Modulators

CED

Communications Engineering & Design/The Magazine of Broadband Technology

August 1985

Ciciora: Interface standards
Sirazi: IPPV ordering
Gates: Open system networks
Taylor: Leading ghosts
Kirby: dB/dBmV basics

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CED™

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About the cover

Pictured is one of the integrated circuits used by ITT for digital TV signal processing. Photo used courtesy of ITT Semiconductors, Freiburg, West Germany.

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Reader Service Number 3

Len Ecker

Len Ecker is concerned about the future of cable. And with good reason. Thirty-five years in the cable industry have given him a pretty clear perspective on where we are and where we should be headed. "A very serious problem exists in the cable industry because nobody that I know of has taken a long hard look at what a cable system really ought to look like in the very near future," he states. "An awful lot of lip service is paid in the industry to providing services other than just straight entertainment TV. But I don't think the modern-day system, as conceived either by the industry or the manufacturers, is conducive to doing anything but entertainment TV. And if someone doesn't take a close look at our actual potential soon, we may be in danger of losing this industry because other people are becoming interested in what could be done on a closed system like cable.

"We have a fantastic plant, but only a small portion of it is being used today. There is absolutely no limit to what could be done. When you get right down to it, cable is just a piece of pipe. It doesn't care what you put on it or in what direction it goes. It's just a shame that we don't do more with it. I guess the cable industry is probably one of the worst examples of ancestor worship around. We do what we do because we've always done it that way. It's easy to operate like that if you can make money doing it, but I'm afraid those days are numbered."

Best known for his training efforts for the Jerrold Division of the General Instrument Corp., Ecker started out in cable in 1950 by designing and building a system in Williamsport, Pa. Two-and-a-half years later, after all the system's initial glitches had been worked out, Ecker began doing consulting work on cable systems in Nevada, Texas, West Virginia and Pennsylvania.

In 1956 Ecker joined Jerrold as a design and development engineer. He was chosen to be part of a training team from Jerrold to work with technicians on Jerrold systems. When Jerrold received a contract from the Federal Communications Commission in 1962 to do a survey in New York City to determine the merits of UHF versus VHF television transmission, Ecker was appointed the project engineer for the study. "I really got into the training aspects of the project because all my employees in New York were temporary with little or no electronics background." Based in part on the Jerrold survey, the FCC mandated in 1965 that all television sets manufactured for use in the United States be UHF and VHF compatible.

Upon returning to Jerrold headquarters in Pennsylvania, Ecker became the chief test engineer at its manufacturing facility. From there, he was promoted to plant manager of the microwave division. When Jerrold stopped making microwave equipment, Ecker returned to headquarters as a staff engineer. "At that point, I organized for Jerrold the first almost world-wide service organization consisting of field engineers. Again, a big function of that job was training."

Shortly, Ecker found himself in charge of Jerrold training efforts, giving three-day seminars to cable techs all over the country. And he has been giving his famous seminars ever since. Ecker managed the field engineers for 10 years before forming the applications engineering department at Jerrold.

After retiring in October 1982, Ecker returned to his first love—consulting. He still conducts one seminar each month for Jerrold in addition to taking care of the technical part of its trade shows and acting as a sort of liaison for its management and engineering departments.

Considered by many the master of technical training in cable, Ecker has some pretty definite thoughts on the subject. "The entry-level technician has got to be much more technically knowledgeable than he is at this moment," Ecker claims. "The industry is moving into areas that require a lot more technical competence than was needed a few years ago. Then, cable was a fairly simple technology, but with the advent of computers, addressable systems, status monitoring and attempts to use cable for more than just entertainment television, more demands are placed on the people who operate and maintain the cable system."

A background in electronics should be a prerequisite for cable technicians, according to Ecker. "A lot of the things written for the cable industry are a little bit difficult for people who do not have a good solid background in electronics to understand," he notes. Ecker would also like to see more cable systems provide or, at least, actively encourage basic training for their technical staffs.

The gauntlet is down. Let's take it up before it's too late.

—Lesley Dyson Camino

Direct pickup

By Archer Taylor,
Malarkey-Taylor Associates

Most cable people attribute direct pickup (dpu) in TV receivers to inadequate shielding. In 1965 Ronald Mandell and George Brownstein invented the dual heterodyne cable TV converter to deal with this problem (U.S. Patent 3,333,198; July 25, 1967). They believed that shielding was at fault. The first model they built and demonstrated in Manhattan, N.Y., was shielded with multiple solid brass plates carefully soldered to form a highly effective topological shield through which no self-respecting signal, however strong, could leak. It was a beautiful piece of brasswork and very heavy.

Look at the converters you are using today. Shielding is obviously not comparable to Ron Mandell's brass box.

True, 300 ohm twinlead does have some radiation resistance, and ordinary shielding integrity can be penetrated at field intensities of one or more volts per meter. However, common mode coupling turns out to have been the major culprit.

Consider the diagram below of a typical 300 ohm TV input circuit. Currents are induced by the strong local fields on the aluminum sheath of the distribution system and the drop cable braid, acting like a long wire antenna. These currents are connected directly to the center tap of the 300 ohm side of the external matching transformer supplied by the cable operator. If this point is located *precisely* at the center, the induced sheath currents will divide equally; exactly half flowing in one side of the twin lead, half in the other side. If the internal transformer at the tuner input also is precisely balanced to the chassis ground, these two equal currents will oppose each other in the 300 ohm primary and produce zero current in the secondary connected to the tuner.

However, if either (or both) of the transformers is not precisely balanced, the unequal opposing currents in the tuner balun will not cancel; and a residual current will be coupled to the tuner. This would happen even if the twin lead were perfectly shielded from the strong fields.

Signals picked up on the cable sheath arrive directly, over the air, from the transmitting antenna. It takes a longer time for signals picked up at the cable headend to travel through the coaxial cable to the subscriber, along a roundabout route. Thus, the desired signal arrives later and is displayed to the right of the undesired signal coming directly from the TV stations. It is said that the direct signal is a "leading ghost" of the desired cable signal.

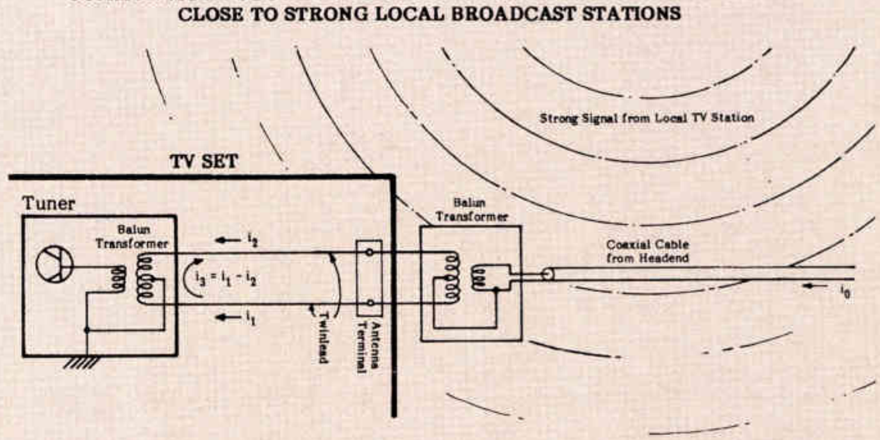
The dominance of common mode coupling can be demonstrated with a portable, battery-operated monochrome TV set that has been completely covered with aluminum foil, operated within several miles of a VHF TV transmitter. No trace of the TV picture can be seen, whether the 300 ohm antenna terminals are open, short-circuited or terminated. But connect a cable TV drop, through a cheap 75/300 ohm balun, and the picture with its leading ghost appears. Insert a 40 dB in-line pad between the drop and the TV set to take out the picture transmitted by cable. The picture that remains is the leading ghost, picked up on the drop cable braid and introduced into the TV set through common mode coupling.

Fortunately, many of the newer-model TV receivers appear to be much less susceptible to direct pickup interference. Elimination of the 300 ohm twinlead and both balun transformers is almost totally effective. However, merely providing a 75 ohm F-fitting at the back of the TV set may not be effective if there is also a 300 ohm antenna terminal connected to it through a balun, or even a switch with insufficient isolation.

Except in rare situations, a converter with 75 ohm terminals, and output on an unused channel, effectively avoids the problem. Headend conversion of local channels to unused channels also solves the problem for the local station, but not for any other programs that may be assigned to the off-air frequency of the local station. Because of the widespread use of converters in VHF markets, some cable technicians may have never encountered the problem of direct pickup in TV sets.

Increasing the subscriber terminal signal level may be helpful up to the point where overload distortion takes place. Well-balanced matching

COMMON MODE COUPLING TO TV SET WHEN CONNECTED TO CABLE TV CLOSE TO STRONG LOCAL BROADCAST STATIONS



$i_0 = i_1 + i_2$

If the transformers are balanced, $i_1 = i_2$ and $i_3 = i_1 - i_2 = 0$

But if they are not balanced, $i_3 \neq 0$

and i_0 is coupled to the tuner.

transformers may help, but cannot solve the problem if the internal balun is not also well balanced. Connecting a center tapped potentimeter across the antenna terminals permits precisely matching the external balance to the internal, so the common mode signal can be nulled. This only works for one channel, however, and tends to drift over time. Some success has been reported with ferrite chokes properly spaced on the outside of the drop cable. Again, this works best when the chokes are spaced ¼ or ¾ wavelength. The spacing is a compromise at other frequencies. Reversing the 300 ohm leads of the external balun sometimes helps by making the balance error of the external transformer more nearly the same as the balance error to the internal transformer.

None of these cures for dpu can have any effect on leading ghosts caused by ingress of the direct signal into the cable system itself, through loose or corroded F-connectors, cracked cable, or any of the many other sources of ingress. Direct signal ingress is probably a more sensitive detector of coaxial cable defects than signal leakage, especially if the signal on cable is not phase-locked to the strong local fields, as in all HRC and some IRC systems.

A leading ghost that is not eliminated with a converter is almost certainly caused by ingress in the cable. To determine whether a leading ghost, with no converter, is caused by direct pickup in the TV set or ingress in the cable network, connect a variable attenuator between the TV set (75 ohm terminal or balun) and the cable drop. The ghost picked up in the TV set is normally weaker than the desired cable signal. Therefore, the ghost will get stronger as the attenuation is increased and the desired cable signal is decreased. If the ghost gets weaker, along with a decrease in the desired signal, the ghost must be picked up in a cable leak. In fact, as a rough measure, the effective signal level of the ghost picked up in the receiver is roughly equal to the level of the desired signal transmitted by cable when the latter has been attenuated to the point at which the TV set is unable to synchronize to either.

If the desired cable signal is phase locked to the direct pickup signal, the effect will be simply a leading ghost. But if there is a small difference in the frequency of the two signals, horizontal co-channel interference bars will be observed. In an HRC system, where the cable channel cannot be phased locked to the direct TV signal, the interference is likely to be a cross-hatch interference pattern. Processors that use a common local oscillator for both up and down conversion inherently provide phase lock to the direct pickup. The threshold of interference is 20 to 30 dB better when the desired signal is phaselocked to the direct pickup.

A flood of applications have been submitted to the FCC for low power television (LPTV) permits proposing to utilize previously unused VHF channels with 100 watts or less ERP. Apparently, some LPTV applicants were not aware that the channel they proposed to use may have been the same channel selected by the cable operator for the converter output, precisely because it was unused. Direct pickup interference from the LPTV station would certainly cause severe problems that could only be solved by replacing converters already in service. The FCC recognizes the potential for interference with CATV converter output channels and assigns priority to the earlier user. However, you must be alert to LPTV applications because there is a fairly short window for protests. It will be difficult to upset an LPTV grant if you let the protest period pass without action. So far, the FCC has not had to rule on the kind of evidence required to support such a protest because all cases to date have either been withdrawn or settled by negotiation.

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Volume 11, No. 8

CED

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In Perspective

Witches' brew?

It isn't clear yet whether the continuing changes in consumer electronics will give us indigestion or provide a tasty meal. But there's no doubt major changes are simmering, and consumers are holding the ladle.

We can bemoan, applaud or fear the stimulation of consumer appetites for VCRs, stereo-capable or cable-compatible TVs. It makes little difference. Consumer appetites are being whetted, the fire under the cauldron is lit and, so far, people show no inclination to give up their spoons.

And as Walt Ciciora and Geoffrey Gates point out in this issue, some major changes in our industry's historic organizational and technical patterns may be in the offing.

Consumers are being exposed to, asking for and using more appliances than ever. They're integrating the components like never before and are seeing and hearing better quality signals than ever before.

