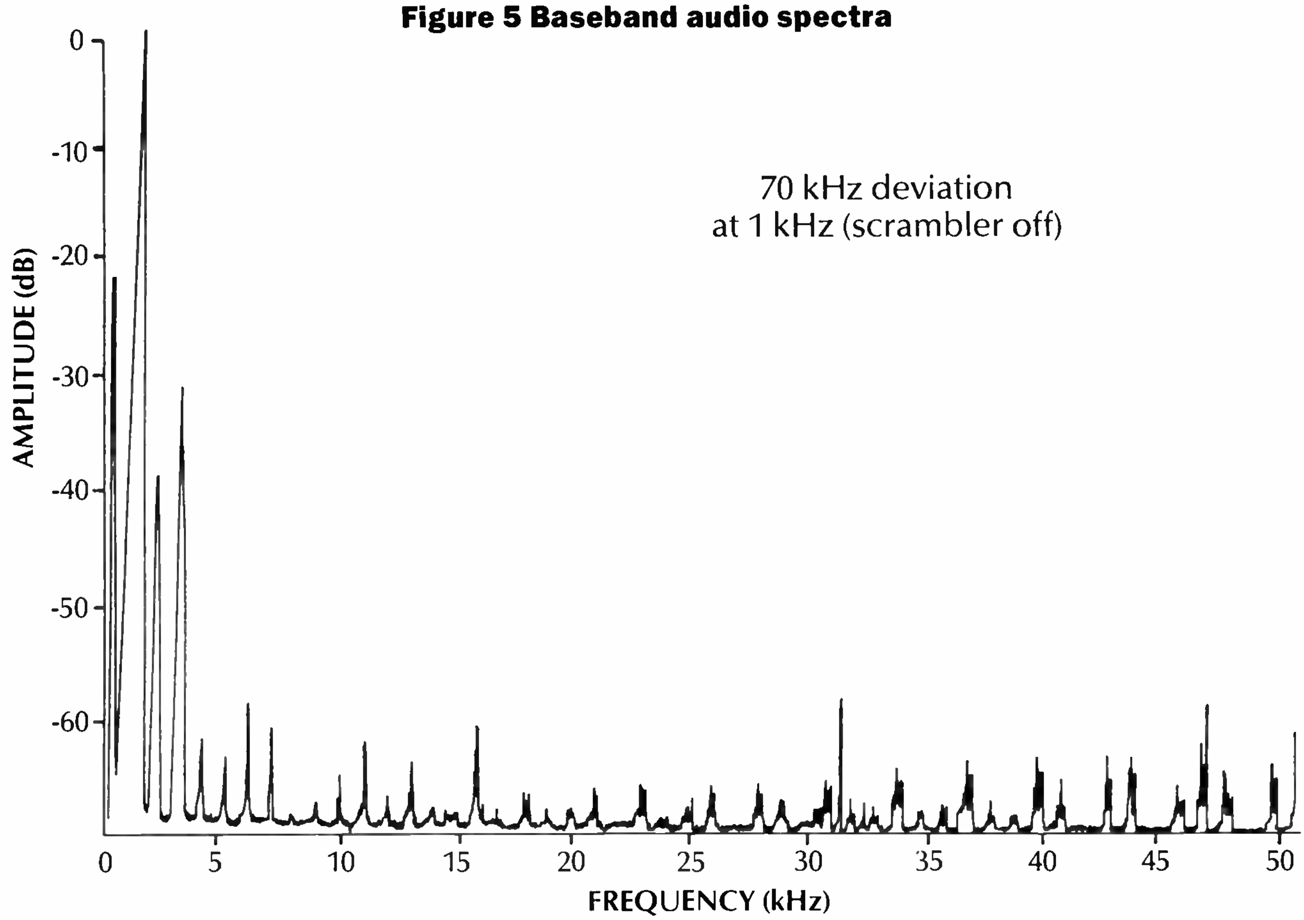
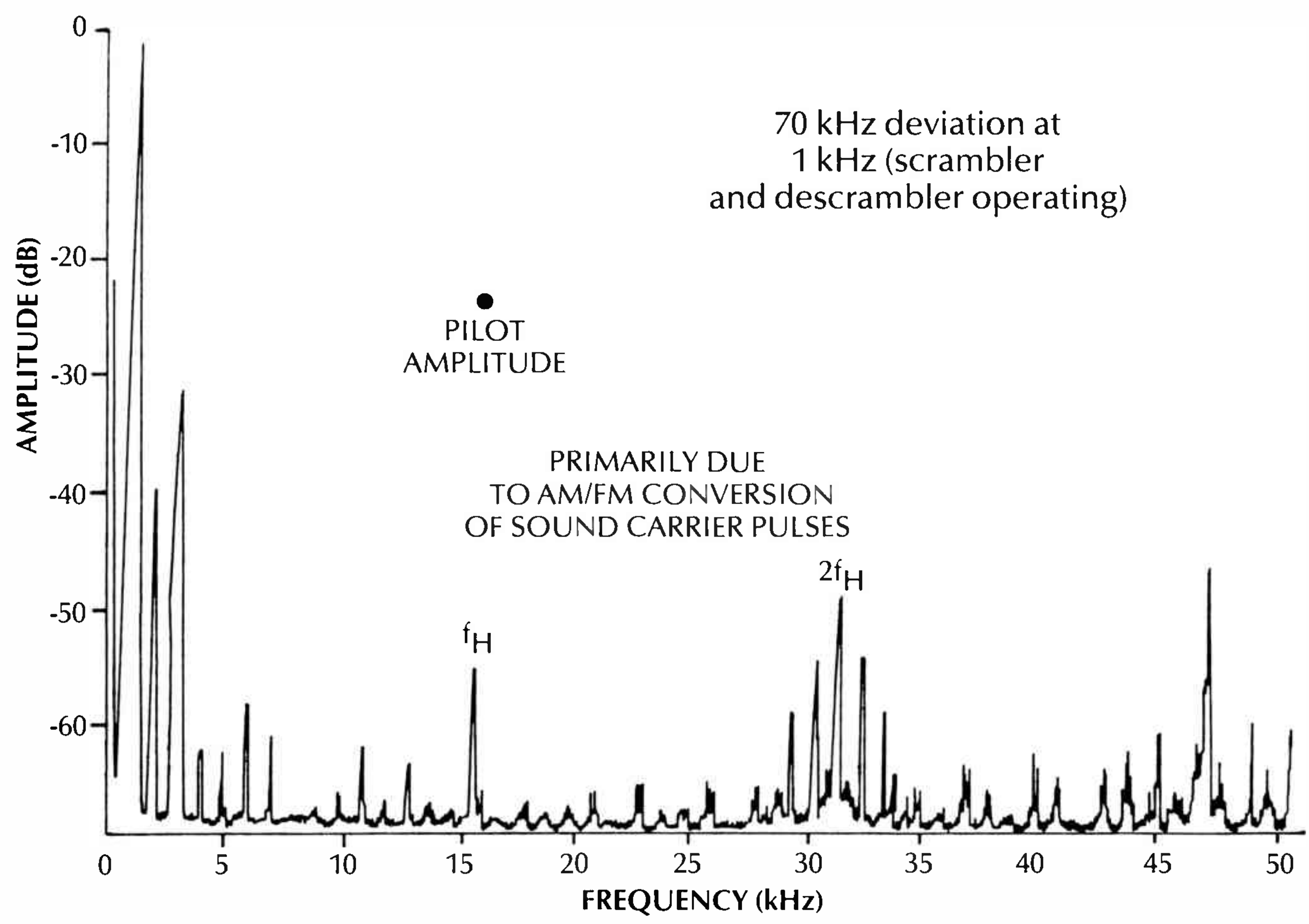
Figure 5 Baseband audio spectra





posite signal is modulated on the sound carrier, along with the SAP and professional signals if used.

This signal is transmitted to the home receiver and demodulated back to the components shown. The next task is to demodulate the difference signal of eq. 1-3, so that we might apply it and the sum signal to the matrix which will yield the left and right signals. The demodulation process is done synchronously by deriving a local carrier from the transmitted pilot. To take into account the possible phase shift of the doubled pilot frequency, we'll write it with phase shift ϕ:

$$V_{si} = \sin(\omega_s t + \phi) \qquad \text{eq. 1-4}$$

The L − R signal is obtained by multiplying Vsc of equation 1-3 by the inserted carrier of equation 1-4. Thus, the demodulation process is represented mathematically by:

$$L - R = A(\sin\omega_m t)(\sin\omega_s t)\,[\sin(\omega_s t + \phi)] \qquad \text{eq. 1-5}$$

After expanding using standard trigonometric relations, we obtain for the difference signal:

$$L - R = A(\sin\omega_m t)(\cos\phi) \qquad \text{eq. 1-6}$$

This is the same as the L—R signal we started with—except its amplitude has been altered by the cosine of the phase error of the reinserted difference carrier frequency. We now dematrix using the L + R signal of eq. 1-2, which we assume was transmitted without distortion, and the L—R signal of eq. 1-6.

$$L = (L + R) + (L - R)$$
$$R = (L + R) - (L - R) \qquad \text{eq. 1-7}$$

Substituting eq. 1-2 and 1-6 and combining terms we obtain:

$$L = (A + A\cos\phi)\sin\omega_m t$$
$$R = (A - A\cos\phi)\sin\omega_m t \qquad \text{eq. 1-8}$$

But what we wanted was the same as in eq. 1-1, which was a left amplitude of A and nothing in the right channel. Thus, phase shift has caused the left channel amplitude to be low and the right channel to become contaminated with left channel information. We define the separation to be -20 Log of the left channel amplitude divided by the right channel amplitude or:

$$S = -20\mathrm{LOG}[(A + A\cos\phi) \div (A - A\cos\phi)]$$
$$= -20\mathrm{LOG}[(1 + \cos\phi) \div (1 - \cos\phi)] \qquad \text{eq. 1-9}$$

The phase shift used above was that of the reinserted subcarrier at twice the pilot frequency. Because of frequency doubling, a phase error in the pilot is doubled at the subcarrier frequency. We may tabulate the pilot phase error versus the separation, as shown in the table above. CED

Reference/Footnotes

[1] Large, David, "Implementing MTS," *CED*, May 1985, p. 46.

[2] Intercarrier detectors make use of the very precise transmitted picture-sound frequency spacing, in order to eliminate set-top tuning errors from placing the sound carrier off center in the bandpass filter. Additionally, by mixing the sound carrier to 4.5 MHz, a higher quality filter can be realized.

[3] Many mechanisms exist for converting AM into FM. One of the more common is a bandpass filter in the sound path, which is not symmetrically tuned to the center frequency. In this case, the two modulation sidebands are attenuated differently, which will cause a phase-modulation component to be introduced. This may be seen by studying a phasor diagram in which the sidebands have unequal amplitude. The result contains a phase modulated component. Frequency modulation is simply a special case of phase modulation.

[4] The descrambling process amplifies the picture carrier during blanking intervals. Since the sound carrier accompanies the picture carrier through the descrambler, it too is amplified. Thus, the sound carrier reaching the TV receiver has AM pulses from the descrambling process as well as the timing pulses placed on it by the scrambler.

Store-and-forward

A practical impulse pay-per-view solution

By Yuske Ishii,
General Manager, Engineering,
and
Larry C. Brown,
Vice President, New Business Development,
Pioneer Communications of America Inc.

To be competitive, the design of one-way addressable converter systems today must include provisions for impulse pay-per-view service. To this end, each major converter manufacturer is offering a solution to cable operators consistent with its view toward the pay-per-view controversy.

Some vendors are offering 'add-on' impulse pay-per-view (IPPV) capability for their addressable converters. In this approach, the fundamental benefits of one-way addressability first can be achieved through installation of the converter itself into subscriber homes. Later, true 'impulse' pay-per-view capability can be added through installation of a companion 'add-on' unit. Pioneer's BA-5000 series addressable converter, and companion PULSE add-ons for IPPV, are an example of this approach.

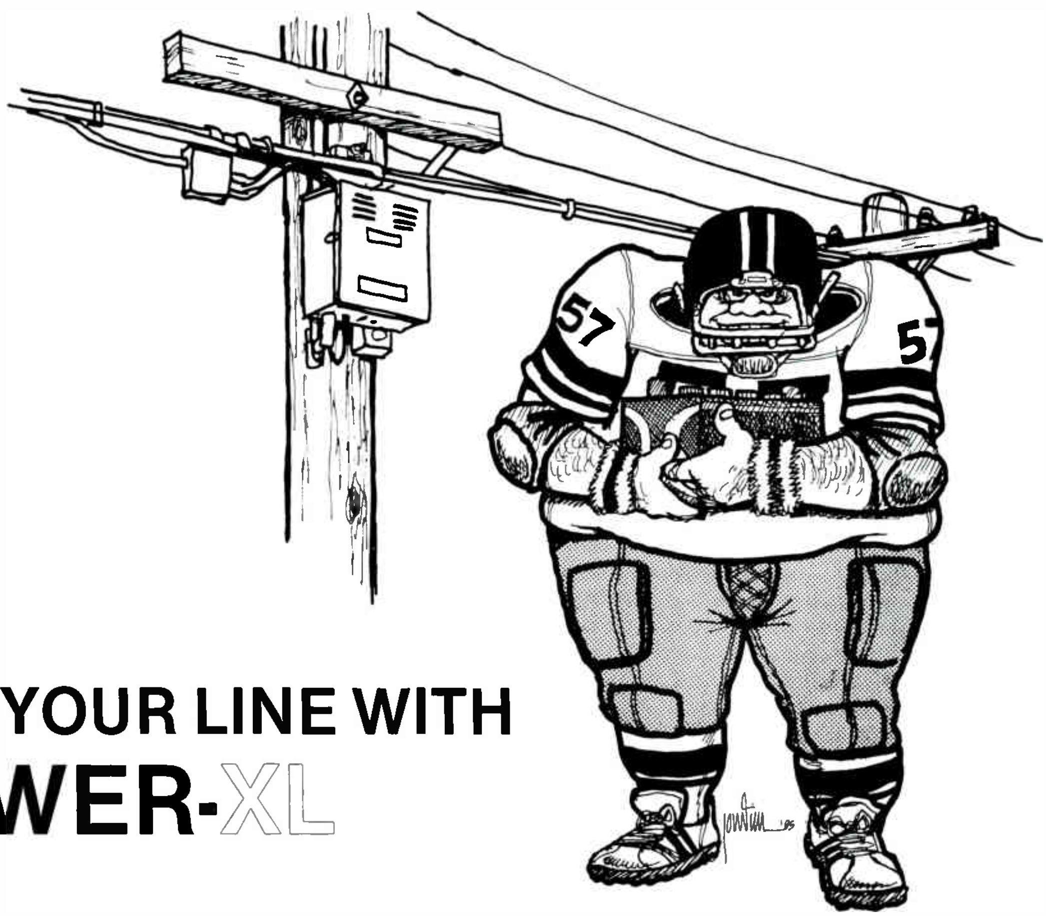
To achieve a practical IPPV system, the importance of clear definition of details of communication between the converter and the 'add-on', as well as overall system design, was recognized early on. Accordingly, Pioneer's PULSE add-on was developed simultaneously with the BA-5000 one-way addressable converter. Design objectives for the BA-5000/PULSE system included:

♦ VIRTUAL REAL-TIME OPERATION BY SUBSCRIBER
Subscriber reception of an IPPV program must 'look like' it has been authorized by the cable operator at the instant the request is made.

♦ LOW COST CONTROLLER
The two-way addressable controller required by the operator for handling IPPV cannot cost substantially more than typical one-way addressable designs.

♦ EASE OF INSTALLATION
It must be possible for the 'add-on' to be installed in the home without any real-time manpower assistance from the headend or cable office.

♦ DATA AND SERVICE SECURITY
The technology and approach used for data communication to and from the subscriber home must be such that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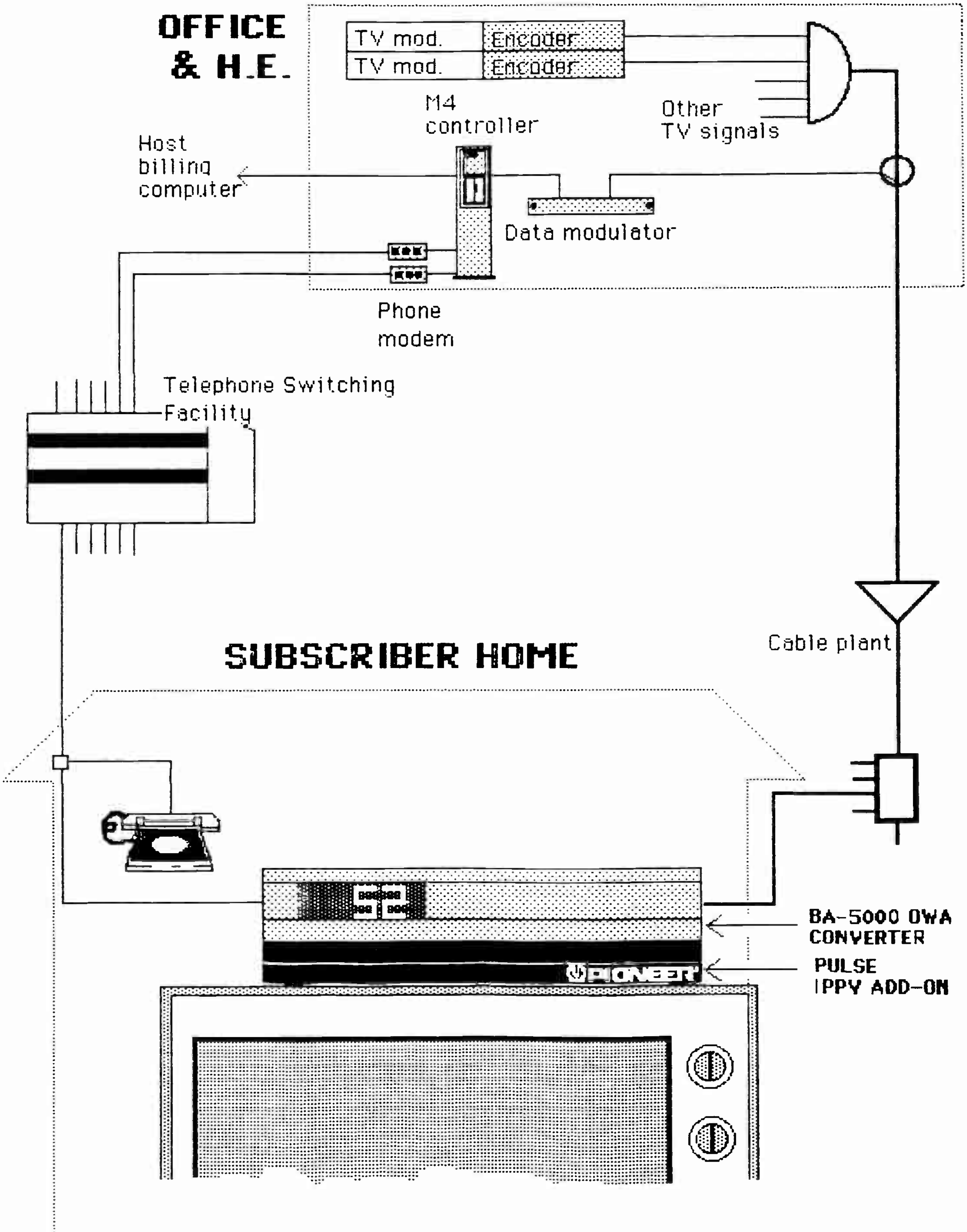

Figure 1 BA-5000 & hybrid PULSE system concept

subscribers cannot defeat accurate reporting of the IPPV viewing statistics required for billing purposes.

♦ MINIMUM BILLING DISPUTES
The system architecture must be such that the potential for subscriber billing disputes, with their attendant high operating expense, is minimized.

Installation

To upgrade a Pioneer BA-5000 one-way addressable system to PULSE IPPV capability, a two-way controller is first installed in the headend/office of the cable operator. Pioneer's Model M4 IPPV controller is an extension of the M3+ one-way addressable controller, which utilizes the DEC Micro PDP-11 minicomputer as its CPU. Both the M3+ and M4 use the same BU-3000 intelligent front-end communication processor, which is connected to the CPU bus via direct memory access (DMA) to offload much of the system's I/O overhead. The BU-3000 has a 16-bit microprocessor with local memory, which is directly connected to the PDP-11's main memory, thereby eliminating any constraints of terminal addressing space with respect to the local memory size of BU-3000. In other words, the number of tiers or terminals in a system does not impact the required controller hardware configuration.