They're paying for more intelligence in most of their appliances and aren't happy when connection to our systems negates all that intelligence. It isn't likely they'll passively tolerate this forever. And they do have other choices.

But so do we. As both Walt and Geoffrey point out, we do have options. We can design better interfaces so consumers don't lose those valued options they've paid for. And we stand to save ourselves an awful lot of money in the process.

How? Primarily by getting out of the converter business. The telephone industry already has done so—separating network management from the business of customer premises equipment.

In essence, both Walt and Geoffrey envision a future in which cable operators provide the pipeline to the home, while subscribers own the rest of their equipment. We'd still have to worry about protecting our systems from ingress, maintain isolation and so forth, but we would radically reduce our capital needs and theft exposure.

Some important work has been going on in the area of making cable plant more friendly to consumer devices of all sorts. Walt's article will bring you up to date.

Geoffrey speculates a bit on the advantages of a transition from closed- to open-system networks. Read both pieces carefully. These ideas may well represent the technical future of our industry, and they deserve close and detailed examination.

We're not selling buggy whips, but what we sell could go that way. The way to avoid such a fate is to pay close attention to the swirling, sudden changes going on out there. We can't stop the changes, but we can adapt.

"Tune in, turn on, drop out" once was a slogan for a generation of youth. We could give those now-grown consumers a new jingle if we're not careful—"Tune out, turn off, change out."

It's a possibility; not an inevitability. What we do now makes a difference.

Gary Y. Kim


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Reader Service Number 6

RF Cable/Decoder Working Group

By Walter Ciciora, Ph.D.,
Vice President,
Research & Development
American Television &
Communications Corp.

Standards committee progress often is painfully slow. To a newcomer, especially someone accustomed to the "fast lane," this activity can be frustrating. There are several points to be made about this. Firstly, if cable interface and decoder interface standards were easy to achieve, they'd have been agreed upon a long time ago. Secondly, the issues being settled are delicate points involving trade-offs that impact the economics and performance of two industries. These two industries have a history short on cooperation and long on animosity. Fortunately, the trend toward cooperation is on the upswing.

At first blush, it would seem difficult to find two industries with more reason to cooperate than the cable television industry and the consumer electronics industry. Better pictures should enhance satisfaction in cable service, and more choices should increase the desire for quality images. I believe that most of the difficulties are caused by a lack of information and misunderstanding. Open, honest and frank contacts should be helpful to all. That is the purpose of this discussion.

Structure

In 1982 the NCTA and the Electronic Industries Association (EIA) formed a Joint Engineering Committee to discuss technical issues that impact both industries. The committee's first order of business was to create a channelization standard for frequency assignment. After considerable debate, the committee recommended the plan which became an EIA Interim Standard for one year. It recently emerged from this probationary phase to become an official recommended standard.

It is important to note that these are voluntary standards. Neither the NCTA nor the EIA has enforcement powers. Adherence to the standard depends on the good faith of the companies involved.

After the channelization standard, two Working Groups formed to consider a cable interface standard and a decoder interface standard. Shortly after formation of the Decoder Interface Working Group, it was discovered that the EIA R-4 Group had its own decoder interface group. Seeing little point in duplication of effort, the Joint Committee Working Group disbanded.

Attitudes

An important reason for the successes of the Joint Committee is a change of attitude on the part of the participants. In the past, cable/consumer electronics relations were marked with finger pointing and name calling. Very important technical trade-offs were the focus of arguments which had significant economic impact. Now, a realization has been achieved of the importance of customer satisfaction. The consumer/subscriber must be satisfied if the two industries are to prosper. It is pointless to shift blame. The customer/subscriber demands satisfaction from both industries.

A significant step in the right direction was the relaxation of what has been called the 70 dB syndrome. In the past, the cable industry tended to demand that any potentially harmful phenomenon be suppressed by 70 dB. The consumer electronics industry has become offended by this approach since this degree of suppression is difficult to measure for most parameters and impossible to achieve in practice. The result has been near zero progress.

The 70 dB syndrome was replaced with a much more reasoned discussion of actual problems. A phased approach was recommended which sets achievable targets, timed to cover frequency ranges as they are implemented over time. When a cable rep believes a specification is needed which the manufacturers cannot presently achieve, a tutorial is included. This motivates the manufacturers to strive for a solution in future designs.

A subject of intense discussion in the cable industry today is the "cable-ready" or "cable-compatible" TV set. Much of this debate applies to other consumer products such as VCRs. But first, a couple of comments. It is a fact of life that nothing is ever really ready. If, by chance, it comes close to being ready, something will change to make it less ready. A second fact of life is that "compatible" is a rubber word that is stretched to meet the needs of the moment. In the strict sense, compatible means that two things, like a TV set and a cable system, work perfectly together without any loss of functionality of either. In the loose sense, compatible means that they both run on electricity. "Compatible" is used in the loose sense more often than in the strict sense.

Cable-ready TV is a receiver with a premium tuner, the correct 75 ohm connection and, usually, remote control. The customer's benefits in selecting such a model include convenience features and substantially increased reliability because of the electronic (versus mechanical) tuner. Under certain circumstances, the customer also may enjoy the ability to connect directly to cable.

Let's investigate the requirements for full cable compatibility. There are only two: 1) The channels the subscriber is interested in receiving must be available without having a tuner ahead of the TV receiver. 2) TV signals must not be directly picked up off-air by the TV's internal circuits. This potential problem is called DPU for direct pick-up.

The first requirement can be satisfied in several ways: a) The cable system uses traps for signal security. b) The subscriber is not interested in the scrambled channels and is satisfied with those that are in the clear. However, the trend will be toward more scrambling for purposes of tiering. c) A decoder and a TV receiver that interfaces to the decoder are used. At the present time, the only example of this

Interface progress report

are recent Zenith receivers and a version of the Zenith cable descrambler.

The second requirement is satisfied if: a) The subscriber is fortunate to not live near broadcast antennas, or b) The receiver's internal shielding is adequate to protect against DPU.

When the above requirements are not satisfied, a cable-operator-supplied converter must be placed ahead of the TV receiver. It should be emphasized that this represents a capital investment and the placing of property at risk of loss. The cable operator would much prefer to avoid these negatives. The cable business is a service business selling programming. The cable operator is better off using his limited capital to build more miles of plant so he can hook-up more subscribers than in putting that capital in the homes of existing subscribers. The investment and maintenance of hardware, particularly in-home hardware, is a necessary evil.

Several problems arise when a cable-ready receiver is connected to a set-top converter. The most severe is that the channel changing feature of the receiver's remote control is lost. Most set-top converters include a switched convenience power receptacle. Unfortunately, nearly all modern remote control receivers behave in an incompatible manner when plugged into these switched power outlets. When power is removed from the line cord of these modern receivers, they go off but will not come back on when power is applied. Thus, the subscriber must separately turn the receiver on.

Additionally, the receivers usually revert to channel 2 and forget their previous volume setting. Since the output of most set-top units is on channel 3, 4 or, occasionally, 5, the subscriber must retune the set.

The cable operator's objection to the sale of cable-ready TV is the frustration his subscriber feels when the promise of cable ready is not realized. Often the subscriber feels that the cable operator should somehow share in the responsibility for this disappointment. In the extreme, the subscription is cancelled. This is a life and death matter for the cable operator, and he has no logical choice but to do all he can to overcome these problems.

In those cable systems where cable-ready TV receivers function satisfactorily, multiple TV receivers can be connected without the need for cable converters. There are several potential hazards centered around unauthorized connection of these receivers. The most obvious potential problem is splitting the signal too many times, resulting in snowy pictures. Both the cable company and the TV dealer will likely receive complaints. But this is not the only problem. There is a more serious reason for controlling multi-set hookups. When the do-it-yourselfer makes these hook-ups, cable signal quality usually suffers. Often he will use TV twin wire or even lamp cord. Even when the proper cable is used, the connections usually are not tight. Signals are picked up and injected into the cable, affecting the reception of other cable subscribers. A more severe consequence is that these improper connections will radiate signals that may interfere with other services. Of particular concern is radiation in aircraft navigation and communication frequencies.

RF cable interface Working Group

The RF Cable Interface Working Group's major concern is the cable-compatible consumer product, such as the cable-ready TV. The committee very quickly got over the issues of connector type, impedence and signal levels. A more serious problem has been DPU.

The committee has taken voluntarily committed receivers and measured them in a T.E.M. (Transverse Electra Magnetic) cell. The tests were funded by the EIA, and each manufacturer received data on its products. However, a non-identified table of data was supplied for committee use. Sets ranged in performance from satisfactory behavior in fields of a couple of volts per meter, to sets with considerably lower levels of tolerance. Manufacturers have been carefully considering the art of radiation immunity as it applies to their products. Progress has been made.

The committee agreed upon an Interim RF Cable Interface Standard and is in the process of gaining the approval and endorsement of its parent groups. The most significant aspect of this new standard is a ten times increase in the direct pickup specification. Under this new standard, a complying product must not show noticeable degradation of performance in the presence of broadcast electromagnetic fields having a strength of one volt per meter. The previous specification came from the Canadian standard and was based on one tenth of a volt per meter. It is expected that the new standard will cover 80 percent to 90 percent of all cable DPU problems. The remainder will require a converter to completely solve the problem.

The TV receiver manufacturers have taken on a significantly greater burden with the new standard. This level of performance will be difficult to achieve. However, the customer/subscriber will benefit. This achievement demonstrates that two industries can work together to resolve difficult issues when a cooperative approach is employed.

Cable converter product also will be measured in other consumer products in T.E.M. cells. The goal is to understand techniques for implementing converter's seemingly better performance.

A reoccurring problem in this committee work is the separation of performance standards from interference standards. It is felt that the regulation of performance is best left to the marketplace. However, the control of interference is a bona fide standards matter. Four kinds of interference have been considered in order of increasing severity: 1) interference with the product's own performance, 2) interference with other products in the same home, 3) interference with other subscribers' reception and 4) interference with other users of the electromagnetic spectrum, such as aircraft navigation and communications radio.

Long term future

The logical conclusion for the trends in CATV home terminals is for subscriber ownership. This is the best outcome for nearly all concerned. The subscriber has his favorite hardware relationship—ownership. Unlike his European cousin, the U.S. TV receiver user has always preferred ownership to rental. The same should apply to the decoder hardware. This will especially be the case if he can

own the tuner, remote control and other convenience features as part of the bargain. These later goals are achieved by having the descrambler come after the TV receiver's tuner.

There are two ways of accomplishing this. One way has a "decoder interface plug" on the back of the TV receiver (or VCR, etc.) into which the subscriber-owned (or leased) descrambler fits. The second method is to build the decoder directly into the receiver by the receiver manufacturer. The latter will happen if there is a de facto or actual decoder standard which would permit free movement from cable system to cable system. If this is not achieved, for whatever reason, then plug-in, re-sell or swap devices will be required.

Most disturbed by this approach are home terminal manufacturers that don't also make TV receivers. More than half of their product's "value added" is eliminated. But from the bigger picture, the waste and inefficiency of having a tuner, remote control circuits and related components in the home terminal, only to have them duplicated in the TV receiver, is undesirable.

From the cable operator's point of view, the program protection method must ensure that subscribers cannot defeat the system and receive the programming free. Other interested parties in all of this are the programming producers. If they believe their products can be stolen, they will not make them available to the cable operator. The cable operator realizes that the would-be pirate has nearly unlimited time and resources at his disposal. Engineers will use their employers' equipment and facilities to try to meet the intellectual challenge. Some would try to convert this mental exercise into a financial advantage.

The system which meets this test will be robust indeed. It can be predicted that the U.S. National Bureau of Standards Data Encryption Standard, DES, will be required to yield adequate confidence. Once this assurance is obtained, the cable operator will gladly give up the capital requirements caused by the need to supply the descramblers. This money would be better invested in more programming, service-enhancing facilities or home terminals that provide new services to subscribers.

The Decoder Interface Working Group

The Decoder Interface Working Group is not a Joint Committee effort; rather, it is entirely an EIA activity. In spite of this, there has been significant friendly dialogue between the two industries. Specifically, there have been cable industry contributions to the design and testing of the interface plug.

The interface plug also is called the Cenelec 20 pin plug. Even with twenty pins, the committee wished it had more! Red, green and blue, RGB, as well as composite video in and out are provided. A data line pair to communicate logical instructions, such as EIA Homebus signals, has been provided. Some day in the future, it will be possible to connect consumer electronics products to a master home system. Fast blank for text insertion and decoder restored sync input pins are provided. Devices with the interface plug are intended to be "daisy chained." That is, devices may be designed in such a manner as to be connected in series, allowing interaction between devices and an extension of product into an easy-to-use, consumer-friendly system.

The most serious and controversial issue regarding the interface plug is automatic gain control (AGC) design philosophy. AGC has two modes of operation with strongly conflicting demands, acquisition and stable operation. The circuit time constants must be different for these two modes. Additionally, the AGC time constants of the cable converter and TV receiver must be significantly different so one is dominated by the other. If the two time constants are close together in value, oscillations may result.

The problem is that some receiver manufacturers are using long time constants while others have decided upon short time constants. An important difficulty to appreciate is the fact that in scrambled mode, most systems suppress horizontal sync pulses. For decades, television AGC design philosophy has depended on finding and accurately measuring sync pulse parameters. The two processes fundamentally conflict. Without sync pulses, there is a tendency for the amplifiers to increase gain and saturate. This crushes the signal and ensures that sync pulses will never be found. This "lock-out" condition is a disaster that must be avoided. It is most complicated in systems that suppress sync pulses in the vertical interval as well. This phenomenon is extremely non-linear and not well understood. Some engineers insist that there is no theoretical basis for these systems to ever work. They claim that each time the system achieves synchronization and decoding, it is simply

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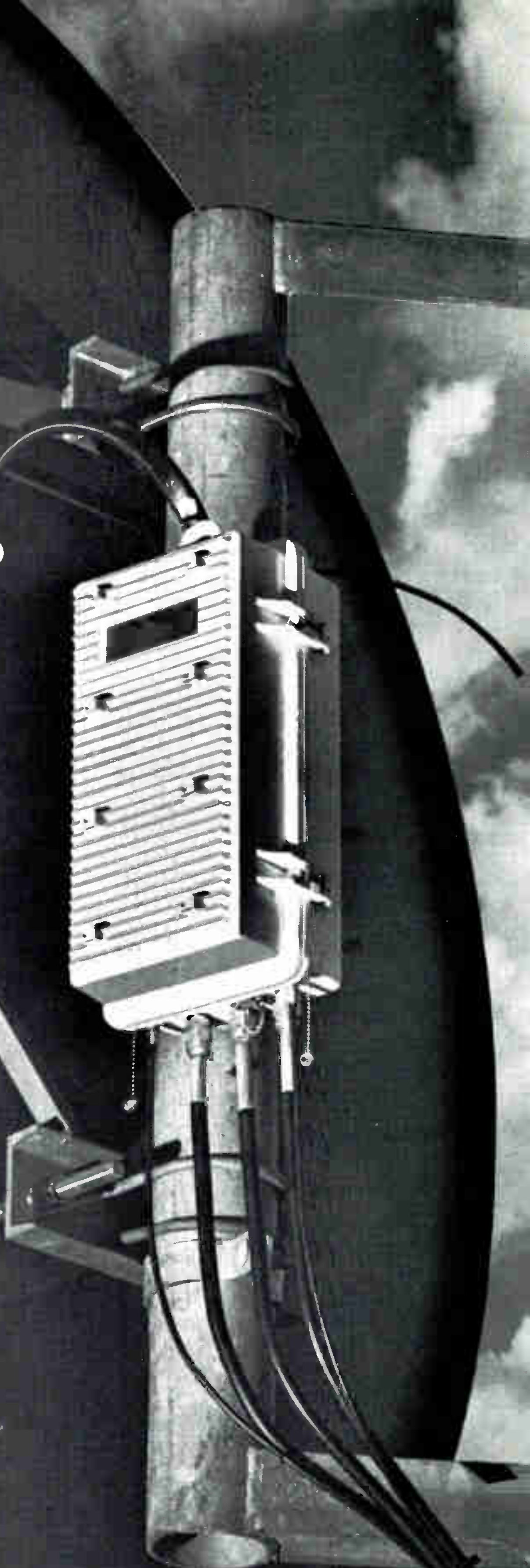

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a fortunate electrical accident!

One serious complication is the fact that AGC expertise in TV receivers is a scarce commodity. There are probably less than 20 experts in the entire world. The subject is very complex with almost no published technical literature. Engineers become experts in this field through years of apprenticeship to an existing expert. A second complication is that competitive performance between manufacturers' products is largely determined by AGC characteristics. To someone who appreciates this, the committee interactions take on a whole new dimension. There is the careful guarding of secrets, the pained release of just enough information to make the interface plug system work, but the anxiety that too much may have been revealed to a competitor.

The Decoder Interface Working Group has had two field tests in ATC's cable systems in Denver, Colo., and a third is expected in October 1985. Several TV receiver manufacturers and several decoder manufacturers participated with varying, but basically very good, results. The level of success exceeded expectations and re-energized the committee. At least one receiver manufacturer's engineers formed a strong alliance with a decoder manufacturer's engineers. Extensive cooperation and mutual sharing of information resulted in a raising of the potential for success of these two companies. At least one other manufacturer took a very unfriendly, parochial approach in the first test which offended the other participants. This caused embarrassment to others at that company who have worked long and hard to establish a record of cooperation and leadership. By the second test, this problem was corrected.

The best indication of the success of the field tests was the lively interchange that took place afterwards, resulting in significant improvements in the proposed standard. The most interesting improvement at the time of this writing is the proposal of an AGC time constant control pin which would yield control of the time constant to the decoder.

Current tests have concentrated on baseband scrambling schemes because the interface plug connections do not include RF signals. However, the October field test is planned to include baseband decoder circuits which will be used with more traditional RF scrambling. This will significantly expand the demonstrated applicability of the concept.

Committee agreement on the interim standard is expected by year end. Then the parent group approval process will begin. Several manufacturers are planning to cooperate in a display of the standard at the January 1986 Winter Consumer Electronics Show in Las Vegas, Nev., and also at the 1986 NCTA Convention. First availability to TV receivers incorporating the interface plug likely will be in late 1986.

The committee has a life cycle of its own. At first there is a small group of attendees trying to make it happen. Slowly, the group expands until so many attend that it's difficult to get anything done. After several months, those low on patience stop attending. Decision-making picks up. Then some dramatic event such as a field trial takes place. Once again, attendance soars posing a new danger to progress. New members attend for the first time. They start questioning the fundamental philosophy. Old ground is revisited. The skillful chairman must maintain progress, yet not turn off the new attendees because they will have their say in the final standards approval process and must not be alienated. As the committee reaches the end of its work, two forces begin to conflict. Those who have put in years of work want to bring it to a close. Others who have been alerted to the committee's work by the expected issue of a new standard become alarmed. They see all kinds of threats to their interests and, of course, better ways to do the job, usually using

Continued on page 29

Hybrid IPPV

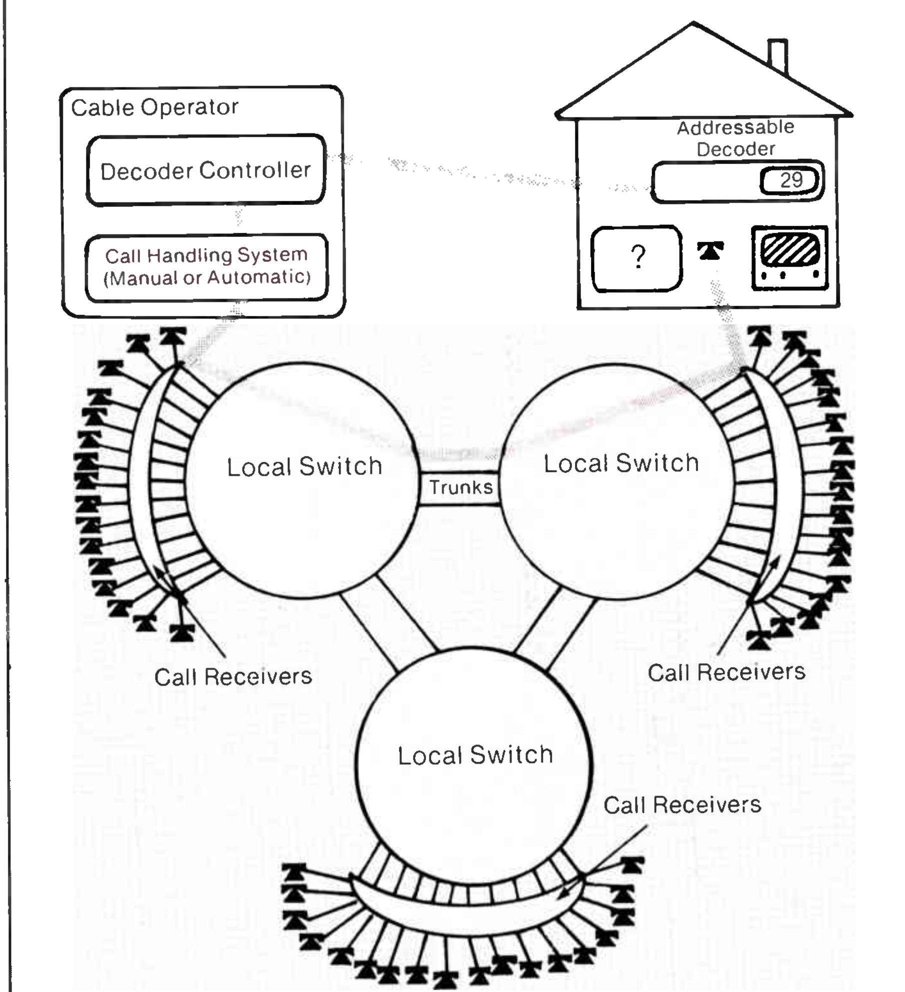
A comparative study

By Semir Sirazi, Chip Bestler,
Tom Rossen and Gordon Reichard, Jr.
Zenith Electronics Corp.

The cable industry has reached a stagnant stage with dwindling revenues. It needs a new marketing approach to generate additional revenue and increased subscriber penetration. The success of impulse pay-per-view now seems to be limited to the small percentage of cable systems with two-way capabilities. Some other less radical technology for collecting user requests on an impulse basis is necessary to bring the potential benefits of IPPV to the vast majority of cable operators.

The public telephone network can readily be used to collect user requests while the cable system is providing the video programming. Economically and technically, this is the only basis for a solution at present. Hybrid impulse pay-per-view, as it is called, has been implemented or considered in several forms. This article describes and compares these varied forms and proposes a new approach utilizing both the present telephone system technology and real-time computer capabilities. The proposed scheme also offloads the central office switch and allows a large number of calls to be processed at a higher capacity than standard call switching. The high volume of requests passed to the cable headend must be translated and validated by the headend computer to allow for timely authorization of addressable decoders. This approach overcomes most of the problems associated with other forms of hybrid impulse pay-per-view (PPV) implementations.

Figure 1
Physically connected hybrid pay-per-view



Hybrid PPV

Hybrid PPV is a system for distributing PPV programming in an addressable one-way system where the orders

cannot be received through the cable plant itself. In a hybrid PPV system, the broadband coaxial cable is used to deliver video programming while user requests are gathered through the conventional telephone switching system, replacing the upstream return cable path with the telephone network. Moreover, "impulse" buying becomes possible if the central office switch and trunks can be offloaded by frontend call processing.

Methods discussed in this article are: manual call-in, auto-dialing, credit downloading, touch-tone ordering and ANI (automatic number identification) ordering.

Manual call-in is the current "solution" used by most cable operators. Customers call in and tell an operator what program they want to buy. This information then is entered into the billing computer which, in turn, instructs the system controller to authorize the decoder.

This solution makes heavy use of phone lines, tying down a physical circuit for a relatively long period of time (approximately three minutes per transaction). In addition, it has a very limited capacity, results in blockage of orders, discourages ordering of R- or X-rated materials and has high transaction costs. Because of the delays and limited capacity, it cannot be considered an "impulse" PPV system.

A customer's picture must unscramble within seconds of their call being completed. Otherwise, there is no feedback on the success of an order.

Part of the reason for the delay is that customers must identify themselves orally. The oral identification must be confirmed and translated into a decoder address for the order to be processed. This system is relatively sensitive to human error at both ends, and the cable operator has no control over how long a transaction actually may take.

An auto-dialing system alleviates some of the problem of manual call-in by establishing the connection automatically, transmitting the information to the headend and then immediately terminating the connection, all in response to the customer pushing a button (or some other simple action). The customer interface is simpler, and identification of the customer is fast and error free. The duration of the call is shorter, averaging 10 to 15 seconds, and its processing is not labor intensive.

However, the auto-dialer is an additional (possibly expensive) piece of hardware that must be bought, installed, maintained and tracked. It also is subject to certain limitations inherent in any call-in system, most significant of which is a relatively low limit on the number of late calls. It is, therefore, not really an "impulse," but rather an advance-buy, system.