There actually are two models of PULSE available, differing only in the medium used to communicate upstream. The 'hybrid' model of PULSE communicates back to the operator via phone lines in the polling process and, thus, can be employed on a cable plant equipped for only one-way transmission. The 'psk' PULSE model communicates upstream on the 5 to 30 MHz return portion of a two-way cable plant.

For systems already equipped with the Pioneer M3+ one-way addressable controller, a software upgrade and addition of asynchronous lines to collect data are all that is needed to make the headend ready to accomodate hybrid PULSE IPPV. Psk PULSE IPPV requires the addition of a BU-3500 two-way cable data receiver at the headend.

Prior to installing a PULSE unit at a subscriber's home, an 'IPPV flag' is first set by the operator in the controller. This flag is subsequently downloaded with other addressable information to the BA-5000 already in the home. Typically, the data entry associated with setting these IPPV flags would be batched daily for forthcoming scheduled installs. This process brings associated subscribers' BA-5000s to the state of 'IPPV-ready,' i.e. awaiting and 'watching for' the PULSE add-on to be connected via the interface port provided on the BA-5000.

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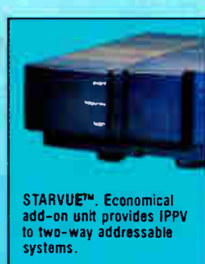
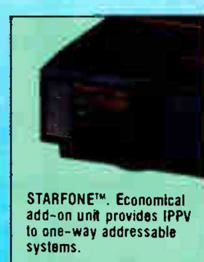

STARVUE™. Economical add-on unit provides IPPV to two-way addressable systems.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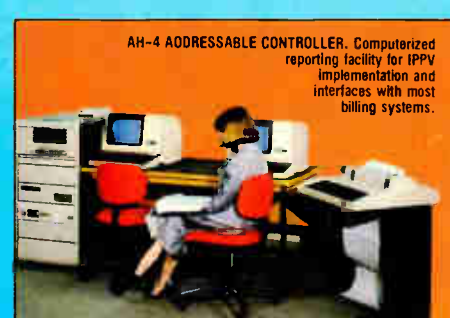
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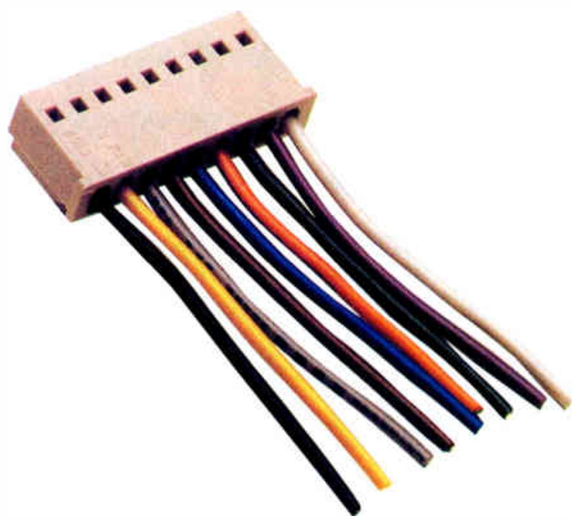
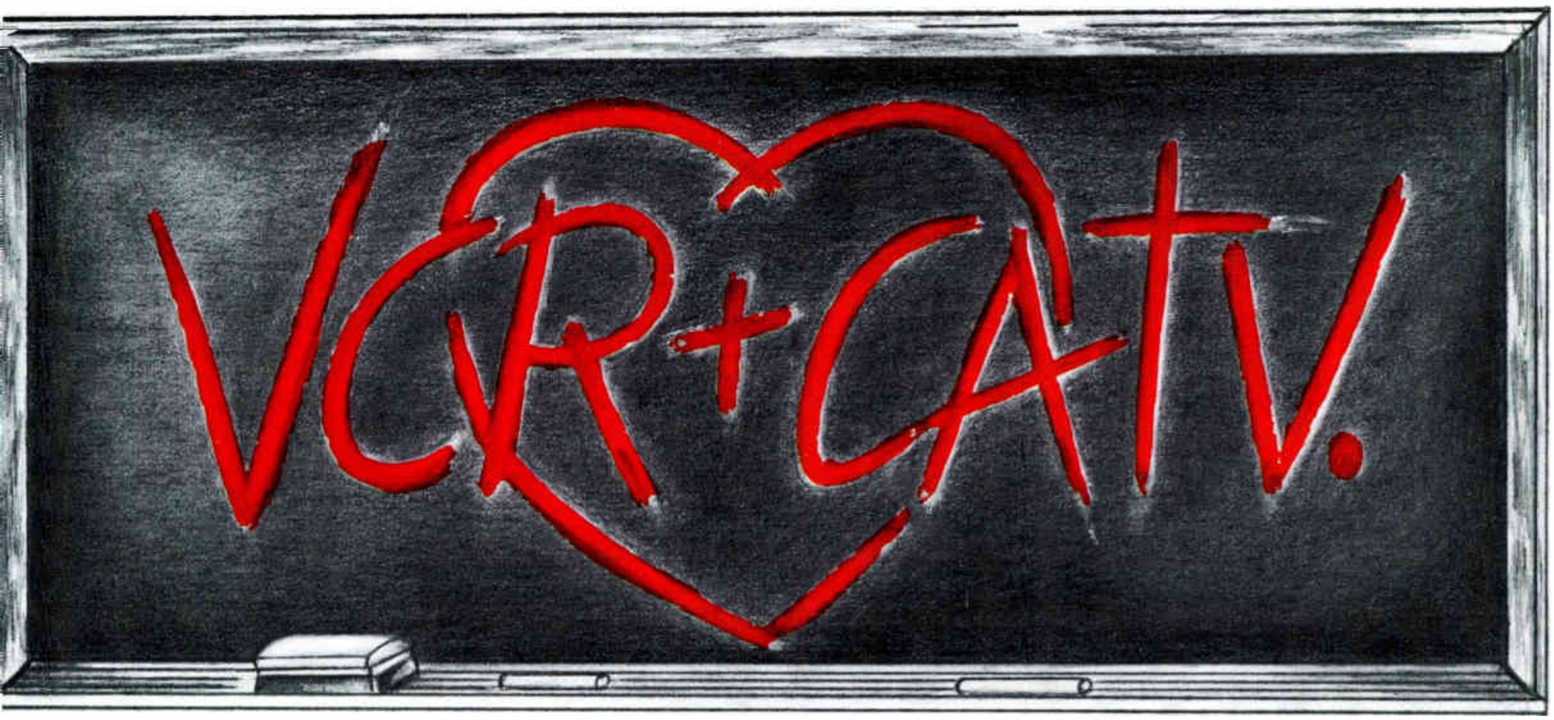


An Empty Jack.



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add-on to the BA-5000 completes the installation process for a subscriber. The PULSE unit fastens to the bottom of the BA-5000, as depicted in Figure 1. This 'piggy-back' mechanical configuration was chosen for its degree of protection of inter-unit cabling and its conservation of set-top physical space. As an additional security measure, once the BA-5000 first 'sees' the PULSE unit has been attached, the PULSE unit cannot be removed without triggering an 'IPPV access trap' mechanism, which disables the ability of the subscriber to receive IPPV programming.

This IPPV access trap is distinct and separate in its function from another access trap function in the BA-5000, which effectively disables ALL subscriber service if a subscriber tampers with his BA-5000 unit. This access trap function is a standard feature of all Pioneer addressable converter designs. It is primarily a result of Pioneer's sensitivity to the subscriber theft-of-service problem, resulting from many years of experience providing two-way addressable converters to Warner-Amex for their interactive QUBE systems.

It also is significant that the installation process for a PULSE unit does not require the technician to initiate any telephone call or other communication to the cable office from the subscriber's home to complete the install.

Operation

Operation of the BA-5000/PULSE system involves a 'store-and-forward' technique, which functions in 'data collection cycles.' The length of this cycle is definable by the operator. For instance, a one-month cycle might be selected—to coincide with an operator's already established billing cycle.

During any one such cycle, a subscriber may view up to 20 IPPV programs. Each such program is authorized by the PULSE unit itself, without any real-time communication to the headend or cable office. This eliminates any need for customer service representatives to contend with a barrage of last-minute purchases from subscribers just prior to the start of a popular IPPV program.

During transmission, each IPPV program is electronically 'labelled' at the headend with an in-band 'event ID.' This ID is recovered by the BA-5000 and, for each program purchased, passed on to the PULSE unit. PULSE 'stores' up to 20 such IDs, holding them for later 'forwarding' back to the IPPV controller to enable billing of subscribers for programs purchased.

At the end of a 'data collection cycle,' the controller manages a process of 'polling' all the PULSE units, collecting the purchased-events information for each subscriber. The data collection process is fully automatic, so data collection on the hybrid version of PULSE can be done in telephone system off-peak hours. Each PULSE unit has a low-cost Bell-103 modem built in. Thus, hybrid PULSE is compatible with any phone system in the U.S. Installed subscribers' BA-5000/PULSE units are, in succession, commanded to initiate a telephone call from the subscriber's home to the operator's controller. During that call, PULSE's stored information is forwarded to the controller.

Using the downstream addressable communications channel associated with the BA-5000, each PULSE unit also can be issued a 'credit limit' from 0 to 20. This is a security measure, enabling the operator to have full control of his 'exposure' at any time with any subscriber. Within the data collection cycle, PULSE will not allow a subscriber to purchase more IPPV programs than his limit.

With PULSE's 'store and forward' approach, the phone system capacity required is only a fraction of that needed in 'order-taking' approaches to pay-per-view. Since order-taking mandates that each subscriber program request be handled individually by the operator, a large quantity of phone lines is required to be ready for a possible flurry of last-minute ordering.

Also available in the PULSE system are 'snapshot registers.' The controller

The rapidly expanding personal computer market has fostered a new breed of 'hi-tech' individuals who potentially pose a threat to system security.

can issue a global command to all converters instructing them to 'take a snapshot' of the current viewing status of all PULSE subscribers at that instant, for collection later. Five such snapshot registers are available. One practical application is the gathering of viewing statistics of subscribers for the purpose of determining Nielsen-type program ratings.

Another application of snapshot registers is 'commercial effectiveness measurement.' When viewers are bored with a commercial, they frequently tune away for awhile to see what is being shown on other channels. Three successive snapshots, taken at the beginning, middle and end of a commercial, would quantify this phenomenon for any particular commercial announcement.

PULSE also allows subscriber response applications. Among the data stored in each snapshot is a single-digit 'response' which the subscriber may have entered just prior to the snapshot global command, perhaps in response to a query during a TV program to: "Press response #1 to receive more information about this offer." In this application, the BA-5000 LED display actually shows the subscriber's response selection until BA-5000/PULSE sees the global 'snapshot' command. The global causes the response digit to be 'cleared' on the display. This technique gives the subscriber the perception that his response is actually being collected at that instant, i.e. on a real-time basis.

A good IPPV system must be able to provide an operator with the ability to convince subscribers that operators are fully aware of what IPPV programs they purchased and for how long.

The rapidly expanding personal computer market has fostered a new breed of 'hi-tech' individuals who potentially pose a threat to system security. Low-cost techniques of asynchronous data communication through telephone lines are now quite well known. Accordingly, there is substantial concern about the potential for IPPV programming theft.

Consider a potential 'record-and-playback' cheating method, for example. A hybrid cable/telco PULSE subscriber could view no programs during a data collection cycle, then 'record' the "no IPPV viewed" upstream data message placed on the phone line by his PULSE unit at the end of that cycle. In the subsequent cycle he might view many IPPV programs, believing that he'll ultimately be able to simply 'play back' the previously recorded "no IPPV viewed" message to the controller to avoid being billed.

Several provisions in the PULSE system would foil such a cheating attempt. First, the system employs a two-way handshake on the phone line, which would be missing. In addition, the controller echoes data received from PULSE units, back downstream on the cable plant, for confirmation. Further, the 'credit limit' function would eventually be exceeded in the subscriber's PULSE unit, preventing him from viewing additional programs until his viewing data is actually collected.

The experience gleaned by Pioneer in its years of supplying the two-way IPPV terminals for QUBE also is relected in the PULSE system's provisions for dealingwith subscriber billing disputes. The most common causes of such disputes with IPPV programs have proven to be:

- an unsuccessful attempt by the subscriber to evade monitoring by the controller/computer.
- a subscriber's claim that the TV was on and tuned to an IPPV program, but no one was viewing it.
- a subscriber unknowingly tuning into an IPPV program.
- 'chain billing,' i.e. a subscriber failing to detune from an IPPV channel at the end of a purchased program and, thus, being billed for subsequent programs on the same channel.

Provisions to contend with such eventualities in the PULSE system include the AUTH button, a standard feature that appears both on the set-top and handheld remote control portions of the BA-5000. Figure 2 explains how the AUTH button is an integral part of the 'foolproof' process by which a subscriber purchases an IPPV program. Experience has shown that the buy process can be simple for the subscriber, yet the majority of billing disputes (and, thus, the costly CSR overhead associated with them) are totally avoided using this approach. The 'authorize channel' in this process is simply a locally originated character-generated channel, the frequency of which can be chosen by the operator and downloaded to all converters with other system parameters.

When the subscriber selects an IPPV program, his BA-5000 LED display shows the number of the channel he is requesting, but the converter actually tunes to the 'authorize channel'—presenting a message (like that shown in Figure 2) to the subscriber. Only when the subscriber proceeds to press the AUTH button does the converter actually tune to the event, and the PULSE unit record the program as having been purchased. Thus, the AUTH button provides a very positive indication of the subscriber's purchase—something a subscriber would find difficult to argue could happen 'accidentally' in a billing dispute. From the subscriber's viewpoint, pressing the AUTH button is equivalent to having purchased a ticket to the event.

But what about the subscriber who admits he knowingly purchased an IPPV program, but claims he was quickly very disappointed and, therefore, contends he's entitled to a refund? Is he lying or telling the truth? PULSE handles this eventuality by reporting to the operator how long each purchased event was viewed. The subscriber's PULSE unit monitors the first 15 minutes of each purchased IPPV program, accumulating the amount of time the converter is tuned to that program. A subscriber complaining he didn't like the program, but spent 15 or more minutes viewing it, would be on pretty shaky ground.

Billing disputes arising out of 'chain billing' are not possible with the PULSE system, even in back-to-back programs, because every time a program ends the in-band 'event ID' changes, causing the BA-5000 to restart the 'authorize' process.

The billing-related functions of an IPPV system are a very sensitive issue among operators—and rightfully so. Should he make access to IPPV channels too restrictive, the potential for impulse buying is lost. Should subscribers discover a good billing argument due to the system's weakness, the word soon gets out to other subs and the problem mushrooms. A good IPPV system must be able to provide an operator with the ability to convince subscri-

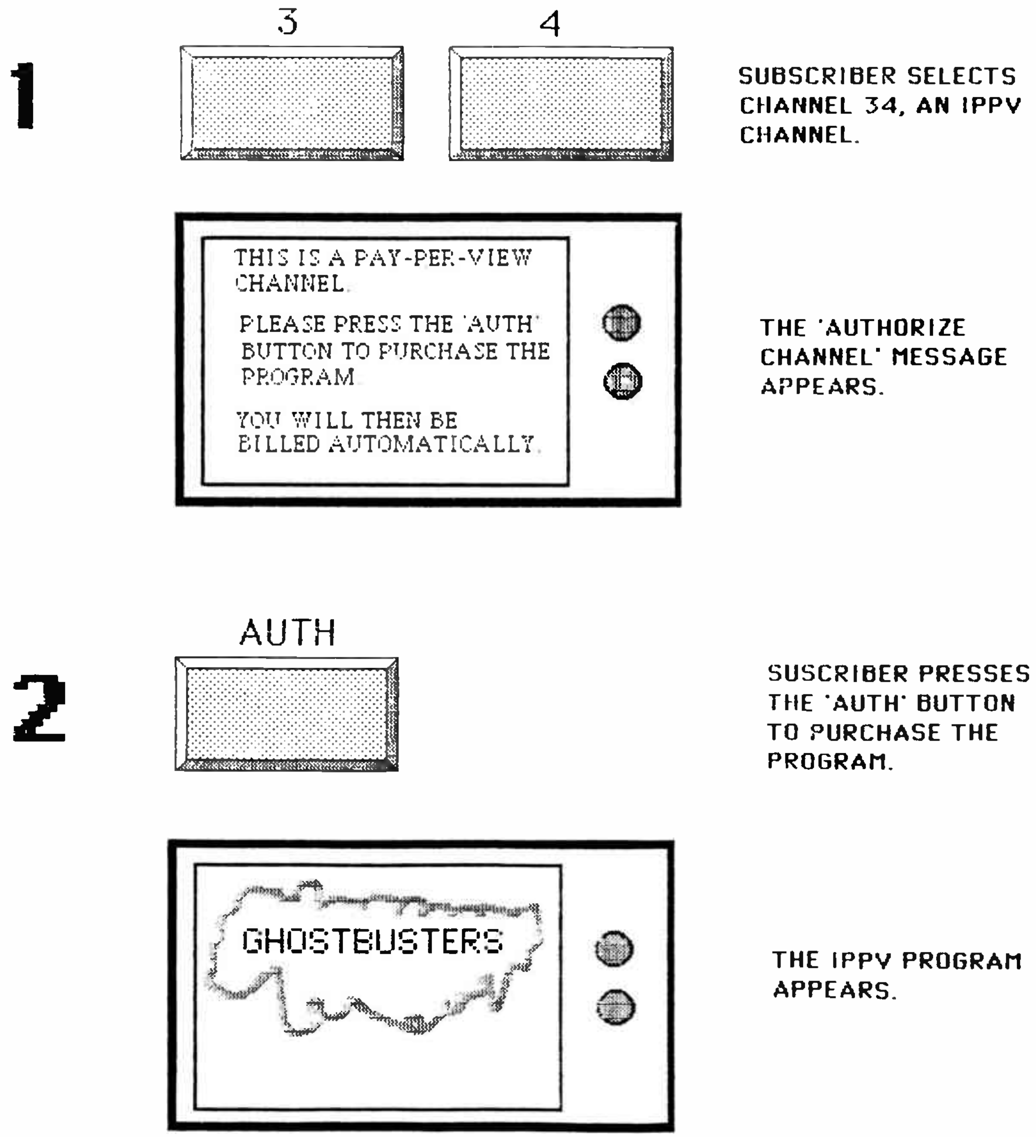

Figure 2 Subscriber purchase of an IPPV program

bers that operators are fully aware of what IPPV programs they purchased and for how long.

Other PULSE features

Among the unique convenience features in the BA-5000/PULSE system is 'purchase while absent' capability, likely to be popular with the rapidly expanding base of subscribers owning VCRs. All BA-5000 one-way addressable systems have a 'program timer' integral to the set-top unit, which functions similarly to the timer on most VCRs. Once PULSE has been added in the home, the functionality of this feature is carried one step further: The converter actually can be programmed by the subscriber in his absence for recording on his VCR. Essentially, this amounts to the converter having the ability to self-authorize a channel, i.e. bypass the need for depressing the AUTH button to buy a program. This self-authorizing capability is restricted to only one IPPV program each time it is used, again to prevent chain billing disputes.

Pioneer's earlier two-way systems for the Warner Amex QUBE systems used terminals with volatile memories employing P-MOS and N-MOS technologies. Although they were state of the art at the time, they required very high-speed 256k bit-per-second two-way communication between controller and terminals to collect subscriber data on a real-time basis. But with the availability of new non-volatile memories such as the EAROM and battery backed-up CMOS devices, the need to poll all subscribers at such a high rate, and to contend with all the resulting data, has disappeared.

Store and forward technology takes full advantage of the new devices available, provides improved protection from theft-of-service and tremendously reduces the amount of data with which the operator must contend to provide IPPV service.