One solution to the mass call-in prob-

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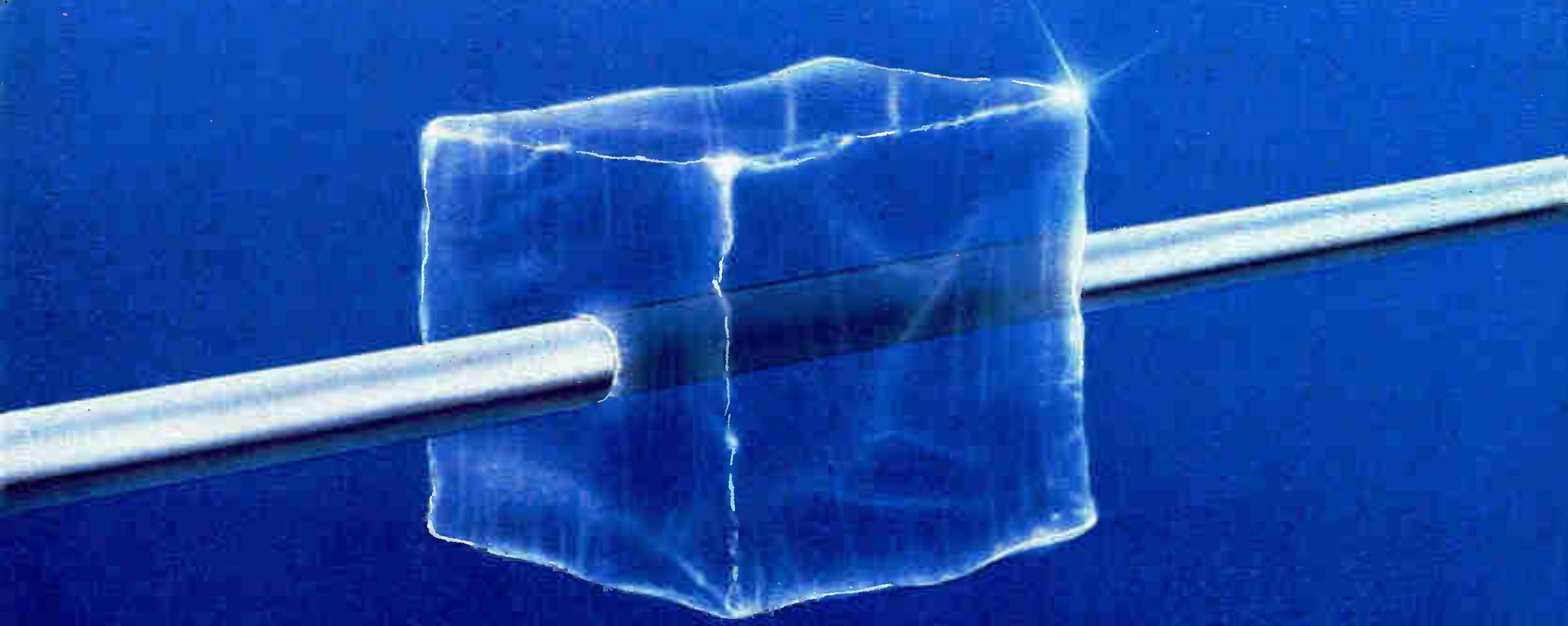

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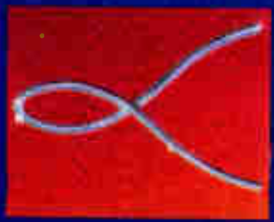

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lem is to allow the decoder to authorize itself, and then call in or be polled at a low background rate. Some sort of ordering limit is downloaded from the controller. This solution allows a very high rate of last minute purchases and has low variable costs per transaction.

However, this is still an add-on unit (or a replacement, more expensive than a simple decoder) that must be bought, installed, maintained and tracked. It is vulnerable to abuse and malfunction and may even require an additional telephone jack. If the decoder can self-authorize, then there likely are numerous ways that cheaters can prevent it from reporting the purchase. It solves the "impulse" problem at the expense of reliability, security and economy.

Touch-tone ordering

A touch-tone ordering system allows the customer to call and "talk" to an automatic order-taking device by pressing a sequence of digits on the touch-tone phone after the connection is established. It requires no additional hardware in the home and no manual processing of the orders. However, touch-tone is not universal (approximately 50 percent of customer premises equipment cannot handle touch-tone dialing), and it still requires a large volume of incoming calls—each with a moderately long connection time (an average of 60 to 90 seconds). The subscriber or user has to enter a relatively long stream of digits, which increases the probability of error.

Telephone hybrid PPV limitations

No automatic system can provide high volume phone hybrid PPV service if it requires a completed phone call—even if it could somehow process the request instantly. The first inherent problem is that the ordering customer must be identified. Customer entry is error prone and slow. Auto-dialing units are additional hardware and cost.

Most importantly, a physical phone connection (circuit switching) must be made. Phone systems are not designed to connect the cable operator to all of the subscribers who might want to order in the last 30 minutes, let alone the last five.

The telephone switching system is designed for long point-to-point sessions averaging three minutes. Hybrid PPV needs to pass one simple request and, perhaps, receive an acknowledgment. The phone system is designed around random independent usage, with 6 to 12 percent of all potential connections active at maximum. See Figure 1, "Physically connected hybrid pay-per-view," which shows that a normal call between two local switches ties up the scarcest resource in a telephone system, the trunks. PPV traffic is bursty in nature. A hybrid PPV system wants to take as many orders as possible as late as possible. The timing of orders is decidedly non-random.

A telephone circuit is a powerful resource, designed to carry the information in a full duplex audio conversation. The connection time represents a significant portion of the total operating cost of a circuit switching telephone system. PPV ordering horribly underutilizes it. It also is the scarcest and most critical resource in a phone system. The cable operator cannot afford to buy, nor can the telephone switching system afford to provide, the number of last minute physical connections needed to support hybrid PPV. The surge of requests for telephone circuits would overload the switching system.

The ANI solution

The acronym ANI (automatic number identification) is used to designate a class of hardware/software systems developed by various telephone companies to accommodate alternate long distance carriers and large PBXs. This class includes the "Bulk Calling Line ID" system.

The four main requirements for a complete ANI solution for hybrid IPPV are as follows:

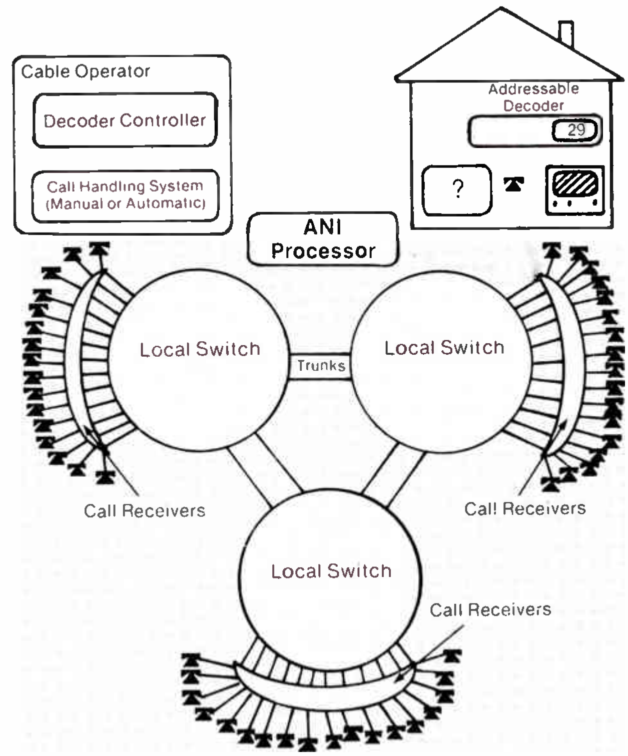
- Determine caller/selection without making a connection for each order.
- Reliably relay this data in real time to the cable operator for automatic processing.
- Perform required processing including addressing and authorizing the decoder.
- Post transactions into billing system.

Getting the orders

ANI alleviates the overload problem by intercepting the ordering "call" *before it becomes a physical connection*. It extracts the information required (caller telephone number and caller-entered digits pertaining to ordering information) and passes it out in serial data output form. Because physical connections are not set up, the switch is not overloaded. See Figure 2, "The ANI solution for impulse pay-per-view," for a graphic depiction of the (pardon the expression) "bypass" of the local switches and trunks made possible by the ANI system.

The caller also is reliably identified because the calling phone number is supplied automatically by the switching system itself. Therefore, no customer

Figure 2
The ANI solution for impulse pay-per-view



entry is required.

To place an order, the caller takes the phone off the hook, waits for a dial tone and then enters information (some of which will be fixed-format routing information, some used for specifying the order). Finally, the call is acknowledged with a tone or voice response.

Getting the data to the cable operators

The telephone switching system will provide serial output at 1200 baud from each central office. There are several problems that must be overcome with this data format:

- The data is at the wrong place and must be relayed to the cable operator's premises for processing. There is simply no feasible way for the cable operator to maintain a decision-making processor and its required data at the central telephone office.
- The data is probably at several wrong places. Unless the cable franchise is very small, it is probably served by multiple central offices.
- The data comes at its own pace because there is no pacing protocol. The receiving device is presumed to be available and working at all times.
- The receiving device assumes the data is correct. There is no error detection capability, let alone the ability to request retransmission of a garbled message.

Most of these problems can be worked around with reliable high-speed modems that accept the data and forward it to the cable operator's office. These modems must have their own buffering, error detection and retransmission capabilities.

At first glance, it might seem strange to intercept phone calls and then forward the data over a phone line. However, the requests are multiplexed at the central office so only a single phone line is required.

At the receiving end, the data from the various central offices must be multiplexed and buffered for input into the main processing computer. Even at 1200 baud, a computer dealing with multiple input streams along with complex processing and output requirements cannot *reliably* accept unpaced input. It can try—it might even look like it's working—but in the field some messages may be lost, and every lost message represents what would have been a satisifed PPV customer and a sale.

Processing the data

Data must be dealt with in real time. For example, if there are four central offices sending three transactions per second, then 12 transactions per second should be multiplexed on a single connection to the cable headend. For larger systems there may be more central offices. Later ANI software/hardware from the telephone companies probably will have even higher capacities.

A customer's picture must unscramble within seconds of their call being completed. Otherwise, there is no feedback on the success of an order. If they supplied an incorrect event number, or if their phone number is not entered correctly into the database, there will be no error indication until they fail to see the program they wanted. By then it is too late.

What must be done at these rates of 20 orders per second (or more)? First, identify the decoder based on the originating phone number and possibly some of the input data (to allow for more than one box per house). Next identify the event being ordered. This information then must be passed to a decoder controller system.

Depending on the rules for addressing the decoder, and how much data is required, processing each transaction requires going through one or two indexes. This requires a real-time computer, not a general purpose billing computer. Billing computers are designed to handle large amounts of data and history about customers and decoders, not to shovel data in and out this quickly.

This real-time processor can control the addressable decoders in one of three ways:

- It can include controller software within itself and, thereby, talk to the addressable decoders itself.
- It can communicate with a controller, using a special optimized protocol designed for the application.
- It can pretend to be a billing computer and instruct existing controllers. This is not likely to be feasible in many situations. Since billing computers are not designed to process high data volumes in real time, few controllers are prepared to take 16 or more unsorted "turn on" commands per second from their billing computer interface.

Transaction records must be written to disc as quickly as possible, then unloaded to the billing computer. Some billing computers have an uploading capability to support two-way IPPV ordering. ANI IPPV postings should be similarly uploadable and processable.

The main ANI processor has to be more than just a dumb pass-through machine with posting. There are a number of other activities that it should manage as well, making it a complete IPPV management system. The ANI processor must either act as or connect to the addressable decoder control system. Since only a deranged controller would be prepared to deal with two management computers, it must totally manage the addressable decoder functions for the billing computer. This can be done by providing a complete higher level definition of the whole problem and using the actual addressable system controller to implement parts of it. More realistically, some degree of "pass-through" command also must be provided.

Orders have to be taken in advance, often farther in advance than the system controller can handle. Many customers will advance order in case their phone is tied up later, and the channel or tag that must be authorized for the desired event may not be available yet because of conflicting earlier usage, thus requiring the "buffering" of authorizations.

Unless the cable operator wants to have extra staff present for the start and finish of each PPV program, there must be an automatic schedule that controls when ANI orders will be taken and required decoder controller scheduling tasks as well. Taking part of the task of scheduling, particularly that of program tag allocation, is not feasible. Once one bite is taken, the whole task must be assumed.