Pioneer's BA-5000/PULSE implementation of this technology, with its drastically lower rate of data collection, offers cable operators affordable IPPV capabilities as part of an integrated addressable system with many practical, built-in IPPV features designed around Pioneer's eight years of experience supplying IPPV-capable converter systems. CED

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Reader Service Number 24

OUTAGE CONTROL

Part Two

By Roy Ehman,
Vice President Engineering,
Kentucky Region,
Storer Communications

Last month, we talked about fuses and standby power supplies and their impact on outage control. A few final thoughts on this before we move on. Some standby power supplies have the fuses or breakers in the secondary (60 volt side)—probably to protect the supply because their transistors will be destroyed if they see a short. If this is your situation, it's time to upgrade! This is particularly true of the critical standby power supplies in and around the headends.

An adequate number of supplies is necessary at the headend and outward to keep every spoke of a hubbed trunk alive until the first major split. In our skeleton map (Figure 1), this would involve keeping the plant alive up to and including amplifiers E1, D1 and B3. If some of your services are very critical, you might consider amplifier redundancy for the first few stations out. This could dramatically reduce the amount of plant you would lose in a given power outage. Placing the standby power in or near the headend also enables you to know when it is operating.

Standby power without monitoring often means you will simply have your outage an hour and a half later. A structured program of battery checking and exercise for all standby units is an absolute necessity.

When considering standby power, we also have to think about keeping as much of the headend alive as practical. Smaller headends lend themselves readily to floating on a 24-volt battery for uninterruptible service. Try using two 12-volt motor-home or tractor batteries in series. The charger needs to be a good unit capable of delivering about 20% more than the full battery load at all times. Unfortunately, the right units run to hundreds of dollars, so you might want to try a system that merely switches to the batteries when required. This application only takes a small, inexpensive charger. For larger headends, I recommend a combination of essential modulators and processors floating on battery and the whole (including some cooling) backed up by a generator of suitable size.

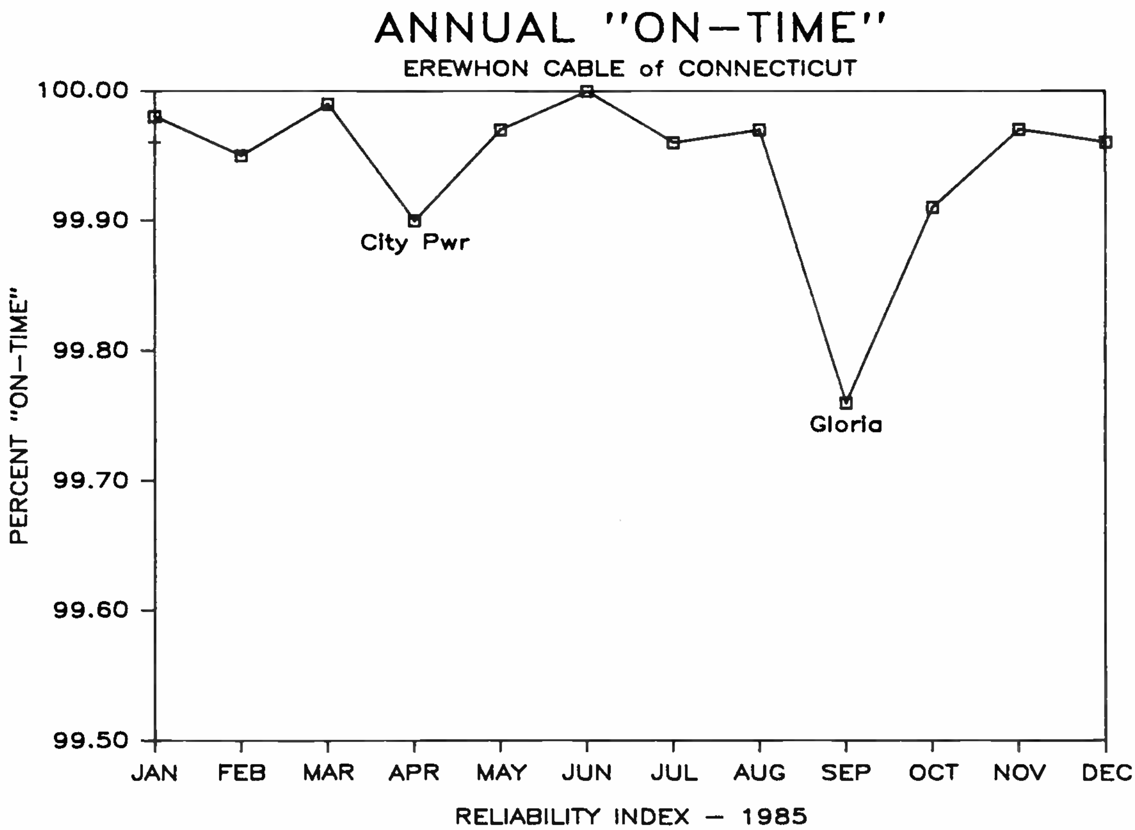
The type of prime mover most likely to start reliably every time is a unit running on natural gas or propane. Gasoline tends to jellify with standing, and diesels can be most intractible when you need them most. If you can get hooked up to the city gas main, you've got it made. But if gasoline or diesel fuel is used, you must have back-up supplies, which can be a storage problem. Whatever backup system is used, the whole outfit must be tested a minimum of once a week for at least 25 to 30 minutes under full load by failing (IE turning off) the primary A/C power. This gives the transfer switch contacts a wipe and time for all mechanical and electrical components to heat up and indicate weakness or failure under controlled conditions when you can still fall back on city power.

How many times have you read on outage reports of long duration: "I used my spare LE module last week" or "Had to borrow an LE from George." Usually not stated is the fact that in the first case the tech probably had to drive several miles through traffic to the warehouse to get another LE or that "George" was 15 miles away. What tends to be forgotten is that after the swap our tech *and* "George" probably are riding around the plant without a replacement LE on board. Worse yet, have you ever read: "I replaced the amp, but my spare was also dead." Bad bench QC! Techs are not always to blame for carrying insufficient or inappropriate replacement material since they frequently are unaware of how much stock they are permitted to have.

A typed list in a durable plastic sleeve should be supplied to each operator showing the number and quantity of the truck stock that is to be carried according to the functions to be performed—such as service calls, sweeping or whatever. An occasional field check of the vehicle and its contents will help raise everyone's preparedness level.

All service and maintenance techs must be fully equipped to handle all emergencies at all times. This includes, among other things, a spare guts for the

Figure 3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Reader Service Number 30

Then there is the area of "after-hours" and weekend deployment of personnel. Outages and major impairments somehow refuse to restrict their occurrence to normal business hours. Answering services, standby duty and the call-out system have all been tried and found wanting in various degrees. Cable television is a twenty-four-hour, seven-day-a-week service; we need to be responsive to the needs of the plant and the public for as great a portion of this time as possible. Obviously, to cover it all would be inefficient, so some compromise has to be found. The following shift schedule, with slight variations, comes close to approximating the ideal and has been employed by a number of advanced systems over the years:

DISPATCH:
Mon.-Fri.—8 a.m. to 11 p.m. or Midnight
Sat. & Sun.—9 a.m. to Noon & 2 to 9/10 p.m.

TECHNICIANS:
Mon.-Sat.—8 a.m. to 9 p.m.
Sundays—9 a.m. to 2 p.m. & 3 p.m. to 6 p.m. + standby

The word "shift" is used loosely and could mean anything from one to several persons depending on system size. This schedule may come as shock to some, but it is easier to accomplish than it looks.

The main dispatch function consists of two shifts with probably a dispatch supervisor/coordinator/trainer working swing-shift to bridge the middle of the day and the changeover period. All will agree with the early start needed to pick-up any overnight recordings or an early morning outage and be up to speed for the day. The late shift is used to cover night problems, trouble calls, outages and complete paper work. The dispatcher has at least one technician at his disposal (depending on system size) during the early evening and the same man, with vehicle, is on call for the rest of the evening. This tech does high priority service calls, such as customers whose service is completely off or totally unwatchable. This is a very rewarding activity and generates a lot of favorable PR but, above all, the evening tech is instantly available, fully equipped and rolling in case of an outage. This is true outage control at its finest—during prime-time when needed most. The weekend dispatch can be handled by one dispatcher or technician plus overtime on a rotating basis.

The cross-training afforded to the personnel in manning dispatch for short periods during light loading is invaluable and should not be neglected since it also provides a source of back-up for vacations and illness and may, on occasion, be a source of qualified dispatch recruitment. An experienced and organized field tech, who would prefer less physically demanding work, often makes a fine dispatcher or dispatch supervisor.

On weekends an attempt is made to keep the dispatch hours within reason —while spreading coverage over as much of the day as possible. The Sunday duty technician can take over for the dispatch lunch hour(s). This breaks up a rather long and lonely day for the dispatcher while extending the coverage hours.

The weekday quitting time for techs can vary according to season and locality. It is often unproductive to be knocking on doors after 9 p.m. except where service is off and the visit has been confirmed by a dispatch phone call.

Notice that a six-day week has been suggested for technical service. This provides the Saturday service which is so essential for the plant and many customers. Here again, outage control is available all through Saturday. Assuming adequate staff to cover the full six days, it still could be unpopular and, therefore, difficult to implement. One creative method of constructing the duty roster which was found acceptable was to have two "long" weeks followed by a four-day weekend.

Measuring outage control

Having done everything in our power to control outages, we now need a convenient and, hopefully, universal way of measuring our performance and comparing it with our previous results and those of other systems. We can do this by generating an "on-time percentage," which could also be called a System Reliability Index (SRI). The SRI is a measure of the continuity of service provided to customers which, in turn, hinges on the vulnerability of the system to outages and the ability of the technical staff at all levels to reduce their number and duration by appropriate plant design and outage procedures. This is also where we are going to use the box (shown in Figure 2) at the bottom of our outage log. (The complete outage log was shown in Part One of this article, October, *CED*, p. 36.)

EXAMPLE: Half the plant is off for 30 minutes. The outage is logged as 50% plant for 30 minutes. For statistical purposes, this could be considered the same as 100% of the plant being off for 15 minutes. We call this process normalizing for 100% plant equivalent.

To properly calculate these normalizations, we will need the skeleton map in Figure 1 showing the amplifiers only. Amplifier numbers are not totally essential in this application,

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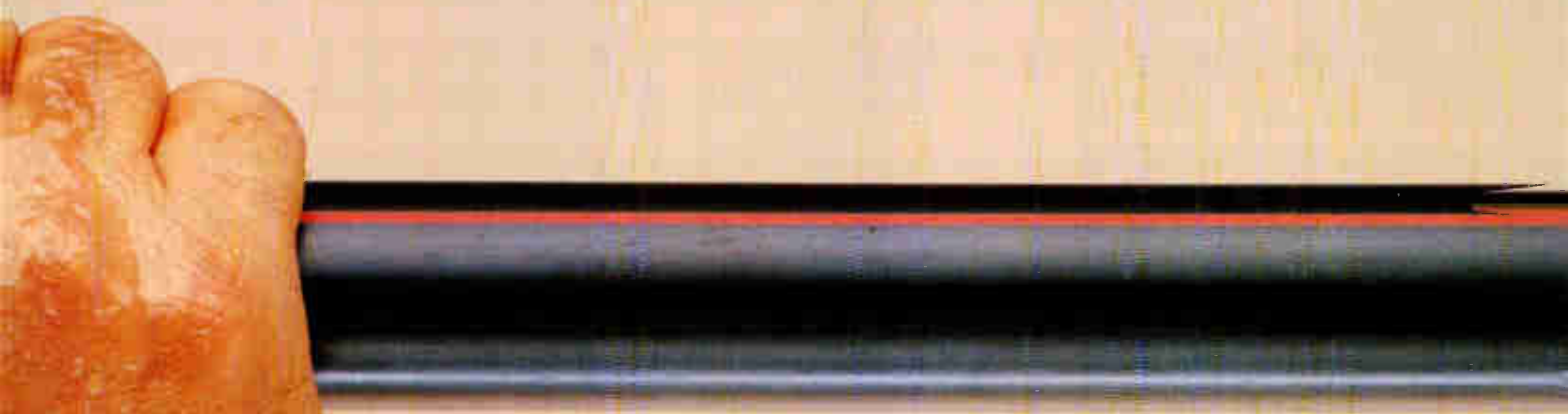

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Reader Service Number 33

In order to reduce the well-documented customer aggravation caused by outages and make our systems more attractive to data/communications services, we need to reduce the quantity and duration of all outages.

but they are invaluable when conducting an outage and for other maintenance considerations. An amplifier tally at the top of each major split is a real convenience for making a rapid count.

The basic problem with outage reporting has always been to equate large or small outages with varying downtimes so they can be added and expressed in a meaningful, industry-wide figure. We can do this by factoring all off-times to what the equivalent would be if 100% of the plant were off.

Here is how to do it in step-by-step detail with an example at each step. It looks kind of complicated, but actually it takes longer to show than to do. The relevant portion of the outage log form is shown in Figure 2 with the example numbers correctly filled in.

1. Determine the DURATION of the outage in MINUTES. This is the time from first awareness of an outage until restoration is verified by phone calls to two or more customers in the area. Let's say the outage started at 16:30 and ended at 17:25. The end time is entered first followed by the start time, making for a simple subtraction giving a duration of 55 minutes.
2. COUNT the number of amps that were "out." Let's suppose there were 77.
3. VERIFY the number of amplifiers in the system. This usually is a fairly constant number. Let's say it's 1,235 amplifiers.
4. NORMALIZE the outage for 100% plant equivalent as follows:

a. $$\frac{\text{NUMBER OF AMPS OUT}}{\text{NUMBER OF SYSTEM AMPS}} \times \text{TIME OFF (min.)}$$

and, using our numbers:

b. $$\frac{77}{1{,}235} \times 55 = 3.4 \text{ min. OFF-TIME (100\% plant)}$$

This little calculation must be done for each and every outage. The partly filled block could well be completed by the night dispatcher but certainly should not be left to the end of the month.

5. At month-end, or whenever your cut-off point is, ADD all the normalized OFF-TIMES together. This gives the total off-time in minutes for the period. Let's assume it totalled 27 minutes.

6. Next, calculate number of minutes in the period to obtain the POSSIBLE ON-TIME.

Example: 31 days X 24 hours X 60 minutes = 44,640 minutes possible ON-TIME

7. Subtract the off-time from the possible on-time to get the ACTUAL ON-TIME.

Example: 44,640 min.—27 min. = 44,613 min. ACTUAL ON-TIME

8. CONVERT this actual on-time to a PERCENTAGE on-time.

$$\frac{44{,}613}{44{,}640} \times 100 = 99.94\% \text{ ON-TIME}$$

This figure is the System Reliability Index—a very valuable tool in assessing system performance and a figure sought after by firms such as MCI, SBS, etc., when looking for systems to carry services other than entertainment.

Evaluating on-time figure

After you have obtained your monthly on-time percentage, it's a good idea to run it backwards to see what it means as a "reasonableness test."

EXAMPLE #1:
System ON-TIME percentage was 99.55%
Off-time = 100% —99.55% = 0.45%

$$\frac{0.45}{100} \times 44{,}640 = 200.9 \text{ min.} = 2 \text{ hrs. } 20 \text{ min.}$$

Does that look good? No, it doesn't. Either the logging or the calculation was done incorrectly or that month was an absolute disaster.

EXAMPLE #2:
System ON-TIME percentage was 99.96%

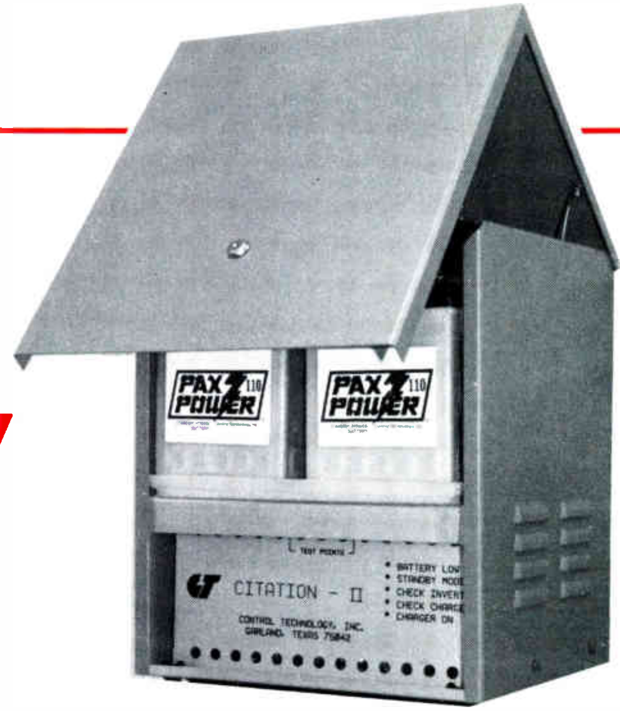
That's simply a way of saying that the 100% plant equivalent was off for 100—99.96 = 0.04% of the time. The time in a month (from above) is 44,640 minutes. So total time off must have been:

$$\frac{0.04}{100} \times 44{,}640 = 17.9 \text{ min., 100\% plant off.}$$

Does that look good? Yes, it's a "good" number. In fact, anything over 99.90% would be good.

Experience has shown that in larger systems, say over 100 miles, only trunk amplifiers need to be counted in the total data base and in the outages. The effect on the monthly on-time is insignificant, and it saves having an unduly large and detailed system skeleton map and much paper work. Outages caused by extenders must, of course, still be reported on the outage sheet and handled just like any other outage. They just do not come into the monthly on-time calculation in either the amplifier data base or the outage amplifier count.

Once you have built up an on-time track record for a few months, it is quite instructive to draw a graph showing the portion from 95% to 100% and add any relevant notations regarding significant



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Reader Service Number 38

dips in performance.

Figure 3 shows such a plot of an actual well-controlled system in Connecticut.

In order to reduce the well-documented customer aggravation caused by outages and make our systems more attractive to data/communications services, we need to reduce the quantity and duration of all outages. Before we can even begin to take action, it is imperative that we, first, log all outages on an on-going basis and, second, that we analyze every outage by problem and possible solution. Without these first two essential steps, we are just shadow-boxing. These procedures will lead us to one or more of the following avenues of improvement:

Frequency of Occurence:

FUSES/BREAKERS

Eliminate or beef up all fuses and circuit breakers to the limit of prudence and legality.

SURGE-PROOFING

Surge proof your system in the trouble spots revealed by analysis using effective (< 2 Ohm) "private" grounds and fast, heavy crowbar or zener semiconductors capable of handling hundreds of amperes for 15 to 50 milliseconds (not microseconds).

STANDBY POWER

As a minimum, install "indestructible" standby power for the headend and the first few trunk amps on each spoke of the trunks. These units must be properly maintained and exercised. Monitoring of at least the first mile of standby is highly recommended. Monitoring the ends of the trunks via return plant or dial-up modem is, of course, the most desirable—but a luxury not all may be able to manage.

IMPACT PROTECTION

Where analysis reveals a repeat occurrence of plant being hit by vehicles or other physical damage, do something positive such as planting four-inch concrete-filled pipes around pedestals or, if worse comes to worst, move the plant!

DURATION

DISPATCH

Create a highly effective, properly equipped, technically oriented dispatch with extended hours.

THE PHONE SYSTEM

Rationalize the phone system so that reception problem calls go directly to dispatch or other experienced, technically oriented personnel who are qualified to walk a customer through reception problems and who can conduct an outage. The telephone directory listing should say "Reception Problems" and avoid the ambiguous word "service."

PERSONNEL

Service technicians need to be dispersed through the system at all times—not "bunched-up." One or more technicians need to be available in the system for extended hours, including weekends, and then on call with their vehicles.

EQUIPMENT

Steps must be taken to ensure that all techs are provided with full, functional truck stock, tools and equipment so they can handle any emergency without assistance or delay.

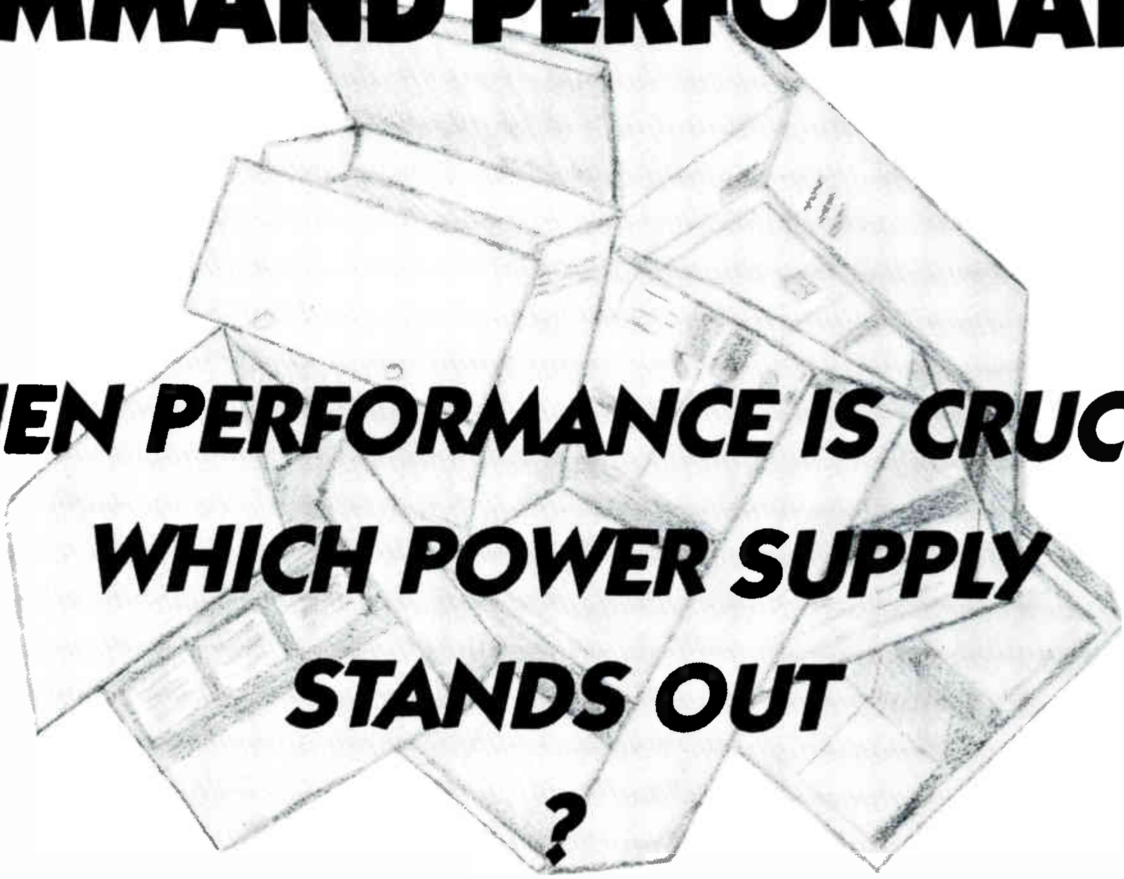
TRAINING

Specialized training in rapid, logical trouble-shooting is needed. On-the-job training, while valuable, may not necessarily lead to correct methodology. A working mock-up-board of the system is a must.

It is clear from the foregoing that the frequency of outages is largely dependent on your plant configuration, whereas the duration can be controlled, to a significant extent, under the general heading of organization.

A good outage control program means happier customers and, in some cases, reduced customer credits. Why not start your program today and begin harvesting its benefits tomorrow—or even tonight! CED

COMMAND PERFORMANCE



WHEN PERFORMANCE IS CRUCIAL WHICH POWER SUPPLY STANDS OUT ?

- Hinged lid
- Easy access battery location
- Spill-guard battery trays (available)
- Insulated shelf for battery protection
- Modular construction
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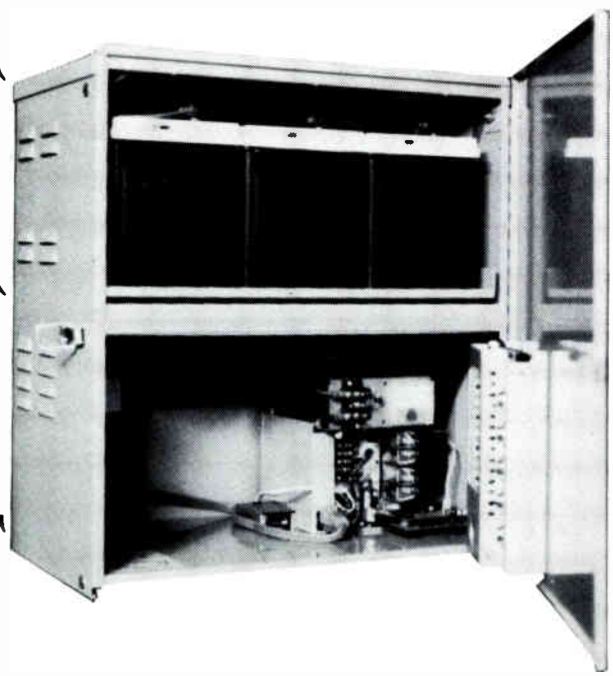

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Spectrum analyzers in CATV measurement systems

By Tom Babb, Owen Brown and Debbie Overberg, Hewlett-Packard Co.

The challenge to provide quality service for cable television subscribers grows as CATV systems expand their capabilities. With more channels, wider bandwidths and two-way cable communications to handle, the test equipment of operating companies and manufacturers alike must offer better performance and greater versatility than in the past. The spectrum analyzer, a general-purpose communications test instrument, is an ideal tool for making many of today's CATV test measurements.

We recently had the opportunity to perform a number of CATV system measurements at Total Television of Santa Rosa, the Capital Cities TV franchise in Santa Rosa, Calif. This 12-channel franchise was founded in 1964. In 1981 it expanded to 36 channels forward and 7 channels upstream. In the process, the system engineer's test-equipment requirements increased. The test measurements we made at Total Television using a spectrum analyzer are among the many that now must be performed frequently to ensure good service for customers. The tests included maintaining proper amplitude levels of all carriers, in both absolute and relative terms, as well as measuring the various types of interference: cross-modulation, double and triple beat, intermodulation, co-channel and radiation. In addition to the tests we performed, diagnostics and troubleshooting of system components also can be performed rapidly with the analyzer.

The measurements we discuss were made on Total Television's system using the HP 8558B spectrum analyzer plug-in with the portable HP 853A digital display mainframe. Annotation was provided with an HP-75C calculator and results were plotted on the HP 7470A. Reviewing the spectrum analyzer block diagram in Figure 1 shows the similarity to the dedicated selective level meters also used to test CATV systems. Both use the superheterodyne receiver technique found in simplified form in AM radios. The spectrum analyzer, however, can display multiple channels simultaneously to the operator and demodulate the video signal as well as monitor single channels.

The superheterodyne receiver technique provides a mixer and local oscillator (LO) to convert the incoming signal to a fixed intermediate frequency (IF). The signal then is detected and displayed. The conversion process defines the tuning equation as follows:

If $f(s) < f(LO) - f(IF)$, then
$f(s) = f(LO) - f(IF)$

Where $f(s)$ = input signal frequency
$f(LO)$ = oscillator frequency
$f(IF)$ = intermediate frequency

For example, if the IF is 2,000 MHz and the LO tunes from 2,000 to 3,500 MHz, the analyzer has a 0 to 1,500 MHz tuning range. If a signal up to 400 MHz is present at the analyzer input, then a signal will appear on the display when the LO frequency is 2,400 MHz.

The swept-frequency display of the spectrum analyzer is made possible because the local oscillator can vary in frequency, allowing the analyzer's tuned frequency to be swept through a broad frequency range. This is accomplished by supplying a ramp voltage (or current) to the frequency control element of the local oscillator (LO). The same ramp voltage also controls the horizontal CRT deflection to provide synchronization between LO sweep and displayed frequency.

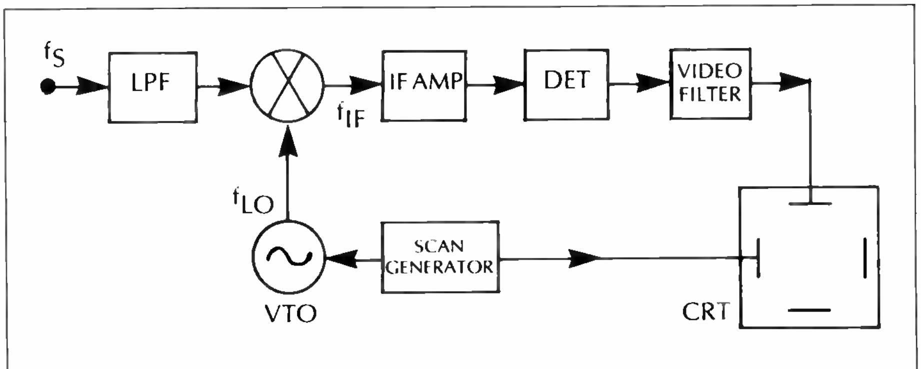

Figure 1

Block diagram of a swept superheterodyne spectrum analyzer. The input signal is mixed with a tuned LO frequency to produce a fixed IF which can be detected and displayed.

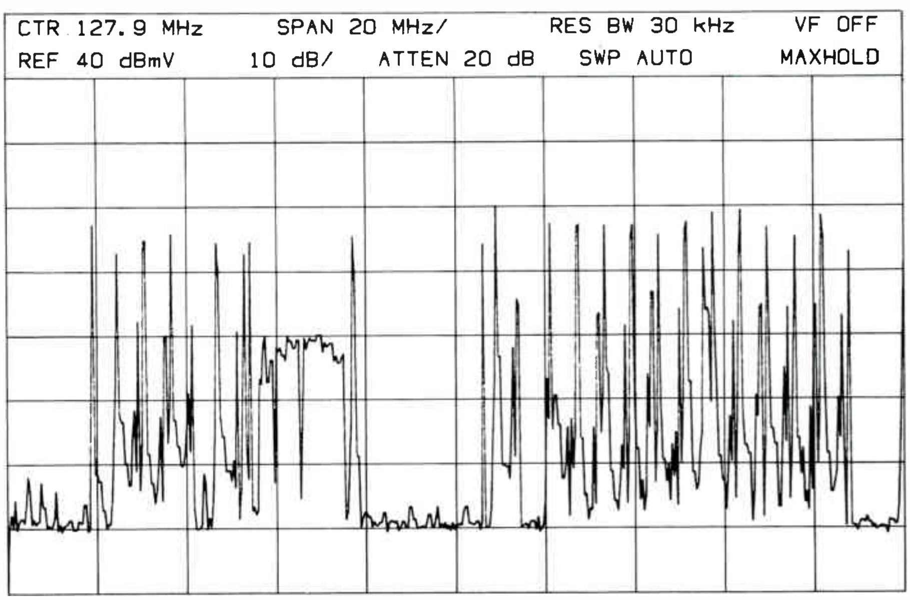

Figure 2(a) Class 1 broadband spectrum

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Multi-channel analysis

A major contribution of the spectrum analyzer to CATV maintenance is its facility for quick multi-channel analysis. Consider, for example, the 36-channel system at Total Television. All channels measured must be at the normal 0 dBmV absolute power level, while adjacent channels must be within 3 dB of each other (NTSC U.S. Standards).

Having similar channel levels prevents wide variations in picture quality. Too small a signal causes picture dropouts; too strong a signal causes compression, adjacent channel interference and radiation problems. The measurement illustrated in Figure 2 was easily performed on both Class 1, standard DBS programming, and Class 2, specialized programming, each with a single sweep of the spectrum analyzer.

A related measurement, field strength, entails testing of the video carrier amplitudes at the far reaches of the cable system trunks, where signal losses are greatest. The spectrum analyzer can perform this measurement with relative rapidity. As it can sweep throughout the cable TV spectrum, there is no need to tune and re-tune to each channel. The measurement can be made in a few sweeps lasting approximately three seconds each.

Single-channel analysis

A multi-channel analysis as described above could alert an operator to problems in a particular channel. With a spectrum analyzer, the operator can move directly from measuring the system as a whole to measuring a single channel merely by centering the channel of interest in the spectrum analyzer's display and narrowing the span and resolution bandwidth until the channel fills the display. The video and audio components of that particular channel then can be measured for proper relative amplitude levels.

Carrier-to-noise

In single-channel testing, some measurements are of particular importance. The carrier-to-noise measurement, for instance, is a figure of merit for the overall channel performance. The noise contributed by the system directly affects picture quality, showing up as "snow." The higher the C/N ratio, the better the picture. In the logarithmic display on the spectrum analyzer, this ratio is simply the difference between the peak video carrier value and the noise level referenced to the proper bandwidth (4 MHz for NTSC). The full carrier amplitude is obtained by widening the analyzer's resolution bandwidth to encompass the significant video sidebands; typically 100 kHz is used, as shown in Figure 3. Accurate noise measurements are assured by using a preamplifier such as the HP 8447A in front of the analyzer. A 10 kHz bandwidth is used for measuring noise. The appropriate correction and normalization factor given in Table 1 then is applied to the difference.

Double and triple beat

Intermodulation distortion products can be found anywhere in the channel spectrum. These are caused by the sum and difference frequencies of the numerous carriers generated in the amplifiers. The number of potential intermodulation products increases dramatically with increased channel capacities. Amplifiers have improved significantly, suppressing these higher-order modes, but second- and third-order products, sometimes called double and triple beat, continue to cause problems.

The sum or difference of two frequencies is the second-order product, called double beat. Similarly, the signal resulting from the sum or difference of any three frequencies is the third-order product, known as triple beat. The easiest method for detecting triple beat is simply to tune to a channel and use a narrow (10 kHz) bandwidth to decrease the noise, then to look for any spurious

Continued on page 82

Off-premises addressability

System design and operational considerations

By Joseph Preschutti,
President,
E-Com Products Division,
AM Cable TV Industries Inc.

Off-premises jammer systems have been receiving higher interest because of the intangible benefits associated with improved customer satisfaction: the use of VCRs, multi-channel sound, additional outlets for extra TVs and FM radio, etc.

This article describes system design concepts required to deploy the off-premises Tier Guard System in a variety of CATV applications. Differences from traditional tapped feeder concepts are highlighted. In addition, financial models for initial installation costs and operational benefits are provided, showing the Tier Guard System to be a cost-effective design concept in a variety of systems including urban, suburban, rural, new build, rebuild and upgrade situations.

System design

A cost-effective system design that takes full advantage of the characteristics of off-premises addressable equipment must take into consideration design rules and concepts that are different from the standard tapped-feeder concepts used in a traditional broadband system. Several categories of inherent differences are indicated, namely the clustering or grouping of outlets to take advantage of shared electronics, the resultant longer drops produced by this type of cluster design, powering methods and costs and, most importantly, limited deployment of active electronics.

The purpose of a traditional broadband system design approach utilizing low-cost directional taps is to, at minimum, provide an outlet for every potential subscriber. The use of standard directional tapping devices in configurations having two, four and eight outlets results in deployment of 115% to 125% of outlets as a percentage of homes passed. This is a naturally cost-effective system design since the cost per port for a standard directional tap is very low.

The cost per port of an off-premises addressable system such as the Tier Guard System is quite low compared to an addressable converter or an off-premises addressable tuner. Consider, however, a hypothetical system design that treats the Tier Guard tap as a standard tap in a system that, for example, has 60% penetration and 120% deployment of outlets. This would result in deployment of two outlets for each subscriber and would double the cost of the Tier Guard implementation. This is clearly an undesirable situation.

A system design technique that achieves 70% to 80% utilization of deployed ports was devised to overcome this situation. An explanation of the concepts underlying this system design technique along with the advantages and disadvantages follows.

Figure 1 shows a sample design area with 21 homes passed, 14 subscribers and six four-port taps allocated.

Figure 2 shows the same area with the Tier Guard off-premises system deployed with the following results:

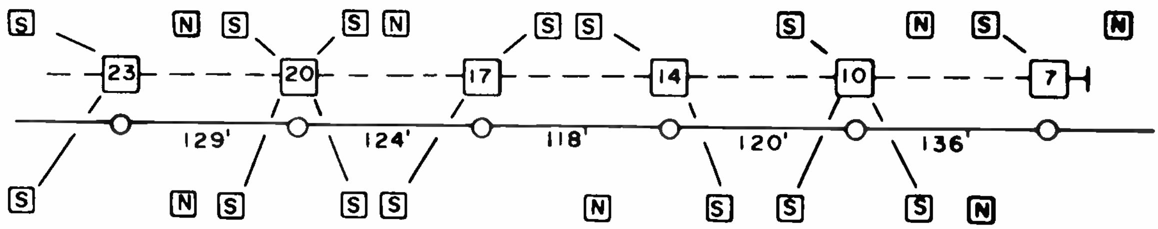
- End of feeder is reduced by one span.
- Two active locations are utilized instead of six.
- Sixteen ports are allocated to serve fourteen subscribers.
- Two blank plate (TGT-0) locations are available for further expansion.

Several advantages are presented by this system design concept:

Efficient port usage. Deployment of active electronics and efficiency of active port usage is optimized, reducing installation costs.

Increased system reliability. The shared electronics have reduced the number of active components in the system and reduced the number of serially connected devices in the feeder.

Figure 1
Traditional tapped feeder



S = SUBSCRIBING HOUSEHOLD
N = NON-SUBSCRIBING HOUSEHOLD

PORTS ALLOCATED = 24
HOMES PASSED = 21
SUBSCRIBERS = 14

Lower tap losses. This particular example shows a loss of 1.2 dB per TGT or 4.8 dB passive loss. The traditional passive losses in Figure 1 total 8.6 dB without the terminating 7 tap! This increases the efficiency of line extender use in the system.

Lower cable-bearing strand footage. The result of reducing each and every end of feeder in the system by one span has a dramatic effect on reducing cable-bearing strand footage and reducing installation costs.

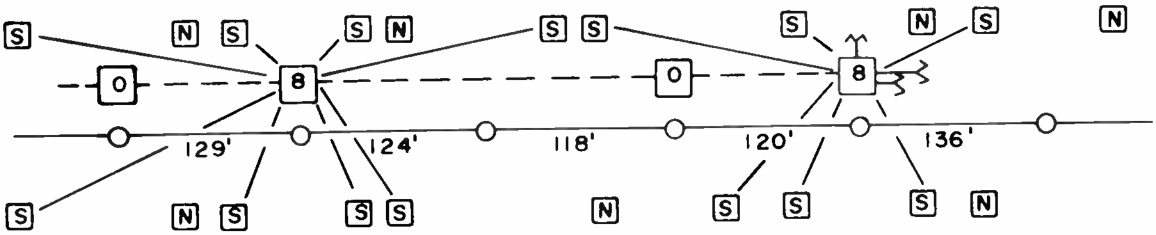
Lower passive installation costs, fewer connectors. As demonstrated by the examples presented in Figures 1 and 2, the traditional design required installation of six passives, one at each pole, while Tier Guard off-premises design required installation of four passives for the same feeder. This results in lower installation costs for the passive themselves and use of fewer connectors.

There are several limitations in this system design technique that should be identified by the system designer:

Longer drops required. In order to take advantage of the shared electronics of the Tier Guard System, the subscribers must be served from more concentrated tap points. As can be seen in the example, instead of providing services for two, three or four subscribers from each of six poles, active TGTs are deployed on a limited basis at only two locations. Service that would traditionally be provided from the poles adjacent to the Tier Guard tap must be handled by running an extended drop. The installation and materials cost for the longer drops must be added to the initial system installation cost for the Tier Guard system.

Added power supply costs. The Tier Guard is capable of being powered from the feeder system or, optionally, by the drops. Since the Tier Guard tap power consumption is quite low (14 watts for a TGT-8), powering from the feeder system is preferred. In this case, the initial installation costs will be in-

Figure 2
Tier Guard tap feeder design



creased by the added costs of power supply locations. A rough estimate of the number of additional power supplies required when using the Tier Guard System can be calculated based on the following assumption for a moderately dense system of about 100 subscribers per mile:

- ♦ 70% efficiency of power supply use
- ♦ 900 watts available from the power supply location (60 volts at 15 amperes)
- ♦ 42 poles per mile
- ♦ 14 Tier Guard taps per mile (one every third pole)

With the above conditions and further assuming that the powering system will be current-limited, not voltage-limited, 640 watts of power is available to power the Tier Guard system. At 14 watts per Tier Guard tap, 45 taps may be powered from a single power supply location. Assuming 14 active taps per mile, an additional power supply will be required every 3.2 miles of cable-bearing strand plant.