The main advantage of ANI as a hybrid PPV system over a real two-way plant impulse PPV solution is low startup cost and low risk. However, once a successful IPPV market has been established, it would make sense to phase over to an interactive two-way IPPV solution with its lower transaction costs and higher speeds. A good IPPV management system should facilitate this transition by providing a single source of control for all PPV scheduling and a single source for PPV postings.

Conclusion

If pay-per-view will provide the revenues cable operators need to become profitable; if the ability to buy on impulse is a significant key to that profitability; if building a new two-way plant or upgrading an existing one is an unreasonably risky expense for a prudent operator, then the ideal solution is a hybrid system involving the public telephone companies.

Given the serious problems with traditional approaches to hybrid PPV, only the ANI-based system with a real-time IPPV processor on the cable operator's premises can provide the necessary functionality. CED

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Continued from page 19
advanced technology that wasn't available when the committee started its work. The committee chairman must manage these forces or total gridlock will result.

Another practical committee difficulty is the fact that the most likely contributors are industry experts and industry decision-makers. By definition, these individuals are very busy and in demand by their company's engineering departments and by other committees. Getting the right people involved is critical to success. Occasionally, a company management's view of committee work is too parochial. Important contributors are denied permission to attend or are not supported in this activity.

An important element of the committee process is the mutual education of the two participating industries. Committee work is an excellent means of communication between experts in the cable and the consumer electronics industries. Well before an agreement on standards is reached, the TV receiver design experts are applying what they have learned from the committee work and are anticipating the new standard. This process makes timely introduction of product, based on the new standard, possible.

While it will be years before a significant penetration of product built around these standards takes place, those customers with an urgent need or desire will be able to purchase products in the second half of 1986. Thus, a timely impact will be made even though extensive use of the standard will take many years.

Thanks go to the EIA and the NCTA for their leadership in these issues. Special thanks to the EIA for sponsoring the meetings and to Tom Mock, of the EIA, in particular. The task would have been much more difficult, if not impossible, without his time and energy. And, of course, thanks to the committee participants for their participation and time away from home.

Conclusion

Progress is being made on two fronts, the RF cable interface and the decoder interface. Interim standards for both committees can be expected by late 1985 or early 1986. Progress is slow and painful but essential if the customer/subscriber is to be provided with the maximum utility potential of the technology. These are long-term solutions, but they will never arrive without heavy investment of energy and time in current committee work. CED

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Is the terminal business ours?

By Geoffrey Gates,
Senior Vice President,
Engineering & Technology,
Cox Cable Communications Inc.

Over the past two years, we have seen a major refocusing of effort in our industry. As franchising has wound down, we have seen the emphasis change from high technology blue-sky services to basic operating principles. Today, the watchword is: How do we run our day-to-day business smarter and more efficiently?

During this same period, our industry has been overwhelmed by spiraling technological development. We have gone from 270 MHz one-way plant to 550 MHz two-way plant. With all of this excitement concerning our new technological abilities, it has been easy to lose sight of our reason for being in business. Perhaps you have seen signs of it in your own company. In discussions with cable television engineers around the industry, I have been informed that we must build fiber optic switched star networks because the telephone company is doing so. Or that 1,000 MHz is feasible and just around the corner in order to provide us additional channels. Between our historical infatuation with technology and the current emphasis on efficiency, it is critical that we keep focused on our business—the delivery of entertainment and information to consumers.

In answer to the question "What product does a cable system sell?", one of two perspectives can be taken. Historically, we have been in the business of selling clear pictures and different program viewing opportunities to our customers. More recently, an alternative answer based on the broadcasting model might be appropriate: We are in the business of selling our viewers' time and attention to advertisers. Nowhere does it say we are selling technology. The technology is simply a means to an end. It certainly can enhance the viewing experience for our customer by providing full-color stereo-sound entertainment. Or it can increase our customers' convenience by providing full-function remote control or time shifting through a video cassette recorder. But this technology is not an end in itself.

In the following sections, I will outline several environmental considerations which impact our business today, the technical tools we have to address these concerns and the effectiveness of our current approaches. Based on this analysis, I will suggest a business model to guide our future strategy. Two terminal equipment configurations are analyzed with respect to the model. This exercise is based on the belief that our industry has reached a level of maturity that now requires us to take a long-range view of our ultimate destination. Our current practice of discarding our plant and completely rebuilding every 15 years cannot continue.

There are three forces in our environment that must be considered in building a foundation for future developments: the operating business parameters of a cable system, our customers and the entertainment marketplace in which we and our customers meet.

Historically, the cable TV business has been a capital intensive one. Despite dramatic decreases in the general cost of electronics, our capital investment per subscriber has increased because of two factors: our desire to provide more services yielding greater revenue and the franchising authority's desire to get the ultimate, state-of-the-art communications system built. While the total demand for capital is decreasing as our newbuild period concludes, there is a continuing requirement as we rebuild our older, more mature systems. A portion of this expenditure is justified as we add the capacity necessary to introduce profitable services, but a portion is driven by the desire of each community to have at least the bells and whistles of its neighbors. Within the "utility" business, we are probably unique in this regard. When was the last time your local telephone company rebuilt its plant and increased services in order to get its franchise renewed?

As we have gone from delivering a few off-air signals to importing distant signals to providing unique satellite-delivered services and premium movie services, we have continually increased the value of our product. Today, the entertainment value we provide to our customer is so great that we have created a parallel shadow industry in the selling of "black boxes." Obviously, this has a negative effect on our ability to achieve a fair return on our capital investment. While we have demonstrated that smart management and legal protection can contain theft of services to manageable levels, the need for a more secure delivery technology continues. Our practice of changing converters periodically to increase our signal security just aggravates our capital requirements.

While the industry has been evolv-

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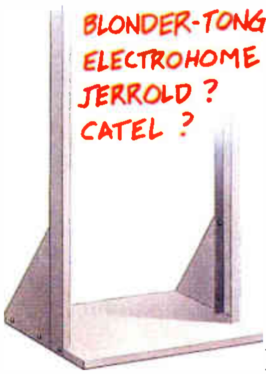

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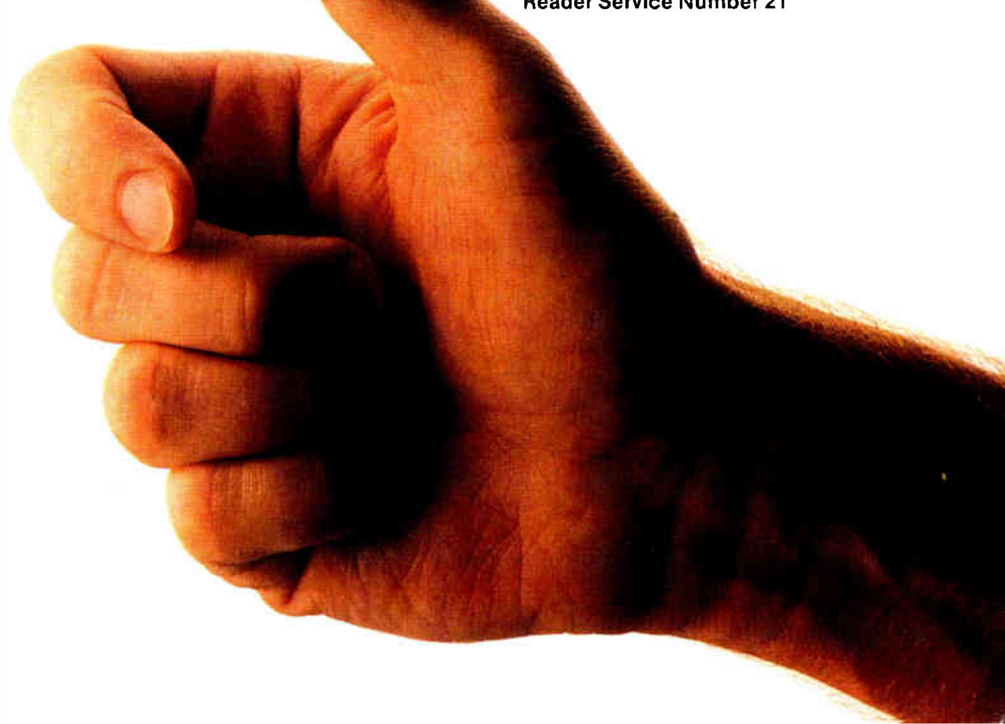

ing, so has the consumer. Today, convenience is foremost in the mind of the consumer, what some have called the "7-11 mentality." Their battle cry is: "I want what I want when I want it." This attitude has been mirrored by the growth of the service sector. The consumer electronics industry has been one of the most successful respondents to this attitude. Success in the consumer electronics marketplace is no longer based upon functionality. Rather, it is based upon responding to diverse individual requirements by providing a wide selection of features and benefits.

For example, one manufacturer of audio cassette decks has 14 current models in its lineup ranging in price from $87 to over $500. The increase in quality from the bottom of the line to the top of the line, i.e., frequency response of the recorded signal, is marginal. The variety of features and packaging options is great: one transport or two to allow high speed dubbing, with or without automatic reverse, with a mechanical or electronic revolution counter, with rotary or linear volume controls, etc.

Similarly, a few years ago Sony had a hit product in the Walkman. Today, Sony makes at least eight different models of what is a very simple product. These models range in price from $40 to $400, and, again, the difference is not function or quality but rather features.

Probably the ultimate example is the compact disk (CD) player which has been such a success this year. By employing digital recording techniques, these devices produce no measureable difference in the audio quality from the bottom of the line to the top of the line. Yet, there is a sufficient range in features to warrant a price range from $250 to $1,500. Again, this price difference is justified on the basis of ancillary features, e.g., sequential playback of random access, remote control, portability, etc.

In reviewing spending patterns for consumer electronic products, it is difficult to say whether this diversity is cause or effect. Over the last five years, consumers have spent an increasing percentage of their disposable income on consumer electronics, increasing from $66.60 per capita in 1980 to an estimated $103.80 in 1985, adjusted for inflation. (See Table 1.) The message here is that our marketplace can be expanded by responding to the consumers' desire for diversity and convenience.

At the same time our industry and consumers have been changing, we have entered into a new and different marketplace as well. Historically, cable TV was a product introduced in the

Table 1
Consumer Electronics Expenditures
(all amounts in 1985 dollars)

YEAR	PER CAPITA EXPENDITURE	% OF DISPOSABLE INCOME
1980	$ 66.60	0.60%
1981	$ 65.20	0.59%
1982	$ 80.40	0.74%
1983	$ 96.10	0.88%
1984 (est)	$100.00	0.89%
1985 (est)	$103.80	0.89%

Source: Link Resources

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suburban and fringe areas, except for New York City and San Francisco. Today, we have moved into the middle of the urban marketplace. What we have found there is that the demographics are much more diverse, varying from the stability of home owners to the transience of renters. We also are operating in an environment where there is increased competition for the entertainment dollar. The options available to the urban consumer range from live theater to video cassette rental, with many more in between. While the overall demand for entertainment continues to increase somewhat, the consumer has a much greater opportunity to become increasingly selective. She will pick those options which are found to be most desirable. Satisfying this consumer requires a range of solutions.

Terminal equipment options

As the value of our product has increased and the consumer electronics industry has adapted to the cable environment through cable-ready TV sets, an important function of our consumer interface has become protecting our product. The two principle devices for performing this are converter/decoders and traps.

The converter/decoder has provided a reasonable solution to extending the tuning range of the customer's receiving equipment while at the same time providing for signal security through the selective descrambling of the signal. However, there are specific shortcomings:

♦ **Capital intensity:** Use of converters currently requires placement of up to $200 of our equipment in the customer's home. In this environment, our investment is subject to theft, tampering and damage, an added cost of doing business.

♦ **Customer convenience and selection:** With converters, we are still in the era of the "black dial telephone." The only option we typically offer the customer is remote control, generally not full function and at an extra charge, even if the customer already has the remote control feature on his TV set. We don't even offer an option as simple as color coordinating the converter with the customer's furnishings. And, as becomes more apparent daily, our devices are incompatible or awkward in the developing consumer entertainment environment. The confusion and misunderstanding generated by cable-ready TV sets and VCRs has just begun.

♦ **Enhanced services:** Our equipment currently depends upon the signal format being delivered, leaving us vulnerable to changes in television technology. Thus, the development of multichannel sound or high definition TV can have serious capital investment implications for an operator. Our systems do not provide transparent pipelines. Thus, the introduction of enhanced services generally will require either incremental investment, aggravating our capital intensity, or the denial of the services to the customer and the revenue to us.