For those systems employing standby power, the cost of added power supplies might be reduced by using standby power on the trunk with traditional supplies in the feeder area.

Summary of Tier Guard System design rules:

1) Deploy TGT-0s throughout the system, assuming each tap will be capable of providing an outlet for eight subscribers. This typically will result in 50% to 65% of the poles in the system having the capability to provide active TGT outlets. This will result in potential outlets for 100% of homes passed.

2) Populate only those TGTs required to service the projected penetration. Typically, this will require active TGTs at only 50% of the locations indicated above or, in other words, an active Tier Guard tap at every third pole in the system.

3) An objective for the system designer should be to achieve a minimum of 70% efficiency in active TGT port deployment. That is, seven out of every ten active TGT ports deployed should be used.

The specified output level of the TGT is +15 dBmV at the highest frequency. This limits long drop lengths using RG-6 to approximately 300 feet. If the designer places TGT-8s optimally so that full reach is achieved in both directions along the feeder line, the minimum number of TGTs that can be deployed is about 10 units per mile. In systems that have only 30 or so subs per mile, efficient deployment of the system will rely on implementing system design techniques that minimize the number of TGTs required by extending the length of the drop. Two methods have been investigated:

- ♦ Use of a "Booster Amplifier" of a low cost variety which will allow drop levels to be increased to +23 dBmV in long-drop situations.
- ♦ Use of 0.412 inch backfeed cable to lower the insertion loss of the drops.

Both of these alternatives have been selected by designers of off-premises systems using TGT.

The replacement, on a one-for-one basis, of existing taps with either a TGT-0 or an active TGT is a straightforward matter. The option to relocate line extenders remains with the system designer. In a system that is already over-extended (three extenders or more in series), it is possible to take advantage of TGT to reduce the number of extenders, increase reliability and reduce the maintenance costs. On the other hand, the designer may choose to leave intact existing line extender locations.

Upgrading with TGT theoretically requires extending the drop length of approximately two-thirds of existing drops to cluster existing subs for more cost-effective deployment.

Calculating installation costs

In projecting the cost to deploy the Tier Guard System, the designer must consider several parameters. New systems, rebuilds and upgrades each have requirements that will affect system design, installation and deployment tactics. This section attempts to model the new-build situation and presents the variables that change the model for rebuild and upgrade scenarios.

In order to accurately predict the installation cost of the Tier Guard Systems in a new build, it is necessary to quantify the following parameters;

1) Homes passed per mile
2) Projected penetration
3) Number of TGT-0s deployed
4) Number and value of active TGTs deployed (TGT-4, TGT-6, TGT-8)
5) TGT-0 installation costs
6) Active TGT installation and activation costs
7) Added costs of longer drops
8) Added power supply costs
9) Number of "plain vanilla" converters used taking into account cable-ready sets.

In order to compare the installation costs of the Tier Guard System to a set-top addressable system, the following additional factors need to be quantified:

1) Lower distribution system costs with TGT because of lower cable-bearing strand footage, fewer taps, fewer extenders, fewer connectors, etc.
2) Number of addressable set-top converters used, taking into account how basic subs are provided service, addi-

tional outlet requirements and inventories, etc.

3) Use of "plain vanilla" converters.

4) Although a significant number (about one-third) of the total drops in the system are standard length, about two-thirds of the total will be longer than normal. Some of these longer drops will require a complete span to the adjacent pole location (about 50%) while the remainder can be handled by a half-span extension in drop length. Both material costs and added labor costs must be considered.

5) The effect of the savings produced by fewer taps, lower strand footage, lower passive installation costs plus cost adders on the distribution plant including additional power supply costs are detailed for a specific design example at the end of this paper.

Operational benefits

Off-premises equipment should be deployed in many systems for reasons that vary in importance, depending on the unique characteristics of the individual system. The primary operational cost benefits which may be calculated directly from data available from operations are:

- Reduction in theft or service losses.
- Reduction in hardware losses.
- Reduction in churn losses.
- Reduction in equipment repair costs.

In some systems the payback associated with only one of these benefits will justify the off-premises approach. In most systems a combination of these items will produce significant operational improvements which should be analyzed when a new build or rebuild of a system is being planned. A payback model for each of these benefits is presented in the following sections.

One of the valuable benefits of an off-premises system is the increased revenues that can be generated by eliminating theft-of-service and converting non-paying subscribers to paying subscribers.

The following model calculates theft-

of-service benefits on a per-subscriber basis using the initial subscriber count before service theft is eliminated as a basis. The following parameters are used as required data for the calculation:

Parameter	Equation Variable
Homes Passed per mile	HP
Penetration, %	PEN
Illegal connections, % of HP	ILL
Illegals caught, % of ILL	CAUGHT
Illegals converted, % of ILL	CONV
Average takeout/ sub/month, $	TAKEOUT

The number of converted subscribers per mile is calculated as follows:

$$(NEW) = (HP)\times(ILL/100)\times(CAUGHT/100)\times(CONV/100) = \text{new subs/mile} \quad (1)$$

The additional revenue per mile per year generated (NEW $) is calculated as follows:

$$(NEW\ \$) = (NEW)\times(TAKEOUT)\times 12 = \$\text{Mile/year} \quad (2)$$

This additional revenue (based on original subscriber count) is as follows:

$$\$/sub = (NEW\ \$)/(HP)\times(PEN/100) \quad (3)$$

Theft of Service Example #1 (High Theft):

The following example presents an actual system which has a high theft-of-service problem, with the following parameters:

PEN	=	17% existing subscriber penetration
ILL	=	30% illegal connections
CAUGHT	=	100%
CONV	=	50%
TAKEOUT	=	$20 average per subscriber per month

Justification for an off-premises TGT system installation is almost completely based on projected cash from improving penetration from 17% to 32% as follows:

(NEW) = (220)x(30/100)x(100/100)x(50x100)
= 33 subs per mile

(NEW) = 33x(20)x12 = $7920/mile
$/sub = $211.76 per existing sub per year!

Theft of Service Example #2 (Average Theft):

The previous example was an extreme (but real) situation in a problem system. An "average" urban system is presented below with the following numbes:

HP	= 220 homes/mile
PEN	= 50% of HP
ILL	= 10% of HP
CAUGHT	= 100% of illegals
CONV	= 25% of those caught
TAKEOUT	= $25/month

Figure 3
Tier Guard cost comparison versus addressable set-top urban system

SYSTEM INFORMATION	
Homes Passed	225.00
Penetration, %	45.00
Subscribers	101.25
Additional Outlets, %	20.00
Cable Ready Sets, %	20.00
Poles per Mile	42.00
Truck Roll Cost, $	25.00
Avg. Sub Bill/Month, $	25.00
Hardware Theft, %	15.00
Service Theft, % of HP	10.00
% Illegals Converted	25.00
Disconnects, %Subs/year	10.00
New Connects, %Subs/year	2.50
Reconnects, %Subs/year	7.50
Upconvert Pay, %Subs/year	10.00
Downconvert Pay, %Subs/year	10.00
ADDRESSABLE SET TOP INFORMATION	
Addressable Price, $	100.00
Inventory, %	10.00
Failure Rate, %/yr.	15.00
Repair Cost, $	20.00
Customer Deposit, $	30.00
PLAIN CONVERTER INFORMATION	
Converter Price, $	40.00
Inventory, %	10.00
Failure Rate, %/yr.	15.00
Repair Cost, $	11.00
Customer Deposit, $	30.00
TIER GUARD INFORMATION	
TGT Price, $	
TGT-8	590.00
TGT-6	550.00
TGT-4	510.00
TGT-0	40.00
TGT Inventory, %	5.00
Failure Rate, %/year	3.00
Repair Cost, $	30.00

In this case:

(NEW) = 5.5 new subs/mile
(NEW $) = $1,650 per mile
$/Sub = $12.50 per existing sub per year

In this "average" case, the improvement in revenue brought about by an off-premises system is still substantial, but one must also look at other areas for additional operational savings in order to justify deployment.

The reduction in hardware losses when comparing on off-premises system to a set-top addressable system is a function of two elements:

1) The cost of in-home electronics is substantially reduced by the difference in cost between a "plain vanilla" converter and an addressable converter ($40 versus $100).

2) Converter deposits represent a much larger proportion of total exposed cost. For example, with a $25 deposit, the exposure to a converter theft would be as follows:

Plain vanilla = $40—$25 = $15
Addressable = $90—$25 = $65

In other words, with a reasonable deposit on in-home electronics, the exposure to theft of equipment with off-premises equipment can be a fraction of the exposure with an addressable converter system.

Assuming a 15% hardware loss for theft-of-service, the following calculations can be made for the "average" urban system, taking into account an additional converter needed for additional outlets and no converter needed for a TGT system with a cable-ready set.

HP	= 220 homes/mile
PEN	= 60% of HP
LOSSES	= 15% of equipment annually
DEP	= $25 deposit on converters
% ADD	= 20% additional outlets
% Cable-ready	= 30% cable-ready sets

Hardware loss, set-top addressable:

#Converters lost per mile = (HP)x(PEN/100)x (LOSSES/100) x(1 + ADD/100)
= (220)x(0.6)x(0.15)x(1.2)
= 23.76 lost converters/mile/year

$ lost/mile = $23.76x($90—$25)
= $1,544.40 per mile per year

Or, on a subscriber basis.

$ lost/sub/year = $11.70/sub/year

Hardware loss, TGT:

$Converters lost/mile = (HP)x(PEN/100)x (Losses/100) x(1 + ADD/100)x(1—cable loss/100)
= 16.63 lost plain converters/mile/year

$lost/mile/year = 16.63x($40—$25)
= $249.48

$lost/sub = $1.89/sub/year

Hardware loss savings:

This represents on operational savings of $11.70—$1.89 = $9.81 per sub per year!

Churn analysis

Many systems have unusually high churn because of the nature of the community. Classic examples include resort

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communities, university communities and the like. The off-premises Tier Guard approach has been, so far, universally advantageous in each of these types of communities analyzed to date.

Several transactions need to be identified in analyzing what this article defines as churn. These are:
1) Disconnects
2) New Connects
3) Reconnects
4) Upconverts—to add a pay channel
5) Downconverts—to delete a pay channel

When comparing the TGT system to addressable set-top systems, the primary benefits of the TGT system are obtained by eliminating truck rolls for disconnects. When considering the TGT system instead of a trapped system in high churn environments, the reduction in upconverts and downconverts along with disconnects must be determined.

One of the key system operational strategies that should be employed in reducing the costs of churn with the TGT system is elimination of the need to make a service call to collect the converter. Since homes with cable-ready sets require no converter (the penetration of cable-ready sets will increase continuously in the future), this type of subscriber naturally does not require a truck roll. Since a "plain vanilla" converter is used in homes without cable-ready sets, it is assumed that a modest deposit will provide adequate incentive for an effective converter return policy.

Neither upconverts nor downconverts of pay channels require truck rolls with either a TGT or an addressable set-top system. Also, quite naturally, a new connect requires a truck roll with both systems. The key to a comparison in the operational costs of these two types of systems relies on comparing disconnect and reconnect losses.

The data required to calculate the operational benefits in this case are:

Parameter	Equation Variable
Homes Passed per mile	HP
Penetration, %	PEN
Illegal connections, % of HP	ILL
Illegals caught, % of ILL	CAUGHT
Illegals converted, % of ILL	CONV
Average takeout/sub/month, $	TAKEOUT

Disconnect Costs

Since the disconnected subscriber generally is not a cooperative one, it is assumed that an average of 1.9 truck rolls/disconnect are required to retrieve the set-top addressable box, while no truck roll is assumed for the TGT system.

The following is an example of a typical urban system:

HP	=	220 homes/mile
PEN	=	60% of HP
DISC	=	20% of subscribers
ROLL	=	$25

The calculation for the churn benefit on a per-subscriber basis of the TGT system is as follows:

$$\text{Churn Benefit} = \frac{[(HPxPEN/100)x(DISC/100x1.9)x(ROLL)]}{(HPxPEN/100)} = (DISC/100)x1.9x(ROLL)$$

The first conclusion is that this churn benefit on a per-subscriber basis is independent of houses passed and penetration. The value of this benefit in this example (20% disconnect rate) is:

Churn Benefit = (0.2)x1.9x$25 = $9.50/sub/year

Systems that experience a high churn rate (100%) with the above truck roll cost will experience the following operational benefit with TGT versus an addressable set-top system:

Churn Benefit = (1.0)x1.9x25
= $47.50/sub/year

Figure 4
Initial system installation considerations

TGT SYSTEM COSTS

Poles per TGT (design spec)	3.00	These figures were derived from TGT tap utilization programs. Avg. subs/pole assumes min design goal of 50% HP.
Avg. Subs per TGT Pole	7.23	
Total Active TGTs used	18.20	
TGT Tap Utilization		
TGT-8	9.80	TGT-0. . . . Amount used to allowed potential TGT outlets to achieve 100% HP.
TGT-6	4.20	
TGT-4	4.20	
TGT-0	9.93	
TGT Cost per Mile	10,631.00	
Cost per Sub	105.00	
Number, Plain Converters	106.92	Adl. Outlets, Cabl Rdy, Invtr
Total converter Cost, $	4,276.80	
Cost per Sub	42.24	
Total Cost, $ TGT + Conv.	14,907.80	
Cost per Sub	147.24	
Plus Added Drop Cost, $	7.00	
Minus Distribution Plant, $	13.95	
		140.29. . . . .GRAND TOTAL TGT SYSTEM

ADDRESSABLE CONVERTER SYSTEM COSTS

% Subscribers Addressable	100.00	
% Subs with Plain Basic	0.00	
Number of Addressable Units	133.65	Addl. Outl, Inventory = above with cable ready
Plain Units	0.00	
ADDR. Cost	13,365.00	
Plain Cost	0.00	
Total	13,365.00	
Per Sub		132.00 . . . . .GRAND TOTAL ADDRESSABLE

INITIAL SYSTEM COST DIFFERENTIAL = $8.29

Reduction in repair/maintenance costs

The effect of the ideal TGT system on repair and maintenance costs is dramatic. The number of active electronics in a TGT system with no subscriber equipment is less than 20% of the electronics needed to deploy a set-top addressable system. Assuming that the cost to repair and maintain TGT hardware is 50% more than that for set-top addressable converters, the net result is still 30% of a set-top system or a 70% savings in maintenance and repair costs. An example of the scenario follows:

Parameter	Equation Variable
Addressable set-top failure rate, %	ADDFAIL
Addressable set-top repair cost, $	ADD$REP
Truck roll cost, $	ROLL
TGT failure rate, %	TGTFAIL
TGT repair cost, $	TGT$REP
Additional outlets, %	ADD

Repair benefit value calculation:

Addressable set-top repair $ =
(HPxPEN/100)(1 + ADD/100)(ADDFAIL/100)(ADD$REP + ROLL)/
(HPxPEN/100)

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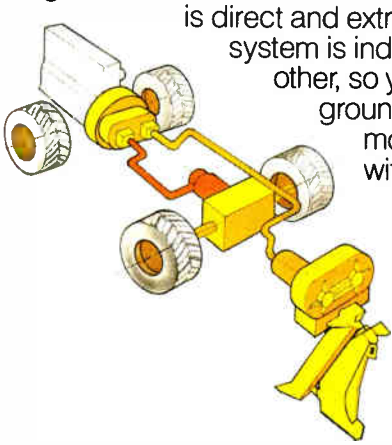

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Figure 5
Tier Guard operational benefits

HARDWARE THEFT

% Converters Lost, Stolen	15.00		
	ADDR	TGT	
Addressable Converters, $	1,403.33	0.00	
Plain Converters, $	0.00	160.38	
Total	1,403.33	160.38	
Per Sub	13.86	1.58	
TGT advantage			12.28

SERVICE THEFT

% Illegal Connections	10.00		
% Caught	100.00		
% Converted to Paying Subs	25.00		
Annual Revenue Increase, $	1,687.50		
Per Sub			16.67

CHURN ANALYSIS, TRUCK ROLLS ONLY

Transactions			
Reconnects, %	7.50		Annual Percent of Homes Passed
Disconnects, %	10.00		
New Connects, %	2.50		
Upconvert, %	10.00		
Downconvert, %	10.00		
Truck Rolls	ADDR	TGT	
Reconnect	16.88	13.50	Addr. = 1, TGT = 0.8
Disconnect	42.75	0.00	No roll for plain con.
New Connect	5.63	5.63	Deposit covers loss
Upconvert	0.00	0.00	
Downconvert	0.00	0.00	
Total Truck Rolls	65.25	19.13	
Cost of Rolls, $	1,613.25	478.13	
TGT ADVANTAGE		1,153.13	
Per Sub			11.39

REPAIR ANALYSIS

Cost of Repair	ADDR	TGT	
Plain	0.00	577.37	
Addressable	902.14	0.00	
TGTs	0.00	30.03	
Total	902.14	607.40	
Per Sub	8.91	6.00	
TGT ADVANTAGE			2.91
ADDED POWER COST/SUB			2.26
TIER GUARD OPERATIONAL BENEFITS/YEAR TOTAL $			38.07

Figure 6
Financial summary
Tier Guard versus addressable set-top

	Costs per Subscriber		
	ADDR	TGT	
Initial Costs, $	132.00	140.29	
Cost Difference			8.29
Annual Savings, $	0.00	38.07	
Payback, TGT versus Addressable Set-top, Months		2.61	
TGT COST ADVANTAGE first year		29.78	
after five years		182.07	

Again, the penetration drops out on a per-subscriber calculation, leaving:

Addressable set-top repair $ =
(1 + ADD/100)(ADDFAIL/100)(ADD$REP + ROLL)

Example:

ADD = 20% of subscribers with additional outlets
ADDFAIL = 10% failure per year
ADD$REP = $20
ROLL = $25
Addressable set-top repair $ = $5.40/sub/year

The TGT system repair costs are as follows assuming 80% efficiency of TGT outlets and average use of TGT-6s in the system design:

TGT FAIL = 10%
TGT $REP = $30

$$\text{TGT Repair \$} = \frac{(\text{TGTFAIL}/100)\,(\text{TGT\$REP} + \text{ROLL})}{(0.8 \times 6)} = \$1.15/\text{sub/year}$$

This represents a substantial operational savings per subscriber each year. However, this also represents a boundary value condition in the future when most sets are cable-ready. At this point in time, assuming 20% or so existing penetration of cable-ready sets, the repair costs tend to be equal in both systems because of the need to maintain and repair the "plain vanilla" convertors used in the TGT system. Depending upon specific system parameters, the TGT advantage is approximately $1/sub/year with a projected increase towards $4.05/sub/year as cable-ready sets increase in number.

Example summary analysis

The following figures represent a computer program printout of a Tier Guard versus addressable set-top cost comparison for an urban system. Figure 3 lists the various assumptions. Figure 4 indicates initial system design considerations. In this section, the total effect on the distribution plant is added as one line. This includes reduction in strand footage, line extenders, taps, connectors and increased power supply costs. Cost of longer drops is included as a separate item.

This particular situation indicates a slightly higher installation cost with a very quick payback favoring the off-premises approach.

Summary and conclusions

Off-premises systems such as the Tier Guard Tap can be effectively deployed in a variety of systems. Installation costs will vary depending upon projected penetration and subscriber count. Design techniques somewhat different from traditional tapped-feeder concepts need to be employed for cost-effective deployment of the shared electronics.

Installation costs are comparable to addressable set-top systems. Operational benefits result in very short paybacks on investment compared to addressable set-top systems. Benefits vary from system to system and a thorough analysis is justified in any system design opportunity, whether urban, suburban or rural, new build, rebuilt or upgrade. CED

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Flash addressing with the ORION-NET system

By Frank Pennypacker,
Director, Systems Engineering,
Satellite Systems Division,
Oak Communications Inc.

Over the last several years, CATV systems have been linked to a large multi-source satellite network which has been developed to deliver premium programs. Cable systems have become, in a way, the earth segment of this delivery system.

Premium programs are very desirable and not available from standard broadcasts. Some people have purchased their own television receive-only (TVRO) earth stations to receive these programs. The number of these TVROs has grown to over 1 million, and their owners have become non-paying members of the network.

Recently, the National Community Television Association requested proposals for a system that would allow controlled sales to the home TVROs from the same network that delivers signals to CATV systems. This article describes the architecture of the ORION-NET system proposed by Oak. The advances described here also are applicable to CATV systems.

ORION-NET is based on the Oak ORION system, used successfully by Cancom (Canadian Satellite Communications) and others since 1982. The system scrambles video by sync denial and random video inversions. Audio is digitized and hard-encrypted. The system uses Dolby adaptive delta modulation stereo instead of pulse code modulation audio. The Dolby system has much better noise tolerance than PCM; this tolerance is further improved by error correction.

The ORION system was designed from the start for maximum flexibility. The Cancom system, as shown in the figure below, requires simultaneous operation from several remotely located uplinks under the control of one computer. The control computer is directly connected to one of the encoders, referred to as "the master." The other encoders, referred to as "repeaters," receive the data from the master over the satellite. The advantages of the system are that only one computer is needed and, more importantly, the system is tied together —a decoder gets the same authorize information regardless of which signal it is receiving. The Cancom system has five uplinks with eight channels.

The master-repeater technique has been taken one step further. The ORION-NET system allows coordination of all programmers serving CATV systems to also serve and control TVROs. A single home TVRO control computer generates authorize messages which are sent to one programmer's uplink. The other programmers' encoders get the data over the satellite. At the same time, each programmer will control his own service to affiliated CATV systems.

The dual nature of the system is achieved by using different VBI lines to communicate with the appropriate decoders. Lines 2 and 4 communicate to decoders used in CATV headends. Lines 1, 3, 5 and 7 communicate with home decoders.

Performance and features of the ORION-NET System:

- Architecture for multiple programmers and multiple centers for home TVRO control.
- Video scrambling by sync elimination and random inversions.
- Stereo audio transmission by Dolby adaptive delta modulation in HBI.
- Hard security through digital encryption.
- Addressability in band VBI. 268 million addresses. One-half million per minute Flash Rate. Fifty-six tiers.
- Robust signalling in presence of noise. Tolerant of receiver characteristics. Error corrected.
- Transparency: Modified NTSC video is compatible with satellite, CATV and SMATV transmission.
- Software: Control, business and manufacturing software available.
- Availability: ORION system is in production now. System deliverable six to eight months ARO.
- Low cost.

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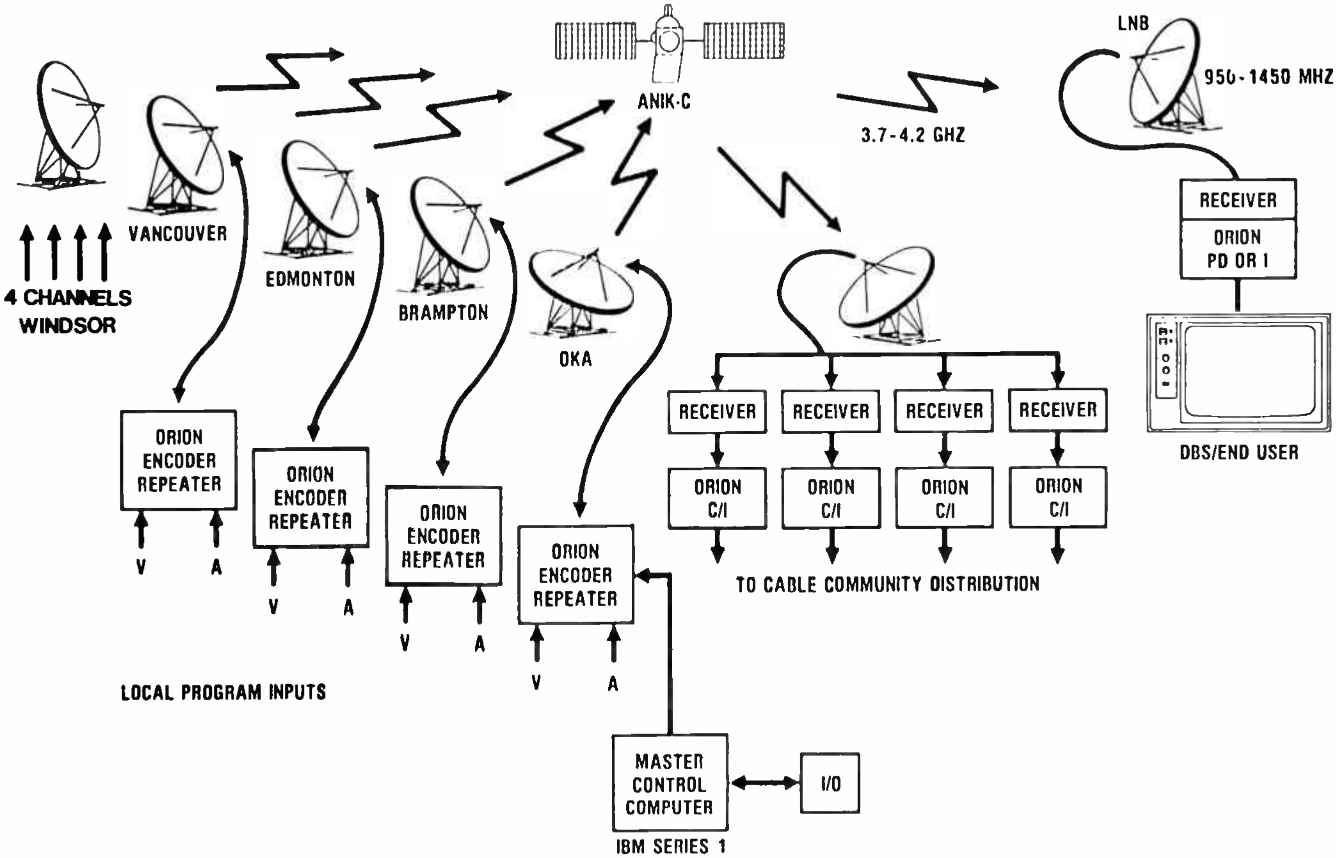

The flexibility of the ORION-NET system can be used to expand the dual system into a three-way system. The same signals can be carried through a CATV system without decoding and re-encoding. (See related article, *CED*, November 1985, pp. 16-26.)

Extremely large systems have a problem with pay-per-view programs. It is a challenge to get very large numbers of decoders authorized in a very short time. Unfortunately, it is human nature to do things at the last minute. A large number of subscribers (with a system of 5 million subscribers, 1% is a large number) will decide that they want the program just as it starts. If there is no way to turn them on, they will not get the program and the system operator will lose revenue.

There are several ways of handling the last minute problem, no one of them ideal. In the "cash box" method, the decoder microprocessor has a part of its memory assigned to keeping track of the subscriber's credit. Either the subscriber pays some money in advance or the system operator advances some credit. In either case, the subscriber starts out with credit. The subscriber views programs as he wants them without any contact with the system operator. At the end of the month, the decoder will display the amount of money that the subscriber owes and a verification number. The subscriber is supposed to write down the verification number and send it with his check. The payment is received at the office, and the payment information is downloaded to the decoder over the air restoring the subscriber's balance.

There are problems with this: It relies on the subscriber to find out what his bill should be, which may not work because some subscribers are inept and some are uncooperative. In addition to this, children can run up big bills in the absence of their parents, the complications can alienate subscribers and security can be compromised without the system operator being aware of it.

Another option is to take telephone calls. This has the advantage of getting the information to the system operator immediately. In the past, there have been problems with telephone line saturation and the number of operators required to take large numbers of calls. These problems are solved by automatic telephone equipment that records calls and relays the phone numbers of the callers to the system computer.

Other systems have an additional problem: They are not capable of addressing more than a few thousand decoders per minute; the systems can be saturated by a large number of last minute orders. With these systems, the "cash box" is the only approach that will work. The ORION-NET system also has a proprietary ultra-high-speed addressing method called "Flash Addressing." By eliminating most of the redundancy associated with older methods, ORION-NET can address almost half a million decoders per minute.

Both of these methods can be supplemented by asking subscribers to order ahead of time. This can be encouraged by offering a discount for early orders.

Satellite systems have a problem that CATV systems do not. The TVRO may be used to receive signals that are not part of the system. It should be expected that a large number of subscribers will tune in at the last minute. If the system is not capable of addressing several million decoders in a few minutes, there will be a lot of unhappy subscribers. Again, the ORION-NET "Flash Addressing" will prevent this from happening.

The best immediate solution is to choose a flexible system that is capable of pay-per-view using all of the above methods. Building a pay-per-view system involves many unknowns, and flexibility in all areas is of prime importance. CED

SMATV industry takes stock

Scale of sales is big story

As the private cable (SMATV) industry took stock of itself at its October convention, several trends stood out. The number of players hasn't changed. According to out-going National Satellite Cable Association President Bob Vogelsang, there still are about 400 "real" operators.

But the quality of the players is changing. Compared to several years ago, the "fast-buck artists" are gone. The players at the top of the heap are showing increasing professionalism and sophistication.

And it isn't looking much like a "mom-and-pop" business anymore. A smaller number of MSOs is emerging. Ownership is concentrating. Subscriber counts for successful companies are rising. And the dollar volume of transactions is up.

NSCA officials say the 400 or so private cable operators now have 1,750,000 passings representing 300,000 to 400,000 subscribers. Vogelsang says 250,000 passings were added last year. And the industry represents about $700 million in investments, he adds.

And while skirmishes with CATV in the legislative and legal arenas took much effort in 1985, the big story for the year isn't political. It's the number and size of private cable transactions.

"At least seven private cable sales this year were in the multi-million-dollar range, representing about $30 million in acquisition activity," says the NSCA's Gary Davidson. Per-subscriber prices of $300 to $1,000 were paid.

Several strategies seem common to the emerging industry leaders. In some cases, single operators have gained dominance in a single geographical area. Prerequisites seem to have been a large local subscriber base; operator awareness of, and rapid adjustment to, subscriber demographics; and a strong relationship with real estate developers.

In other cases, a relationship with a major developer has been the key, allowing single negotiation for up to 30,000 passings.

NSCA leaders uniformly predicted further marketplace consolidation, with a dominant operator in each city or geographic area.

There's also general agreement that "small players with less than 20,000 to 25,000 passings won't make it," says Vogelsang. Other leading players agree.

Paula Herzmark, president of PJH Cable Ventures, looks at 100,000 subscriber markets as a rule. "At 50,000 passes you start to crank out cash and generate real economies of scale." Herzmark expected to reach the 50,000 mark for her Houston systems in October.

And she's aiming for 500,000 passings in five years. Jim Theroux of Cleveland-based Metropolitan Satellite, on the other hand, thinks he'll top out at about 30,000 passings in that city. Both Herzmark and Theroux agree, however, that the key is clustering of systems in a single city.

By way of contrast, Bob Swander, president of ODC Communications in Bethesda, Md., operates in 26 states. Generally speaking, he doesn't like to work with apartment complexes below the 300-unit size and usually works with national real estate developers. By the end of the year, Swander expects to have about 100,000 passings.

As might be expected, each operator has a different way of approaching system operations. Theroux, who used to work for Warner-Amex, has one of the more interesting systems. He's got about 40 Cleveland buildings wired, representing about 25,000 passings. Each system normally carries about three premium channels and 10 basics.

He's also gotten an MMDS license and has activated about eight channels. Once he gets up to about 12 channels, he can take down the earth stations at each site and feed them by microwave. So with the advent of scrambling, he'll have descramblers, of course.

But he won't need a separate descrambler at each of the 40 buildings for each protected signal. What he will have is an interesting interconnect.

He's also experimenting with converter-less operations. The next 6,000 units he wires will use the UHF band on consumer TVs.

Theroux also claims the ability to underprice CATV in Cleveland by about 20 percent. "It costs me about $15 to do an install, so I'm basically indifferent to churn," he says.

He also says he has 50 percent operating margins. All of which has induced some interest. "I'll soon announce that a top-ten CATV MSO is buying a 10 percent interest in the company with a full buy-out in five years."

Theroux, unlike many SMATV ops, has part-time company representatives living at each of the sites. Swander has to handle things differently, since he's got far-flung operations tied together by a VAX mainframe. He says billing and administrative reporting aren't difficult.

But directing actual system operations is, especially turn-ons and disconnects. So he's got regional construction and service personnel under contract.

Having so many operations in so many states is a bit unusual for an SMATV operator, and it's definitely intricate. And because his subscribers are scattered so widely, Swander is more inclined to view addressability favorably. Right now he uses addressable taps and some remote addressables (his clear preference in the long run).

Generally speaking, he sticks to 12-channel systems, varying the programming line-up depending on system demographics. He also has hooked up several of his systems through cable interconnects on adjacent properties.

Herzmark, by way of contrast, has no plans to go addressable in any of the 95 systems she's recently acquired in Houston and Dallas. What she is facing is a massive cleanup effort.

And like other leading MSOs, marketing is the biggest challenge she


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faces. "I've got lots of angry property owners to deal with and need to get a major remarket going."

Paula's very careful about her market research, and she picked Dallas and Houston for several reasons. Both have huge MDU markets. And both cities have seen acrimonious relations with the local CATV operator.

Herzmark also has to do something about the 40 different programming line-ups she's looking at now. The goal: pare the 40 to 20. And while she has no plans to interconnect systems at present, one of her new systems is addressable so she'll experiment with pay-per-view there.

There's no question she'll have to consolidate personnel and service policies, but the big task still is getting penetration up. "It's been incredibly low," she says.

Interestingly enough, regulatory and legal issues don't seem to worry Herzmark, Swander or Theroux very much, despite the attention legal issues like mandatory access seemed to get at the private cable convention. "The real question is making money, generating economies of scale and marketing," Theroux says.

"The legal issues will work themselves out," Swander adds. And Herzmark always has had amicable relationships with the CATV operators in her areas. When she ran Solar Satellite Communications, a dominant Denver-based private cable company, she had interconnects with United.

She's pursuing a CATV business tie in Texas as well. And her business philosophy remains the same. "Ultimately, my job is to make money, not beat up on CATV. I believe in getting along."

Which isn't to say the NSCA necessarily takes the same view. Jack Cory of the Florida Private Cable Association took the rostrum and declared that "mandatory access is the major issue to face us in the years ahead."

Mandatory access refers to municipal or state laws requiring that MDU owners allow CATV companies access to their buildings for subscriber wiring and service. Right now, 11 states have such statutes on the books.

Among them: Florida and Maryland (although, in these two states only condominiums are affected), Illinois, Kansas, Massachusetts, Minnesota, New Jersey, New Mexico, New York and Virginia.

NSCA members were warned to expect a legislative push by the NCTA in early 1986. "They want to introduce mandatory access legislation in as many state legislatures as possible," said NSCA attorney Mark Tauber. So NSCA members were urged to organize at the state level. More important, they were urged to work with real estate and developer interests.

Said Cory, "If the issue becomes CATV versus private cable, you're dead. You have to raise the issue of property rights."

Added NSCA spokesman Jim McNaughton, "Developers can raise issues you can't, like the 'right of sale.' Mandatory access is telling the developer what he can and can't do with his property."

Glenn Jones, who is both a CATV and SMATV operator, argued for a "live and let live" policy. "The customer is key. CATV has to understand that some customers in the franchise area will never take service. And SMATV has to understand that CATV will go for every customer it can get."

The solution? "SMATV operators need to talk to CATV. There can be areas of cooperation. Perhaps certain systems can be sold. And private cable ops should try to build systems that are potentially compatible with the CATV operator," Jones said.

Media General, among others, has set up its own SMATV subsidiary. As a result, it is the dominant player in that area in both CATV and SMATV.

Whether Jones' call for cooperation fell on deaf ears or not, it seems clear that private cable won't blow away.

—Gary Kim

Cherry picking for profit

It may seem unusual to think of cable operators as SMATV operators, but for an enterprising cable operator, it can be advantageous and very profitable.

By Gary Solomon, Technical Sales Manager, Nexus Engineering Corp.

Low-cost headends and satellite programming have created new opportunities for cable operators to increase revenue and improve their competitive position. A major factor affecting cable's future is competition from other methods of delivering television services to hotels, motels, apartment complexes, hospitals, institutions and unwired areas. By installing more headends and offering special services to these customers, cable companies can add new subscribers and avoid losing established customers.

A large number of hotels, motels, office buildings and institutions don't want the full package offered by a cable company, especially if cable-ready televisions or descramblers are not already available at each viewer location. In addition, they often have special interests in specific satellite-fed programming not carried on cable. Cable competitors are approaching these potential customers offering their services using arguments like: "Wouldn't you like to be able to offer your viewers these specialty programs?" or "Why should you pay for all that programming if you don't want it all?" or "Why pay for service that doesn't give you exactly what you want?" or "Why should you have to buy set-top converters or cable-ready televisions?"

Only a few-forward thinking, market-driven cable companies are now actively competing in these markets. Direct benefits for the successful cable company include preventing competition, keeping satisfied bulk accounts, attracting new customers and increasing profits.

Restricted access

Restricted access systems are also referred to as cherry picking, bundling or bulk specialty services. They basically give a bulk paying customer the choice of receiving (and only paying for) the specific programming they desire. The customer and the cable operator negotiate on the selection of programming, the price of the service and the terms of payment. For example, if the cable system carries 35 channels of programming, the agreement might call for only nine basic channels and three descrambled pay channels. These channels would be configured to occupy the twelve low- and highband channels. The signals would be descrambled as necessary, converted to the appropriate channels, combined and injected into the local distribution system.

Restricted access plus

A restricted access plus system is a restricted access system with one important addition. In this type of system, the customer also wants some programming not carried on the cable system. For example, the cable system might not carry, and not want to carry, the specific satellite-delivered narrowcast or specialty programming the customer wants. In this case, the cable company (after receiving the viewing rights if necessary) also installs the appropriate satellite antenna, receivers and modulators at the customer's location and then combines this programming with the processed cable channels.

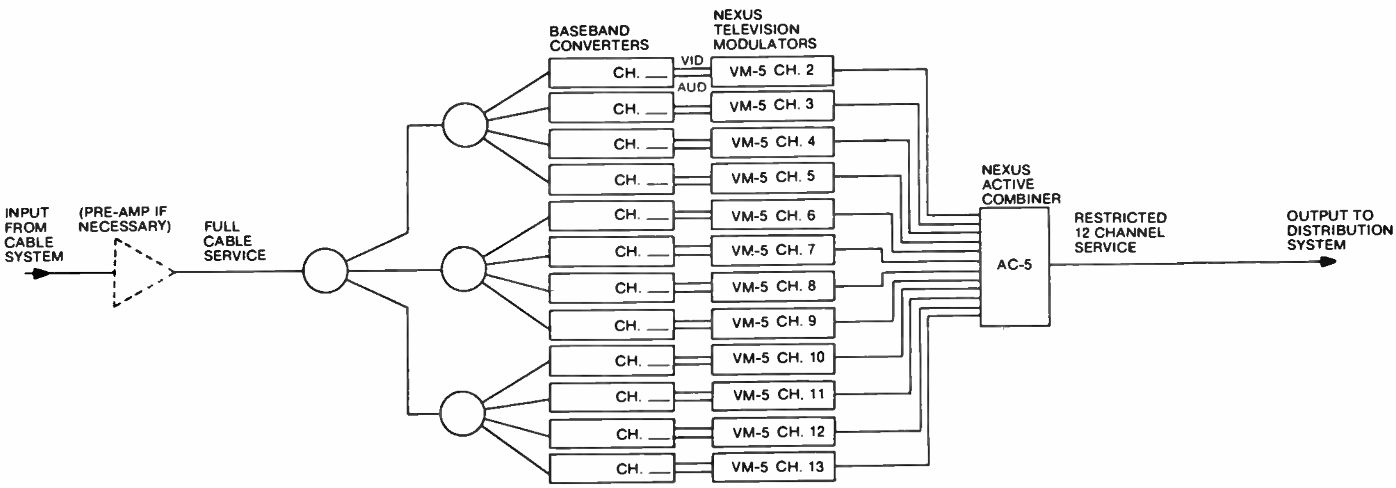
Sub-headends

Several different system designs and headend components can be used to provide restricted access programming. The CATV headend scrambling system determines the most convenient method to decode and rechannelize the cable programming selected by the customer. Each channel to be descrambled will require one decoder at each sub-headend.