♦ **On-premise versus off-premise equipment:** With the diversity of demographics present in the urban market, it is to our advantage to have a range of solutions which include both on-premise equipment for the up-scale market where flexibility is important and off-premise equipment for the transient market where asset protection is important. However, general product incompatibility limits our ability to tailor the solution to our needs.

The principle alternative to converter/decoders for signal security is trapping. With the development of the multi-pay service environment, traps have become impractical. Their lack of flexibility, imperfect security, number of combinations to be stocked and degradation caused by stacking have limited their applicability, especially in the modern urban system. On the other hand, because traps are passive rather than active devices, they provide the greatest degree of compatibility with the developing home entertainment environment by allowing us to let the customer select and invest in the consumer viewing equipment desired. Thus, the home entertainment environment can be directly tailored to the customer's desires and means.

More generally, our technology has developed as a series of small incremental steps in response to short-term goals. We have developed from no interface equipment, using the existing TV tuner for delivery of off-air channels, to an extended tuning range, using the mid-band, and providing a converter for those signals. Security was achieved because TV sets could not tune the mid-band. Further developments extended the tuning range, introduced scrambling, two-way communications and impulse pay-per-view. However, with all of this development, or perhaps because of it, there is little compatibility from one system to another. It is evident that our technology has developed without a long-term rationale to guide short-term decisions.

As a result, we have developed a closed network. Each small step has removed a degree of freedom. We have confused our customer with the variety and complexity of interconnections of our interface equipment. We have introduced incompatibilities between our systems, locking us into single-source purchasing and creating inefficiencies in our inventories. At the same time, our manufacturers have limited

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Table 2
Television Set versus Converter Sales
(all units in millions)

YEAR	INCREASE IN TV HOUSEHOLDS	TV SET UNIT SALES	INCREASE IN BASIC CABLE SUBS	CONVERTER SALES
1983	0.8	19.8	4.3	8.3
1984 (est)	0.8	21.2	4.6	8.4
1985 (est)	0.8	20.9	4.8	7.1

Source: U.S. Bureau of the Census, EIA, Paul Kagan

their markets. In short, we have let our technology get in the way of our customer's enjoyment and our success. My basic premise is that this situation arises, in large part, from one mistake: The wrong person is making the purchase decisions.

The motivation of a cable system chief engineer is radically different from that of his customer. The engineer is motivated to minimize capital expenditures and maximize the life of each converter/decoder or trap. The consumer, on the other hand, is motivated to buy those products which appeal to his fancy. The power of this distinction is illustrated by the difference in converter and television set sales, shown in Table 2.

Business model

This analysis demonstrates two points that are critical to the continued success of our industry. First, responding to the consumers' desire for diversity and convenience expands, but also fragments, the marketplace. Second, although it seems contradictory, this expansion can take place only where there are stable, well understood, standard interfaces. For all the diversity in audio cassette decks, there is one standard for tape size and speed, input signal levels, etc. Diversity of features could not have developed in the absence of these basic functional standards. Even in video cassette decks where there currently are two competing standards, each standard is stable and has spawned a family of functionally compatible but feature-diverse products.

These factors easily are accommodated by a model which divides our business into two complementary sectors: a utility sector and a consumer sector. The business of the utility sector is to provide a high-quality, simple, transparent transport service. The utility sector is capital intensive, based on our investment, with operating efficiency as the key success factor. Important aspects include:

♦ protecting capital investment by limiting customer premise equipment owned by the operator
♦ controlling bad debt through approaches such as addressability
♦ limiting service calls through status monitoring, addressability and better training

The logical terminating point for the utility sector's responsibility is at the ground block.

In contrast, the business of the consumer sector is providing the customer with the desired product with the desired options and benefits. The product is video entertainment and information software packaged to provide the desired content in a manner that balances cost with perceived value. The convenience, features and benefits come from the viewing equipment chosen. The key success factors are selection and price/value. This sector fits directly into the consumer electronics marketplace: Provide a wide range of features and let the consumer choose, and pay for, those desired. Match what is received with its perceived value. Thus, the consumer has options which range from black and white normal definition TV to full-color high-definition TV. Likewise, the options for audio might range from a three-inch low fidelity speaker to full stereo compact disk quality digital sound. The choice of how the signal is viewed and the incremental investment necessary to receive these options is the customer's.

Under this model, the operator's investment is in the utility plant, i.e., the stable, transparent, protected transport medium. The more volatile consumer sector is not capital intense—the consumer has made the investment. The operator now can make a rational business decision whether to participate in the sale and rental of the home equipment.

The viability of this model is based on observation of 30 years of development in the telephone industry. Thirty years ago, the telephone company was in the business of selling dial tone. It provided a black dial telephone, and the concept of consumer choice didn't enter into its business. The local network

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was closed—the telephone company owned everything from one end of the network to the other. Development was stagnant, and there were limited opportunities for additional services.

A combination of regulatory and competitive pressures have forced the development of telephone communications into a dynamic industry in which everyone ultimately will benefit. Today, we see the regulated companies operating in the utility mode. They sell dial tone, the provision of a transparent transport medium. In parallel, we have seen the blossoming of a new consumer electronics business in which there has been a proliferation of manufacturers, equipment options available and new services offered to the consumer. The magnitude of this developing marketplace and the benefit of allowing the end user to make the purchasing decision can be seen in Table 3.

Despite the rhetoric, this appears to be a win-win situation. The consumer today has a range of choices—not just in the color of telephone but in the features it provides and, ultimately, in the carrier providing the service. While we are seeing some temporary price dislocation as subsidies lapse and prices become cost based, ultimately, competition will drive the unit costs of communications down.

At the same time, the telephone manufacturers have benefited. There are many new manufacturers in business, and the range of products offered today has generated an increased demand on the part of the consumers. The regulated companies also have benefited because per capita usage has increased. If you make the service easier to use by providing features that speak to the consumer's individual needs and desires, they will pay you back by increasing their usage. And despite all the dire predictions to the contrary, the telephone network has not fallen apart.

Table 3
Telephone Sales

YEAR	SALES (Thousand Units)	AVERAGE PRICING ($)
1982	5,700	70
1983	19,700	47
1984 (est)	30,300	41
1985 (est)	34,200	40

Source: EIA

Future technical directions

There are two requirements that must be met in order to implement this model. The first of these is stability, the assurance that our long-term ability to receive a fair return on our capital investment depends on the wisdom of our business decisions and not on political whimsy. The recently enacted cable communications bill provides us the stability necessary to operate a utility-type business by providing the presumption of franchise renewal.

The second requirement is the standardization of the interface between our network and consumer reception equipment. This is the more difficult one to meet for several reasons. First, it runs counter to the entrepreneurial heritage of our industry. In this business, everyone is an inventor, most in

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exactly the area which requires standardization—the interface to the customer. Second, there is the fear of legal restriction. In an industry where the largest operator controls less than 10 percent of the marketplace, there is no de facto standard setter as there was in the telephone industry. The necessary cooperation to achieve such standards would require an interaction between operators and manufacturers that might be subject to scrutiny under antitrust laws. Third, any standardization would require the active cooperation of our manufacturers, and they have a valid concern with an increase of foreign competition made possible by standardization. Would the development of an interface standard and corresponding open network have the same impact on the manufacturers of cable TV equipment that it has had on the manufacturers of consumer electronic equipment? Fourth, and foremost, there is no short-term pressure to achieve such standardization. The benefits provided by standardization are all long-term.

It is interesting to note that, even in the "black dial telephone" days, there was a high degree of standardization in the telephone industry. This was caused in large part by the dominance of a single operator and also by the need to interconnect telephone systems as a natural extension of the services provided.

Two potential scenarios for future systems development meeting the conditions of the business model suggest themselves. These are only two out of many potential scenarios and are not necessarily the most likely. While it is important to evaluate many such scenarios, the ultimate implementation would depend upon general agreement on one standard.

Scenario 1: Security the consumer can own. A natural extension of the current trend in set-top converters would be a form of signal scrambling sufficiently secure that operators would feel comfortable with the consumer owning the descrambler. Minimum requirements for such service would include:

♦ addressability with a nationwide addressing scheme to provide for free movement from system to system

♦ mechanical and electrical security sufficient to prevent successful tampering with the device

♦ a parameterized scrambling algorithm with many potential variants

♦ use of a key required for descrambling

♦ use of standard techniques for secure encrypted delivery of these keys

Several products now are coming on the market which have some or all of these characteristics. Typically, they provide for soft video scrambling with hard (digitally encrypted) audio scrambling. This combination is adequate to discourage the manufacture of pirate boxes, assuming that the encryption methodology is secure.

Customer-owned, secure converters fit the requirements outlined above by placing the purchasing decision where it belongs—with the consumer. With the standardization of such a scrambling methodology, it would be feasible to include the descramblers and addressable receivers in all appropriate consumer electronic devices. Thus, the issue of consumer convenience is adequately addressed.

The implementation of such an approach requires overcoming the standardization hurdles mentioned above. Specifically, in addition to standardizing on NTSC signals and F fittings, it would be necessary to standardize the scrambling algorithm, key distribution method and the addressable data transmission protocol. It also would be necessary to establish distribution channels for these products. The logistics of introduction also must be examined but are no more difficult than the situation today when we change converter types in a system.

The benefits to all industry participants are evident:

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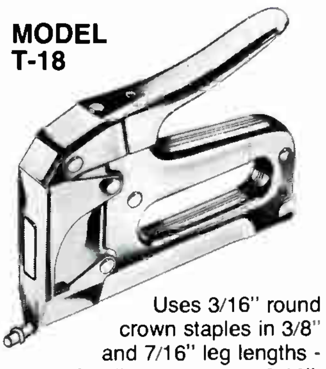

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MODEL T-37

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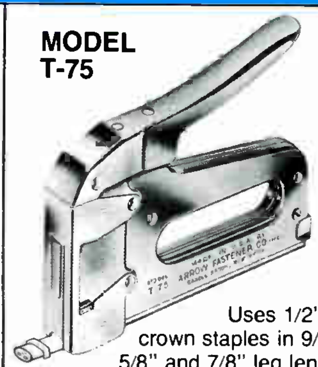
MODEL T-75



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♦ Increased consumer satisfaction through increased selection, convenience and lack of duplication
♦ Reduced capital investment on the part of cable operators
♦ Reduced risk for cable operators in the event of the introduction of new signal types since the interface equipment would be purchased by the consumer. Note that the security can depend upon the signal format since, in the event of a new signal format being developed requiring new security, the consumer has to purchase new viewing equipment anyway. The operator's investment is protected.
♦ Increased demand for manufacturer's product by expanding from an engineering-driven to a consumer-driven marketplace.

Scenario 2: cost-effective, non interfering security. An alternative approach is the separation of security from the consumer interface equipment. Mimimum requirements for such a device would be:
♦ An addressable tap or trap
♦ The method of obtaining security would not be dependent upon the signal format, thus providing compatibility with future signal types
♦ Independent control of each 6 MHz section of spectrum; finer resolution would be desirable
♦ A capital cost of approximately $20 per port

While this attacks the problem from a different angle, it also fits the characteristics outlined above. The capital investment of $20 per port is manageable, and the transparency provides for consumer convenience. In this case, there is no customer interface decision to be made in the home. Rather, current cable-ready TV receivers and other consumer electronic products would work. Further, the ability to control bandwidth without being sensitive to signal format provides a transparency necessary for the introduction of future ancillary services.

Again, the benefits to industry participants is evident:
♦ Transparency to the consumer and, therefore, the convenience of not having to worry about yet another set of control devices
♦ Limited risk of obsolescence to the operator because of the ability to control bandwidth in a signal transparent fashion
♦ A new market for manufacturers in providing such a device

In this scenario, the burden of standardization is less severe: basically F fittings, signal levels, frequency assignments and channel numbering plans. However, the technical hurdles to overcome are much greater.

Conclusion

As our industry matures, reaching the end of its newbuild phase, we have achieved a significant level of penetration and offer a consumer electronics marketplace to be reckoned with. However, we still suffer from considerable technological fragmentation. I have suggested a long-term view which separates the utility and consumer sectors of our business. I believe that all participants would benefit from an evolution from our current closed network to an open network in which we, as operators, provide a transparent pipeline for the delivery of entertainment signals. This pipeline, because of its transparency, provides the long-term stability needed to achieve a reasonable return on our capital investment. The consumer participates by investing in the appropriate interface equipment, thus allowing for the diversity and feature orientation that should rightfully be an individual choice for each person. By putting the purchase decision where the value is perceived, we increase consumer satisfaction at the same time that we reduce our capital commitment.

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Reader Service Number 33

dB/dBmV BASICS

By Allen Kirby,
Sales Engineer,
John Weeks Enterprises

A complete and total understanding of dB and dBmV is essential before continuing onto other aspects of CATV work. Everything from design to proof is based on these measurements.

For a better understanding of the basics, it is necessary to use microvolts. The term microvolt (MV) means millionth of a volt.

dB can be considered, for all practical purposes, a ratio of sorts. Looking at a dB chart we see that 6 dB, for example, is equal to 2 times (2x). This is meaningless, however, unless applied to another number. Therefore, dB is used only in reference to gain or loss of signal.

For example, we might say a length of cable has 6 dB loss. This means we will lose one-half of the signal we put into it.

dB to Voltage conversion chart

dB	Multiply by	dB	Multiply by
1	1.12	24	16
2	1.25	25	18
3	1.4	26	20
4	1.6	27	22.5
5	1.8	28	25
6	2	29	28
7	2.25	30	32
8	2.5	31	35
9	2.75	32	40
10	3.16	33	45
11	3.55	34	50
12	4	35	56
13	4.5	36	63
14	5	37	71
15	5.6	38	80
16	6.3	39	90
17	7	40	100
18	8	43	140
19	9	46	200
20	10	50	300
21	11	56	600
22	12.5	60	1000
23	14		

1,000 Microvolts ■-------- cable / 6 dB loss --------■ 500 Microvolts

If we increase the amount of signal going into the cable, we will still lose one-half.

5,000 Microvolts ■-------- cable / 6 dB loss --------■ 2,500 Microvolts

As you can see, the 6 dB loss represents a loss of 500 MV in one case and 2,500 MV in another. Six dB does not have a fixed voltage value, it simply means ½ (in the case of loss) or 2x (in the case of gain).

If you have 5,000 MV going into an amplifier and 10,000 MV coming out, the unit has 6 dB gain (2x). See the dB chart for values, 6 dB = 2x, 20 dB = 10x, etc.

However, dBmV is an entirely different matter. It has a specific value that does not change. Originally, we measured signal in microvolts and had to compute this against dB. Example:

Input to cable: 150,000 MV
Cable loss: 10 dB
10 dB = 3x (approx.)

$$3\overline{)150{,}000} = 50{,}000$$

Signal level at end of cable = 50,000 MV

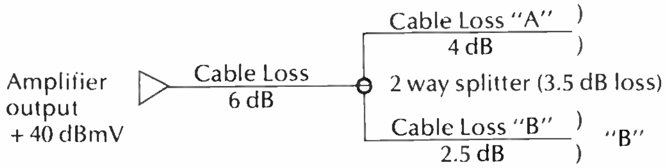
As you can see, this wasn't an easy method, especially if the signal level was 143,000 MV and the loss was 8.5 dB. It was decided to abandon the term microvolt and adopt dBmV to simplify matters. Zero dBmV was used as a base reference and, using the dB scale, the dBmV scale was built from there. The simplest method was to give 0 dBmV the value of 1,000 MV and, referring to the dB scale, a specific value was determined for +dBmV and -dBmV. To clarify this, let's start at 0 dBmV = 1,000 MV and apply our dB scale.

If 0 dBmV = 1,000 MV and 6 dB = 2x, then +6 dBmV = 2,000 MV (2 x 1,000 MV). It then follows that +12 dBmV = 4,000 MV since 12 dB = 4 x (4 x 1,000 MV). -6 dBmV would equal 500 MV since when calculating loss you divide. (6 dB = 2x so 1,000 MV reduced by 2x would be 1,000 ÷ 2.)

As you can see, dBmV means a specific amount of signal as shown below:

+20 dBmV = 10,000 MV (20 dB = 10x)
+12 dBmV = 4,000 MV (12 dB = 4x)
+6 dBmV = 2,000 MV (6 dB = 2x)
0 dBmV = 1,000 MV
−6 dBmV = 500 MV (6 dB = 2x)
−12 dBmV = 250 MV (12 dB = 4x)
−20 dBmV = 100 MV (20 dB = 10x)

To illustrate the ease with which loss calculations now can be made, note the following diagram:



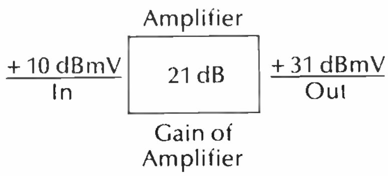
Total Loss —Leg "A"

6.0 dB	Amp to splitter	+ 40.0 dBmV	(Signal entering cable)
3.5 dB	Splitter	13.5 dB	Total loss
4.0 dB	Splitter to end	+ 26.5 dBmV	Level at end of Leg "A"
13.5 dB	Total Loss		

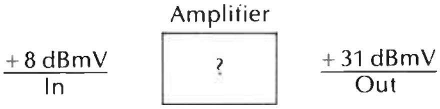
Total Loss —Leg "B"

6.0 dB	Amp to splitter	+ 40.0 dBmV	(Signal entering cable)
3.5 dB	Splitter Loss	12.0 dB	Total loss
2.5 dB	Splitter to end	+ 28.0 dBmV	Level at end of Leg "B"
12.0 dB	Total Loss		

The same procedure is used to calculate gain, except we add instead of subtract.
Example:



To determine gain of amplifier, simply measure the input and output and subtract. The resulting figure is the gain at which the unit is operating.



+ 31 dBmV	(output)
+ 8 dBmV	(input)
23 dB	operating gain of amplifier

A complete understanding of the preceding data is necessary before pursuing any further calculations.

To calculate the loss of any cable, multiply the dB loss per 100 feet (see cable loss figures) by length of cable in hundreds of feet (i.e. 1,000 feet = 10 hundreds, 250 feet = 2.5 hundreds, etc.).The simplist way to convert footage into hundreds is to place a decimal point two places from the right.

Example:

50,000′	=	500.00	=	500	hundreds
1,500′	=	15.00	=	15	hundreds
250′	=	2.50	=	2.5	hundreds
75′	=	.75	=	0.75	hundreds

For loss per hundred feet, refer to cable loss chart. Cable loss varies with size and type of cable and with frequency (the higher the frequency, the higher the loss).

To calculate any loss, we must know the type of cable and the loss per 100 feet of that cable. To calculate what signal level we should have at the end of our cable, we also *must* know how much signal is entering the cable. The following diagram shows a simple loss problem:

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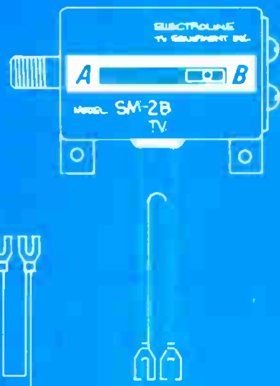

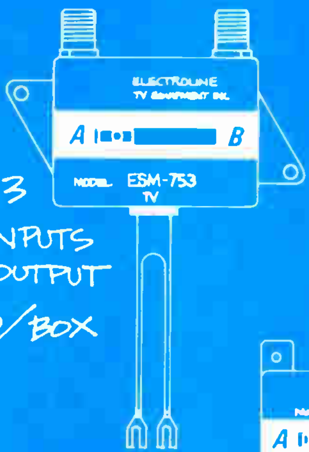

ESM-753
TWO 75 OHM INPUTS
300 OHM OUTPUT
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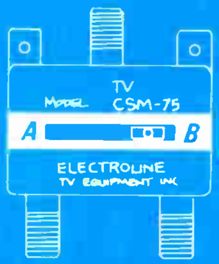

CSM 75
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75 OHM OUTPUT
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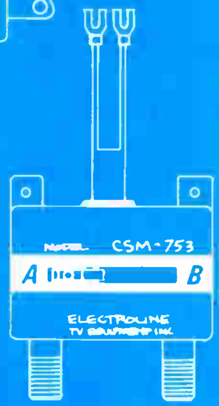

CSM 753
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300 OHM OUTPUT
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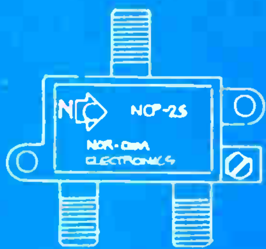

NCP-2S
2 WAY OUTDOOR/INDOOR
SPLITTER W/GROUNDING BLOCK
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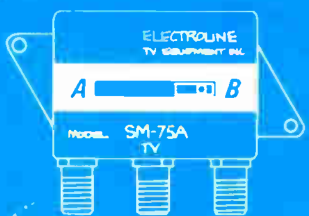

SM-75A
TWO 75 OHM INPUTS
75 OHM OUTPUT
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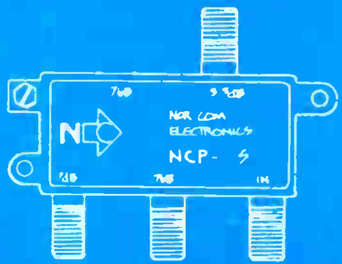

NCP-3S
3-WAY SPLITTER
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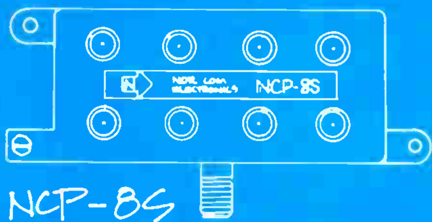
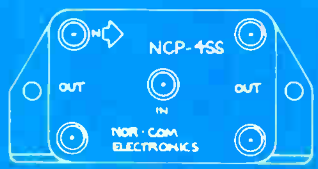


NCP-8S
8-WAY INDOOR/OUTDOOR
SPLITTER W/GROUNDING BLOCK
$1.59 @



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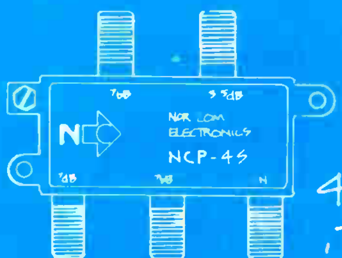

NCP-4S
4-WAY SPLITTER
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CATV SERVICES

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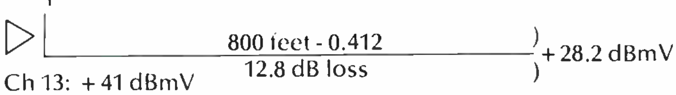
dBmV/microvolt chart

dBmV	µv	dBmV	µv	dBmV	µv
-40	10	0	1,000	40	100,000
-39	11	1	1,100	41	110,000
-38	13	2	1,300	42	130,000
-37	14	3	1,400	43	140,000
-36	16	4	1,600	44	160,000
-35	18	5	1,800	45	180,000
-34	20	6	2,000	46	200,000
-33	22	7	2,200	47	220,000
-32	25	8	2,500	48	250,000
-31	28	9	2,800	49	280,000
-30	32	10	3,200	50	320,000
-29	36	11	3,600	51	360,000
-28	40	12	4,000	52	400,000
-27	45	13	4,500	53	450,000
-26	50	14	5,000	54	500,000
-25	56	15	5,600	55	560,000
-24	63	16	6,300	56	630,000
-23	70	17	7,000	57	700,000
-22	80	18	8,000	58	800,000
-21	90	19	9,000	59	900,000
-20	100	20	10,000	60	1.0 volt
-19	110	21	11,000	61	1.1
-18	130	22	13,000	62	1.3
-17	140	23	14,000	63	1.4
-16	160	24	16,000	64	1.6
-15	180	25	18,000	65	1.8
-14	200	26	20,000	66	2.0
-13	220	27	22,000	67	2.2
-12	250	28	25,000	68	2.5
-11	280	29	28,000	69	2.8
-10	320	30	32,000	70	3.2
- 9	360	31	36,000	71	3.6
- 8	400	32	40,000	72	4.0
- 7	450	33	45,000	73	4.5
- 6	500	34	50,000	74	5.0
- 5	560	35	56,000	75	5.6
- 4	630	36	63,000	76	6.3
- 3	700	37	70,000	77	7.0
- 2	800	38	80,000	78	8.0
- 1	900	39	90,000	79	9.0
0	1,000	40	100,000	80	10.0

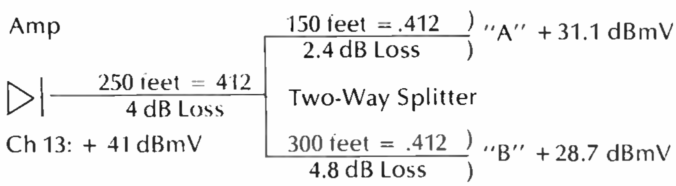
Definition of dBmV: 0 dBmV = 1,000 µv across 75 ohms



1.6 dB	Loss per 100 feet on Ch 13
x 8	Feet in hundreds (800 = 8.00 = 8)
12.8	Loss of cable

+41.0 dBmV Amount of signal going into cable
− 12.8 dB Loss
+28.2 dBmV Amount of signal at end of cable

Let's examine a different set-up as shown below:



Loss in Leg "A":

1.6 dB/100′ Loss (Ch 13)
x 2.5 Length of cable between amp and splitter
8.0 (in hundreds)
32

4.00 dB Loss
1.6 dB/100′ Loss (Ch 13)
x1.5 Cable length (in hundreds)-splitter to end
8.0
16
2.40 dB Loss

4.0 dB Cable loss
3.5 dB Splitter loss
+ 2.4 dB Cable loss
9.9 dB Total Loss —Leg "A"

+41.0 dBmV
− 9.9 dB Loss
+31.1 dBmV at end of Leg "A"

Loss in Leg "B":

4.0 dB Loss-Cable between amp & splitter
3.5 dB Splitter loss
+4.8 dB Cable loss-splitter to end
12.3 dB Total Loss —Leg "B"

1.6 dB/100′ loss (Ch 13)
x 3 Cable length (in hundreds)
4.8 dB Loss

+41.0 dBmV
− 12.3 dB Loss
+28.7 dBmV at end of Leg "B"

Insertion loss will be ignored for the sake of simplicity. It is variable and must be figured for each individual feeder line.