The most desirable technical solution to providing bulk delivery of scrambed signals is to use descramblers that provide baseband video and audio outputs. If the descrambler does not provide baseband outputs but does internally demodulate, a technician can open the descrambler and solder connectors on the video and audio lines. The video and audio signals are used as inputs to commercial-quality adjacent channel modulators. The modulator outputs then are combined for local redistribution as shown in the figure below.

Many cable companies also are using this method to process the

Block diagram of a typical 12-channel restricted access headend



unscrambled cable signals because it is so economical. The set-top descramblers are very inexpensive and function well as demodulators. Good quality adjacent channel commercial modulators, for example, are now surprisingly affordable. This combination provides an agile input, adjacent channel output, demod-remod processor.

If the descrambler does not demodulate to baseband internally, the channel 3 output of the decoder must be converted to the desired output channel using a heterodyne processor. Using RF output descramblers and processors is not as desirable as using baseband output devices and modulators for two reasons:

♦ The RF output frequency of the decoders may drift causing interference with adjacent channels. Drift problems cannot be corrected by the processors. This is the most important reason it is recommended to open the descrambler, locate the video and audio lines and then feed them into a modulator.

♦ Processors suitable for sub-headends cost much more than adjacent channel modulators and descramblers.

A possible problem to be aware of with consumer descramblers is that some synthesized units change channels every time the system loses AC power. If the converters do not have nonvolatile memories, a standby battery for the logic circuits should be added.

Not all restricted access systems require descramblers. If pay channels have not been selected, then the restricted access headend could use either consumer descramblers (or demodulators) with modulators or heterodyne processors to selected desired channels. For example, the customer may want to choose a total of 12 basic channels from the low- mid-, high-, super- and hyperbands. These 12 channels then can be converted to the low- and highbands for reception without cable-ready televisions or set-top converters.

Even if channel conversion is not required, bandpass filters or on-channel processors cannot be used in this type of application because they do not provide sufficient selectivity for processing off fully loaded cable systems. To be able to use adjacent channels in the system, spurious output signals from adjacent and other channels must be attenuated by at least 55 dB. This degree of filtering can be done effectively only at IF frequencies, usually using SAW filters, which is why more expensive heterodyne processors are required.

Sub-headend equipment

The sub-headend equipment should have excellent performance and reliability but does not need many of the features found on cable headend equipment. For example, standby carrier, substitution switching, "IF" loops, metering, test points and other similar, costly features are not necessary.

Restricted access channel processors need very good adjacent channel and image rejection performance to prevent interference because of the large number of adjacent channels on the cable system. The other important processor specifications include cost, reliability, power consumption and AGC.

Features that all restricted access headend components should have are:

Low Cost—A complete headend system can be very inexpensive. Typical small volume purchase costs for the restricted access headend shown in the figure are:

12 Addressable Converters		
	@ $ 70 each =	$ 840
12 Modulators		
	@ $315 each =	$3750
Miscellaneous Equipment		$ 800
Total		$5390

Stability—The modulators must be crystal controlled to guarantee long term frequency stability.

Good Spurious Specifications—To prevent interference to other channels, the modulators must have a spurious output specification of at least 55 dB.

Small Size—Some cable headends can fill a room. A compact headend, however, will fit into a small storage area or closet.

Flexibility—The cable company has a reputation to uphold; the customer is expecting quality and service. Therefore, any products used in the sub-headends should have a proven, very low failure rate.

Low Operating Temperature—Some modulators operate at greatly reduced operating temperatures. This significantly increases reliability and reduces component aging.

Power Consumption—Headend components that use more power can cost much more to operate. The cost to operate a high power consumption headend can actually exceed the purchase price of the system. The cost to power 12 modulators over a 10 year period can range from under $200 for low power modulators to over $12,000 for high power, frequency agile

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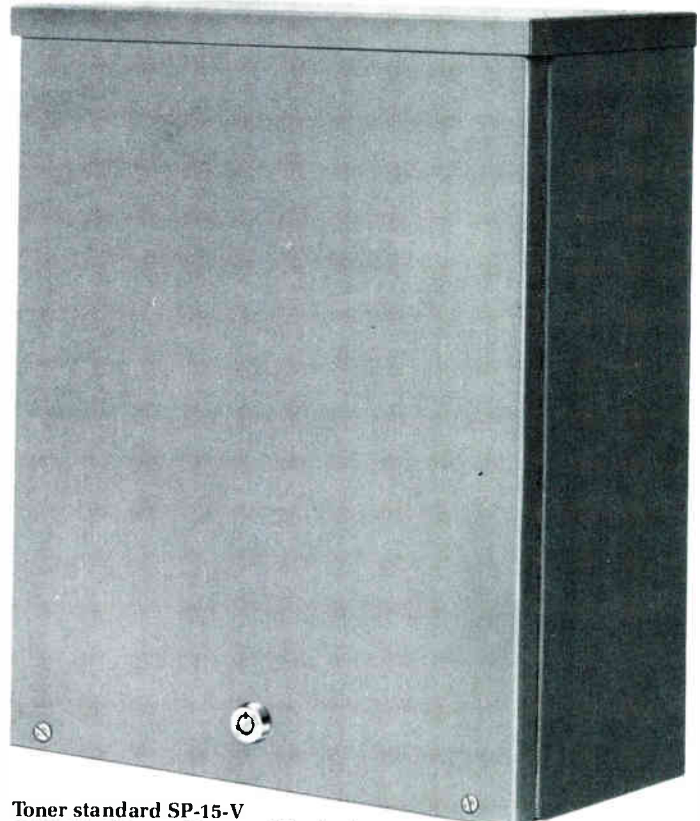

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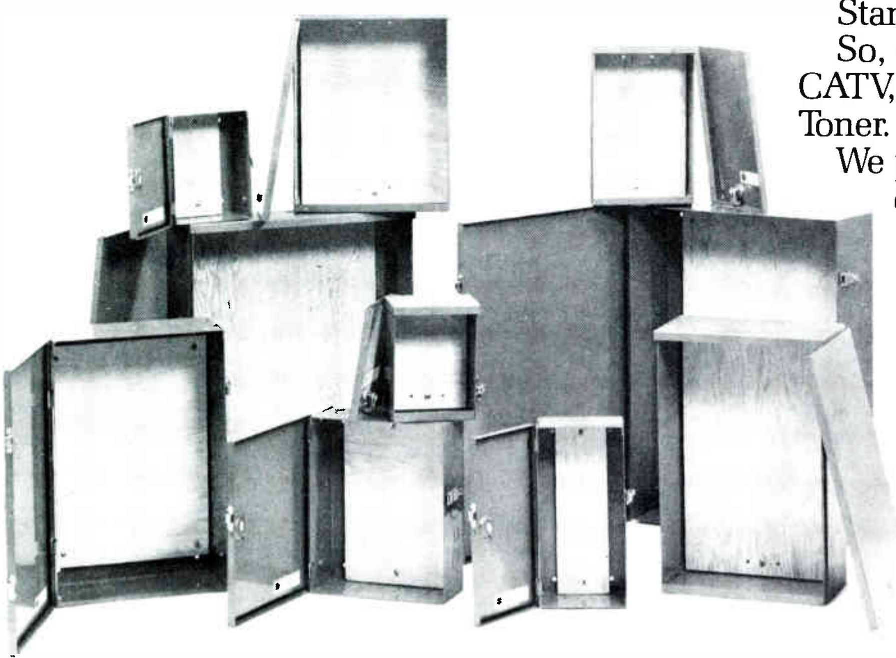

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modulators. Similar considerations should be given to other components. System owners should be shown the comparative operating costs of headend components.

SMATV

It may seem unusual to think of cable operators as SMATV operators, but for an enterprising cable operator, it can be advantageous and very profitable. In a franchised cable system, total construction costs, or system values, can approach $1,000 per subscriber. By comparison, the cost to generate similar revenue in an SMATV system might be $200 or less per subscriber.

In areas which are not yet (or not going to be) wired for cable, a cable operator is not going to generate any revenue unless the cable company is installing SMATV systems. Residential complex owners recognize that a private cable system adds equity value to their property and makes the project' easier to sell or rent. As a result, they often choose a private cable system over cable TV. Installing a private cable system in these situations gives the cable operator an equal, competitive position.

As cable systems are being constructed, many cable operators also use private cable systems to their advantage. If cable operators install private cable systems in areas not yet wired, they will retain these customers after the area is fully built. It is very difficult to approach a potential customer for cable services if the competition has already successfully convinced him to purchase a private cable system. Many cable operators are forming new divisions or even separate corporate entities to handle these new business areas. There are several advantages to doing this:

- ♦ A separate division can approach customers as an alternative to conventional cable, so the cable company wins either way.
- ♦ Through the CATV parent company agreements, rights to all pay TV services are easily accessable.
- ♦ By adding more pay TV subscribers through restricted access or SMATV systems, the effective rates paid to the pay programmer may be reduced.
- ♦ Equipment manufacturers have moved from monolithic price structures to structures based on volume. Cable companies purchase large product volumes, giving them a significant price advantage.
- ♦ Cable companies have the experience, technical ability, test equipment and available capital to successfully compete in these markets.
- ♦ The subsidiary also can lease or sell TVRO systems to rural customers or act as a regular TVRO dealer. There are over 1 million TVRO systems already installed, and many visionary cable companies are getting involved.
- ♦ Cable companies have excellent contacts among developers and builders because of their earlier work with these customers.
- ♦ Municipal licenses (for cabling across roads and property lines) have usually already been obtained.
- ♦ The new division doesn't have to compete with the CATV company in its own area.
- ♦ The subsidiary can help overcome any customer resistence or animosity towards cable.
- ♦ Private cable systems are subject to fewer government regulations.

Conclusion

Restricted access and SMATV systems represent a radical but very profitable departure from normal cable business. Investigating and promoting these and other new services will increase revenue and reduce the effects of competition. Think where the railroads would be today if they had considered themselves "transportation companies" instead of railroads and had started operating airplanes a few decades ago. CED

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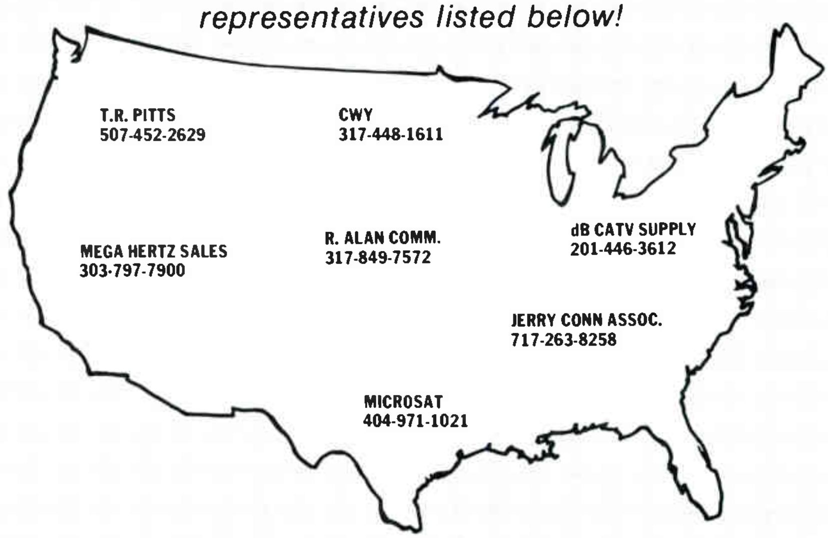

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Alarm/controller applications

By William Ellis, President, Broadband Engineering Inc.

Alarm/controllers can remotely monitor such things as headend or earth station temperature, security and standby power. Controllers can activate or deactivate electrical or electronic equipment from a remote location.

Broadband's system, for example, consists of two units: a transmitter and a receiver. The receiver can be located anywhere downstream from the transmitter in a one-way system, or upstream or downstream in a two-way cable system. Any number of receivers can be operated from a single transmitter. However, only one transmitter can be used with one or more receivers.

With the basic system, you can monitor up to eight functions at the transmitter location. Monitoring simply means that you can use up to eight sensors that result in a contact closure when the sensor input exceeds a predetermined value.

For example, most operators have experienced a remote headend air conditioner failure in the summer. The first indication of trouble is customer calls complaining about poor picture quality. By that time it is so hot in the headend that it takes a long time to get the headend back into proper operation. With a temperature sensor at the headend, you will have an early warning that can prevent customer complaints since you will know about the problem before they do.

With a low temperature sensor, excessively low temperatures also can be monitored.

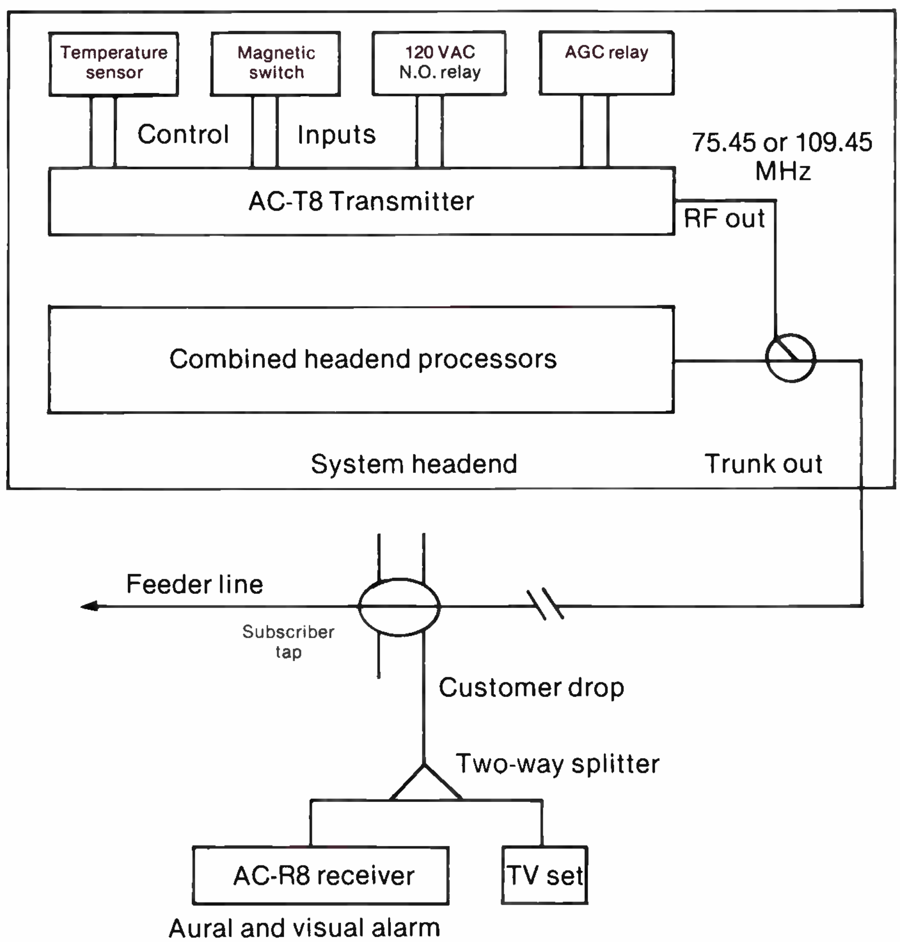

Figure 1
Alarm and signaling applications using 4 of the 8 alarm/control channels

Headend security is another application. With a magnetic switch on the door, unwanted intrusions can be detected. Monitoring of remote warehouses or system offices after hours also is possible.

Since there are eight possible alarm inputs, it is possible to monitor up to six additional devices. (See Figure 1.) Standby power monitoring is a logical choice. If your headend is standby powered, the AC power can go out in a storm. Your first indication of trouble occurs when the batteries run down or the fuel is exhausted from your standby generator. With a standby powered transmitter and a 120 VAC relay connected across one of the transmitter inputs, you will know instantly when the AC power fails.

The alarm/controller is an early warning system that could result in better system operation, fewer customer complaints and protection from financial losses incurred from break-ins.

Receiver operation

So far we have discussed only the transmitter. What happens at the receiver when the transmitter sends a signal? That depends. For the basic system, a transmitter contact closure causes two receiver reactions. Within a few seconds after the contact closure, the receiver sounds on aural alarm (tone) and an LED lights up on the front panel showing which of the eight alarms (channels) has been activated. The aural alarm can be turned off at the receiver so that it will not annoy people in the vicinity. It can be reset, either manually or automatically, depending upon the position of a front panel switch. The LED will remain lighted until it is reset by a front panel push button switch.

The reason? If the system attendant is not available when the alarm is activated, visible evidence remains upon return to the receiver location. A simple reset of the LED tests for a continuing alarm condition. If the LEDs don't light, it means the alarm condition no longer exists.

With the addition of optional DIP relays plugged into sockets in the receiver, a contact closure is available at the output of the receiver whenever an alarm is activated. But the relays will be turned off only when the LEDs are reset from the front panel.

With an additional controller board, up to four channels are controlled from the transmitter location. With the extra board installed and the channel switch set for controller operation, the receiver reset switch must be turned off at the transmitter.

In a two-way system, headend equipment can be controlled from anywhere in the system. For example, a transmitter in the system sweep vehicle and a receiver in the headend would allow the trunk technician to turn the sweep generator on and off at each amplifier

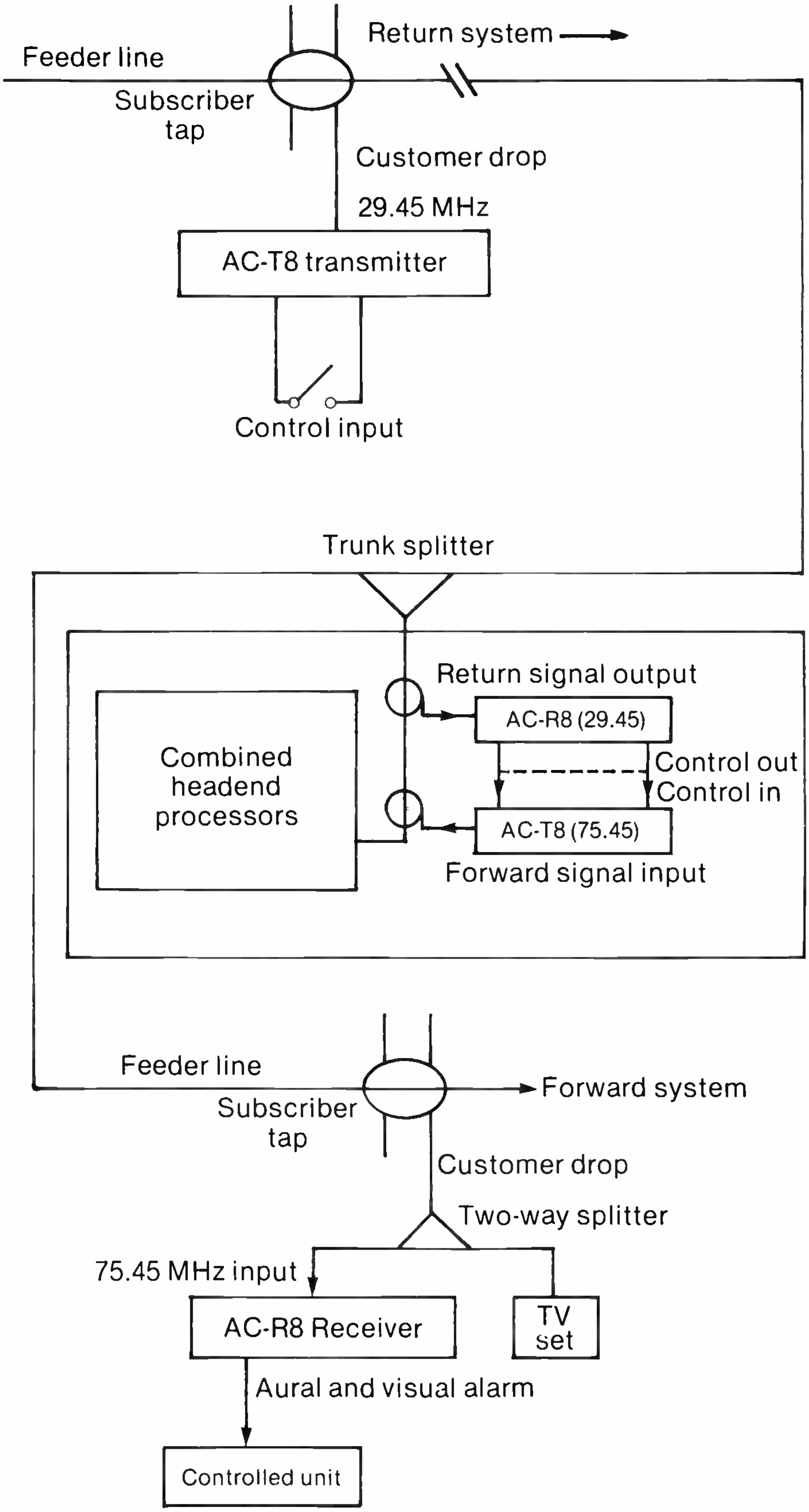

Figure 2
Application: Control or alarm from anywhere to anywhere in a two-way system

location to avoid having the sweep interfere with the pictures at all times during system sweep testing. A return path receiver at the headend connected to a forward path transmitter offers more flexibility and allows any transmitter in the system to control a receiver at any other location in the cable system. (See Figure 2.)

System operation

The system operates on one of four frequencies that must be selected before the equipment is ordered. The frequencies are 74.45 MHz (in the gap between channels 4 and 5), 109.45 MHz (just above the FM band), 160.45 MHz (just above the lower end of the downstream band in a mid-split system) and 29.45 MHz (at the top of the upstream band in a sub-split system).

Because the system operating level is sufficiently low, operation at the 109.45 MHz frequency is possible without exceeding the maximum permissible level in the aeronautical band. This assumes the system maximum bridger level is no greater than 48 dBmV.

The transmitter is intended to operate at 15 dB below a video channel carrier but, because the receiver has a sensitivity of -30 dBmV, it may be operated lower than that if required.

Modulation is FSK, and the digital receiver is set up to respond only to a valid pattern from the transmitter. Therefore, the unit will not respond to noise bursts and is very immune to false alarms. Although the system was designed to operate over a cable or local area network, it will operate as a standalone system with the transmitter and receiver connected together by coaxial cable without amplification.

The transmitter is intended for rack mounting and is housed in a 1¾ inch panel height chassis approximately 3½ inches deep. The receiver is a free standing unit about the size of a converter. Both units are powered by UL-approved class II transformers.

A sync LED on the front panel of the receiver flashes at intervals to show the transmitter is communicating with the receiver. If, for some reason, the transmitter or receiver fail or lose power, the sync light won't flash.

Using multiple receivers adds more flexibility. Receivers at the system office, in the manager's home, the chief engineer's home, the technician-on-call's home and one at the system answering service would ensure that no alarm would go unnoticed.

The alarm/controller is an early warning system that could result in better system operation, fewer customer complaints and protection from financial losses incurred from break-ins. All at a cost about the same as a signal level meter. CED

Pioneer has introduced the BC-4000N, an enhanced version of the BC-4000 series IR remote converter. The 67-channel converter has a new design, handheld wireless remote and an optional parental control feature that operates independent of the remote control. The BC-4000N also has last channel recall and a favorite channel memory feature with 10 programmable channels.

For more information, contact Pioneer Communications of America Inc., 2200 Dividend Drive, Columbus, Ohio 43228, (614) 876-0771.

Invonics has announced the MTS-compatible TV stereo generator. The stereo subcarrier and pilot signals are digitally synthesized with high resolution 24-step segmentation. The Invonics generator may be used in cable applications without audio pre-processing when the audio feed is a dynamically limited satellite service.

For more information, contact Invonics, Inc., 1305 Fair Ave., Santa Cruz, Calif. 95060, (408) 458-0552.

Available in early 1986 from **Scientific-Atlanta** are three digital products. Made for television production studios are the DPS-165 frame synchronizer, the DPS-170 time-base corrector and the DPS-175 time-base corrector/framestore. Each product is available in rack-mount configurations, requiring only one rack unit because of their single-board layouts.

For more information, contact John Fazackerley, Studio Products Market Manager, Digital Video Systems Division, Scientific-Atlanta, (416) 299-6888.

Developed by **Microwave Filter Co.** are two model 4529 traps. The traps are for suppressing microwave interference at earth stations with receivers having final IF frequencies of 134 or 140 MHz. Available with notch frequencies of 124 (4529-124) or 144 (4529-144), the loss is 25 dB minimum, and the 3 dB bandwidth is less than 3.5 MHz. The filters are tunable and have type F connectors.

For more information, contact Bill Louise, Microwave Filter Co. Inc., 6743 Kinne St., E. Syracuse, N.Y. 13057, (800) 448-1666.

Microflect has a new 120-page self-supporting towers catalog (SST785) which provides information on its line of self-supporting microwave towers. The capabilities of adapting standard towers to meet customer specifications are discussed. The catalog is available free of charge.

For more information, contact Microflect Co. Inc., P.O. Box 12985, Salem, Ore. 97309-0985, (503) 363-9267.

Jerrold has introduced a video switching device for connecting and controlling home video entertainment equipment. The Jerrold VCR control unit (Model VCU) enables subscribers to in-

Cover Index

On this month's cover illustration by Rob Pudim, CED salutes the directors and regional directors of engineering at the top 50 MSOs.

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Regional Engineering Director
Sammons Communications
Haimowitz, Ralph
Director of Engineering
American Cable of Florida
Hansen, Larry
Regional Engineering Director
Tele-Communications Inc.
Harbert, Roy
Regional Engineering Director
Tele-Communications Inc.
Harlin, Mike
Regional Engineering Director
Tele-Communications Inc.
Harris, Michael
Director of Engineering
Century Cable of Southern Calif.
Hartson, Ted
Director Engineering Services
Capital Cities Cable
Heathcote, Geoff
VP Engineering
Maclean Hunter Cable Television
Hickman, Richard
VP Engineering
Metrovision
Hill, Greg
Regional Engineer
McDonald Group Inc.
Hinton, Bill
Chief Engineer
Continental Cablevision
Holling, Ernie
VP Engineering
Harron Communications
Houseknecht, Earl
Division Engineering Manager
ATC/American Cablevision Rochester
Huff, Dave
Division Engineering Manager
ATC
Huscombe, Peter
Director of Engineering
TKR Cable Co.
Hutzler, Art
VP Engineering
Heritage Communications
Janes, Larry
VP Engineering
ATC
Johnson, Steve
CATV Project Engineer
ATC
Johnston, Brad
Director of Engineering
Group W Cable
Kenly, Thomas
VP of Engineering
Telemedia Corp.
Kernes, Alan
VP Engineering
Jones Intercable
Kramer, Roger
Division Engineering Manager
ATC/Southwestern Cable TV
Kruse, John
Central Division Engineer
United Cable Television Corp.
Large, David
VP Engineering
Gillcable
Luff, Robert
Senior VP Engineering
United Artists Cablesystems
Majczar, Joseph
VP Engineering
Newhouse Broadcasting
Maldonado, Frank
Director of Engineering
Falcon Cable TV
McDonough, Patrick
Chief Corporate Engineer
United Cable Television Corp.
McIntosh, Gary
Dir. Operations Eng. East
Cablesystems Engineering
Mernell, Gerald
VP of Engineering
Jackson Cablevision
Miller, Mark
Division Engineering Manager
ATC/Capital Cablevision
Muller, Mike
Regional Engineering Director
Sammons Communications
Nee, Chuck
Western Division Engineering Manager
United Cable Televison Corp.
Neese, James
VP Engineering
United Cable TV Corp.
Newberry, Carl
Division Engineering Manager
ATC
Nichols, John
VP Engineering
Cablevision Industries Inc.
Nicholos, John
Division Engineering Manager
ATC
Null, Harold
VP Engineering
Storer Cable Communications
O'Connor, James W.
Eastern Regional Engineer
Tribune Cable Communications Inc.
Page, Jeff
Regional Engineering Director
Tele-Communications Inc.
Pangrac, Dave
Division Engineering Manager
ATC
Pestana, Larry
Regional Engineering Manager
Group W Cable
Petro, Jim
Regional Engineer
Rollins Cablevue Inc.
Pike, Dan
VP Engineering
Prime Cable Corp.
Plate, Otto
Director of Engineering West
Albuquerque Cable Television
Ragone, Frank
VP Engineering
Comcast Cable Communications
Raimondi, Steve
Director of Engineering East
United Artists Cablesystems
Rexroat, Richard
Operations Engineer
Tele-Communications Inc.
Riley, Bill
Regional Engineering Director
American Cablesystems Corp.
Robertazza, Elliott
Corporate Engineer
Adelphia Communications Corp.
Robson, Wayne
Regional Engineering Director
Maclean Hunter Cable TV
Roebuck, Elmo
Division Engineering Manager
ATC
Rogan, Perry
CATV Project Engineer
ATC
Rohrer, Ray
Regional Engineering Manager
Group W Cable
Seefeldt, Roger
Field Engineering Services Director
Jones Intercable
Selvage, Joe
VP Engineering
Adelphia Communications Corp.
Smith, Jim
Regional Engineering Director
Tele-Communications Inc.
Sparks, Allan
Director of Engineering
Cablevision Co.
Stripp, Ray
Division Engineering Manager
ATC/Cablevision of Savannah
Suri, Harry
VP Engineering
Capital Cities Cable
Switzer, Sruki
Consulting Engineer
Tash, Gil
VP Engineering
Times Mirror Cable Television
Tenten, Bob
Division Engineering Manager
ATC/Manhattan Cable TV
Thompson, Roy
VP Engineering
Warner Amex Cable Communications
Timberlake, Herb
Regional Engineering Director
Sammons Communications
Traylor, Chuck
Regional Engineering Manager
Group W Cable
Tyndall, Ray
Senior Staff Engineer
Falcon Communications
Van Loan, Joe
Engineering VP
Viacom Cablevision
Von Ruden, Dwayne
Regional Engineering Director
Sammons Communications
Walsh, John
Division Engineering Manager
ATC
Warner, Jack
Director of Engineering
Service Electric Cable TV Inc.
Weiss, Bill
Regional Engineering Director
Tele-Communications Inc.
White, Gene
CATV Project Engineer
ATC
White, Richard
VP Engineering
Newhouse Broadcasting
Willis, Dave
Director of Engineering
Tele-Communications Inc.
Wonn, Jim
VP Engineering
Group W Cable
Worth, Nick
VP Engineering
TeleCable Corp.
Wynan, Dan
Division Engineering Manager
ATC
Zimmerman, Don
Division Engineering Manager
ATC

terface with their VCRs, television sets and set-top terminals to the cable and each other. The device eliminates the need for external components, fits under a converter and is compatible with Jerrold and all other converters.

For more information, contact Jerrold Division, General Instrument Corp., 2200 Byberry Road, Hatboro, Pa. 19040, (215) 674-4800.

Vermeer introduced the M-455A underground trenching machine, which is also designed to perform a variety of dirt handling functions. The M-455A comes equipped with 15,000 lb. (6795 Kg.) full-floating axles and two power selections (Deutz F3L-912 or John Deere 3164D Diesel). The M-455A digs 6 to 18 inches (20-46 cm.) wide, down to 84 inches (213 cm.) deep with dual auger spoil control. Additional job-matched attachments include offset trencher, combo, backhoe blade, vibratory plow, dozer blade and concrete cutting wheel.

For more information, contact Thom Summit, Vermeer Manufacturing Co., Dept F, Pella, Iowa 50219.

Alpha Technologies has announced the "UP" series of uninterruptible CATV standby power supplies. The power supplies provide continuous uninterruptible power which allows cable networks to carry high-speed data transmissions. The "UP" series will be displayed at Booth 884 at the Western Show in Anaheim, Calif. Delivery of the "UP" Series is expected in January 1986.

For more information, contact Garett Hennigan, Product Manager, Alpha Technologies Inc., 1305 Fraser St., D-5, Bellingham, Wash. 98226, (206) 647-2360.

Gardiner Communications Corp. announced the production of new micro LNAs and micro block downconverters. These units are designed for the LNA, block downconverter and LNB markets. Benefits include a smaller cube, lighter weight, service accesssibility and a two year exchange warranty.

For more information, contact Gardiner Communicatons Corp., 3605 Security St., Garland, Texas 75042, (214) 348-4747.

Available from **RMS** is a new CATV division catalog. The three-ring bound book is divided into 12 sections encompassing the entire product line produced by RMS. The products in each section are depicted with photographs, specifications and selling features (where applicable).

For more information, contact RMS Electronics Inc., 50 Antin Place, Bronx, N.Y. 10462, (212) 892-1000 or (800) 223-8312.

Klein Tools has introduced new cable benders. The cable benders have a black oxide finish, hi-electric double-dip orange coating and contoured handles. The bender #50400 measures 12 inches in length and has a 7/8-inch wide opening head. The bender #50402 is 14

1/2-inches in length and has a 1 1/64-inch opening.

Also available from Klein Tools are two new models in their locking plier line. The 7- and 10-inch locking pliers are made of top-grade alloy steel and are heat treated.

For more information, contact Linda Brill, Marketing Assistant, Klein Tools Inc., 7200 McCormick Blvd., Chicago, Ill. 60645-2791, (312) 677-9500.

Scientific-Atlanta has announced a mid-split diplex filter for its line of LAN distribution amplifiers. The filter is aligned with IEEE 802.4 standard frequency splits for data communications applications. The diplex filter is retro-fitable into any currently installed S-A trunk or distribution amplifier. A frequency split of 5-112 MHz to 150-550 MHz allows for up to 18 reverse and 67 forward channels over standard broadband coax.

For more information, contact Larry Bradner, General Manager, Broadband Communications Division, Scientific-Atlanta, One Technology Parkway, Box 105600, Atlanta, Ga 30348, (404) 925-5517.

Compucon Inc. has announced a service that integrates marketing and engineering analysis into one management tool. The new service, BEAM (Broadcast Engineering and Material), serves general managers and engineers who want to analyze the impact the must-carry rule change will have on their business. BEAM allows cross-media analysis between cable, broadcasting and demographics.

For more information, contact Marjorie Zielke, Marketing Manager, Compucon Inc., P.O. Box 809006, Dallas, Texas 75380-9006, (214) 235-5300.

Zenith announced the introduction of a new VHS hi-fi VCR, model VR4100. The VR4100 includes a 14-day, eight-event timer, built-in MTS decoding circuitry, a 178-channel quartz electronic tuning system, four video heads and two VHS hi-fi audio heads and a video operating guide.

For more information, contact Zenith Electronics Corp., 1000 Milwaukee Ave., Glenview, Ill. 60025, (312) 391-8181.

Introduced by **Topaz Inc.** is a guide for selecting the correct Topaz power conditioning system. *Solutions to Power Problems* discusses power disturbances, identifies their causes and effects and offers solutions to each.

For more information, contact Topaz Inc., 9150 Topaz Way, San Diego, Calif. 92123-1164, (619) 569-7982.

Signal Vision Inc. will unveil a new directional tap at the Western Show in December. The tap offers electrical and mechanical standards, small packaging, 500 MHz bandwidth, brass "F" ports, urathane finish and a new R.F.I. gasket. The taps will be available Feb. 1, 1986.

Also introduced by Signal Vision is The Thread Protectors, a rubber sleeve which seals the area where male and female F fittings meet. The Thread Protectors stop water and chemicals from corroding the two fittings together.

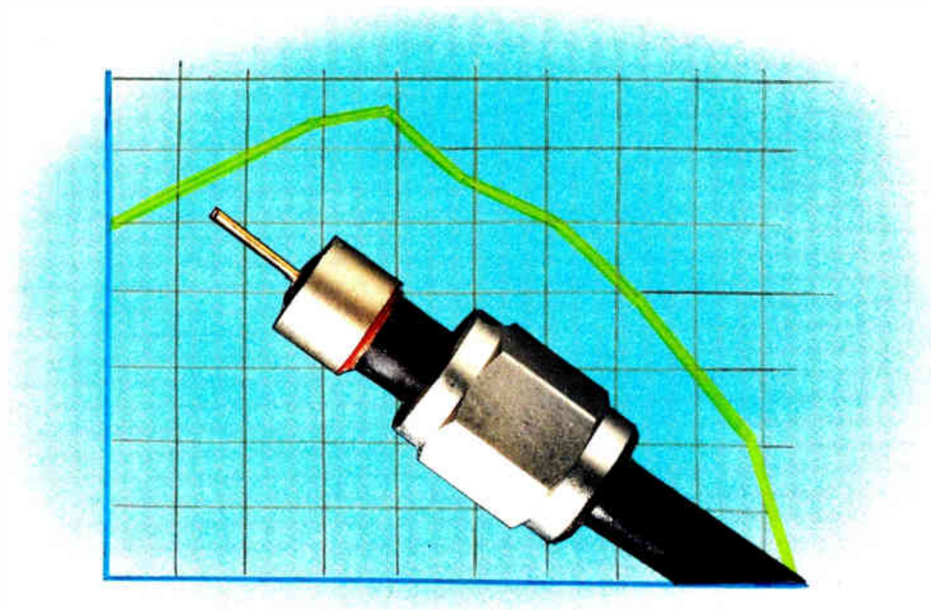
Samples of both products will be available at the Western Show, Booth #984.

Available from **Burkeen Manufacturing Co.** is the Arbor Master 45 tree spade. In either truck or loader mount, the Arbor Master 45 features a 1,500 lb. root ball and is completely hydraulic.

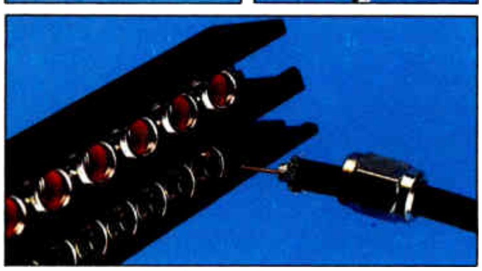
For more information, contact Burkeen Manufacturing Co., 11200 High Point Cove, Olive Branch, Miss. 38654, (601) 895-4150.

Advertiser's Index

Reduce maintenance budgets with the EZF™ Connector System...



Raychem's new EZF Connector System addresses the problems of F-Connectors — RF leakage and moisture penetration — which are among the leading causes of maintenance problems for a cable-TV operator.



EZF is not just a connector, but a system that provides complete, long-lasting performance. Its new design assures superior mechanical strength, tight electrical connections and environmental sealing.

The EZF Connector System has gone thru extensive environmental testing. UV exposure, waterhead testing, thermocycling and salt spray exposure are some of the tests that the EZF System has been designed to pass and still provide exceptional RF shielding.

Features of Raychem's EZF Connector System.

1. One connector fits RG-59, cable and one connector fits RG-6 cable.
2. The only connector available today that provides RF shielding of 100 db at 300 MHz after thermal cycling and salt spray exposure.
3. The system provides an environmental seal at both the cable jacket and port thread interfaces.
4. Reduces finger tight connections and subsequent trouble calls.
5. Crimp tools are no longer needed. A common 7/16" wrench does the final tightening and installation.
6. Cable preps are accurate each time with the EZF Cable Preparations Tool. (For use on both RG-59 & RG-6)
7. Identify customer service with different colored EZF Sealing Boots.

Raychem + ANIXTER®

WEST-ANAHEIM: (714) 778-4414, (800) 854-0443; **ANCHORAGE:** (907) 274-8525; **DENVER:** (303) 373-9200, (800) 841-1531; **FAIRBANKS:** (907) 456-1815; **SEATTLE:** (206) 251-6760, (800) 426-7665; **MIDWEST-CHICAGO:** (312) 364-7000, (800) 544-5368; **DALLAS:** (214) 484-2933, (800) 231-5006; **SKOKIE, IL HDQTRS:** (312) 677-2600; **ST. LOUIS:** (314) 423-9555, (800) 325-8058, **EAST-ATLANTA:** (404) 449-6533, (800) 241-5790; **CINCINNATI:** (513) 733-9100, (800) 543-0113; **NEW JERSEY:** (201) 328-0980, (800) 631-9603; **TAMPA:** (813) 626-7115, (800) 237-6466; **CANADA-CALGARY:** (403) 250-9456; **MONTREAL:** (514) 637-3511; **TORONTO:** (416) 625-5110.

In an emergency, weekends and holidays or after 5 P.M. call toll free 1-(800) 323-8167.

CORPORATE OFFICES, ANIXTER BROS., INC., 4711 Golf Road, Skokie, IL 60076, (312) 677-2600

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