Since it is practically impossible to memorize the entire dB scale, it is good to know how to add dB figures. We cannot say that since 20 dB = 10x, then 40 dB = 20x. The following examples show the proper method:

Add	Multiply	Add	Multiply	Add	Multiply
20 dB	= 10x	20 dB	= 10x	10 dB	= 3x
20 dB	= 10x	6 dB	= 2x	6 dB	= 2x
40 dB	= 100x	26 dB	= 20x	16 dB	= 6x

The biggest problem with dB is that the novice technician tends to relate to numbers she is familiar with. For example:

John Doe has $40 and loses $6, leaving him with $34. He has lost only 15 percent of his money.

Let's use the same figures in dB:

John Doe has +40 dB and loses 6 dB, leaving him with +34 dB. Since 6 dB = 2x, this represents a loss of 50 percent.

A complete understanding of the dB scale is necessary if all the pitfalls are to be avoided. CED

In the next installment, Kirby will discuss the basics of amplifier balancing, the breakdown of equalizers and their function.

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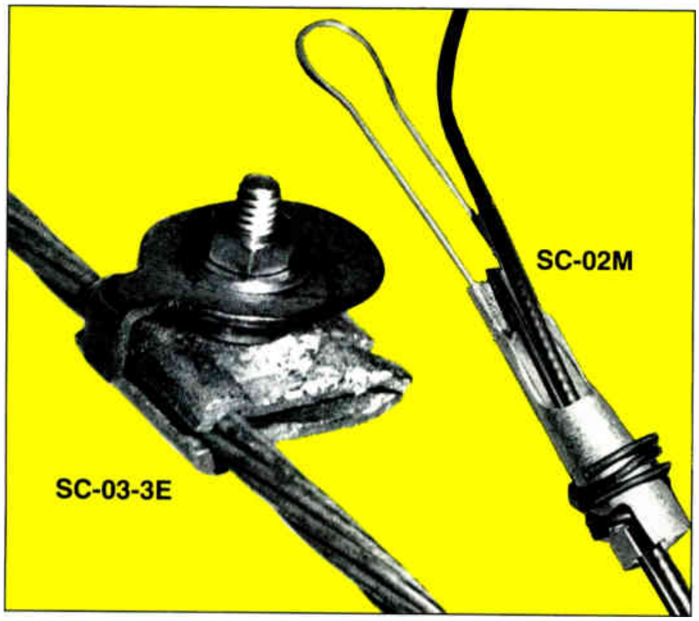

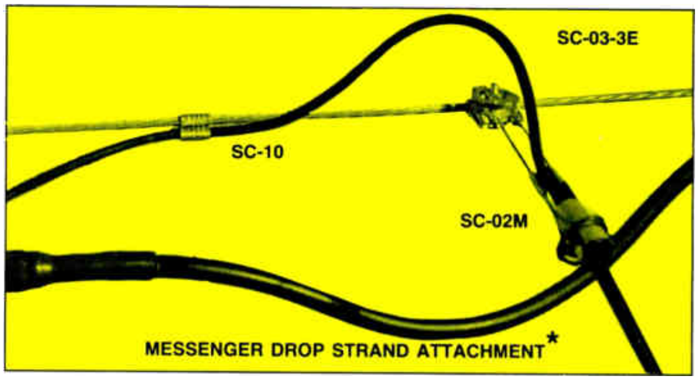

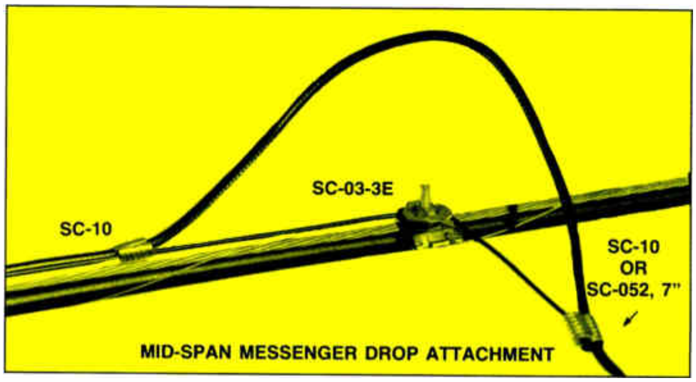

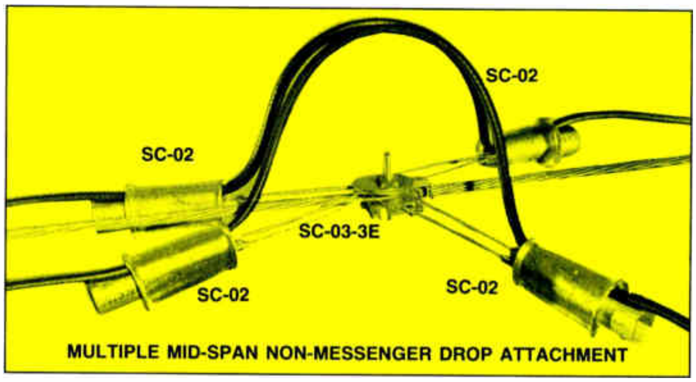

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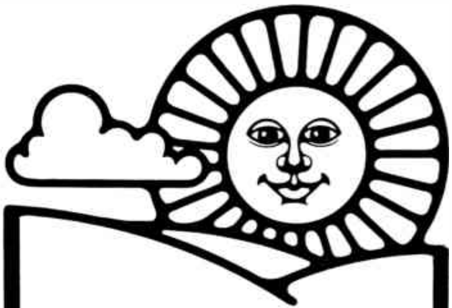

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Manufacturer	Model	Video Input Level For 87.5% Modulation	Output Channels	Peak White Clip	Tilt	87.5% Modulation Diff Gain
Blonder Tongue	ESHM	0.5 VP-P min.	TV channels 2-13, midband (A-1), Superband (J-W)	95%	1% max	2% max
Cadco	350	0.5 VP-P	sub low (T-7 T10 only), VHF midband, high VHF, superband hyperband, HRC and IRC	87.5%	1% max	±0.5 dB max
Catel	CTM20	1.0 VP-P	T7 thru T11, 2 thru 13, and 14 thru 62-standard freq assignments, IRC, or HRC	80% & 95% w/ internal control	1% max	2% max 10%-90% APL
Drake	VM2410	0.7 VP-P	60 channels	82% to 90% mod	—	±5% max
DX Antenna	DSM-100	1.0 VP-P	Any VHF channels 2 to 13, and mid-band channels	—	1% max	±3% max
Electrohome	SM-36	1.0 VP-P	54-300 MHz	87.5%	>2 IRE	±0.5 dB 10%-90% APL
ISS	GL-2600	0.7 VP-P	VHF TV channel 2-13, A-1, J-W midband superband selectable	87.5% internal set	1% max	1 dB
Jerrold	C4MS/C4MPS	0.5 VP-P	T-7 thru T-13, 2 thru 13, 14-61 and 2-69H	80% to 95%	1% max	±0.25 dB max., 10% to 90% APL
M/A-COM	VM-Series	0.7 VP-P	TV channels 2-6, 7-13; Midband channels A-1; Superband channels J-W	87.5% to 96%	1%	17 dB
Magnavox	CTM20	1.0 VP-P	T7 thru T11, 2 thru 13, and 14 thru 62-std freq assign-ments, IRC or HRC	80% to 95% w/ internal control	1% max	2% max 10%-90% APL
Nexus	VM-1	1 VP-P ±3 dB	SUB, VHF, Mid & Super Hyper & UHF on Special order	option	—	⟨0.5 dB 10%-90% APL
Phasecom	1064	0.75 VP-P min.	2 to 13, A to W	87.5%	1% max	±1.0 dB
Pico Macom	M-45	0.5 VP-P	All channels 2 thru W	87%	1% max	≤0.3 dB
Scientific Atlanta	6350	0.5 V P-P min.	Standard VHF, sub-low, midband, superband or hyperband channel	95% depth modulation	1% max	±0.18 dB max
Synchronous	MAC-100	1 VP-P ±3 dB	54 to 450 MHz VHF, midband, superband and IRC channel assignments	adjustable	1% max.	±0.1 dB
Telease	MAAST	1.0 VP-P ±20%	Standard IF	N/A	>2 IRE	>1.5%
Triple Crown	HE-MW	1.0 VP-P min.	any TV channel sub-band to Ch W	N/A	1% max	±.5 dB max 10%-90% APL

87.5% Modulation Diff Phase	Frequency Accuracy	RF Output Level	RF Output Impedence	RF Output Spurious Outputs
±0.5 max	±25 kHz	+60 dBmV max, continuously adjustable	75 ohms	〉 60 dB down at +60 dBmV output
±1.0° max	±5 kHz	+40 dBmV to +60 dBmV, continuously variable	75 ohm unbalanced 16 dB return loss min	60 dB below video carrier with carrier @ +55 dBmV (54 to 440 MHz)
0.5° max 10%-90% APL	±10 kHz	+60 dBmV max	75 ohms, nominal, 16 dB return loss	60 dB below visual carrier at any carrier level +50 dBmV to +60 dBmV
±3° max	±25 kHz	15 dB range	75 ohms	−55 dB typ., −50 dB max
±3° max	less than 0.005%	−10 dB cont. adjus.	—	−60 dB max
±1.0° 10%-90% APL	>25 kHz	+60 dBmV max	75 ohm	−60 dB 50-215 MHz −55 dB 215-300 MHz
1°	±5 kHz	+65 typ	75 ohms unbalanced	−60 dB
±0.5° max 10%-90% APL	±14 kHz FM 32°-120° F ±5 Hz FM, 15°-40°C	+30 dBmV	75 ohms	−60 dB at +dBmV output
2°	±.001	40 dBmV typical	75 ohms	60 dB down, typical. A/V carrier ratio 15 dB, color subcarrier @ −25 dB
0.5° max 10%-90% APL	±10 kHz	+60 dBmV max visual carrier	75 ohms nominal, 16 dB return loss	60 dB below visual carrier at any output level +50 dBmV to +60 dBmV
〈3° 10%-90% APL	±10 kHz VHF (±15 kHz superband)	+54 dBmV typical (+50 dBmV superband)	75 ohms	−60 dB w/visual carrier @ +54 dBmV aural carrier 16 dB down
±1.0°	±10 kHz	+60 dBmV min	75 ohms 14 dB return loss	60 dB down or better at +60 dBmV output
±0.5° max	±8 kHz VHF midband ±10 kHz superband	+40 to +60 dBmV continuously variable	75 ohms unbalanced	60 dB below video carrier at +60 dBmV and sound carrier at +45 dBmV
0.5° max	±0.0025 % FM +20° F to +100°F	+55 to +63 dBmV	75 ohms	60 dB below video carrier set at +60 dBmV and sound carrier set at +45
1.5°	0.00001%	+10 dBmV ±3 dB	50 ohms	60 dB below video carrier
±3° max	±5 kHz	+45 dBmV to +55 dBmV	75 ohms	〉58 dB below fully rated output with audio carrier set to 15 dB below video carrier
2°	0.005%	+45 dBmV	75 ohms	60 dB down (with A/V carrier ratio -15 dB)

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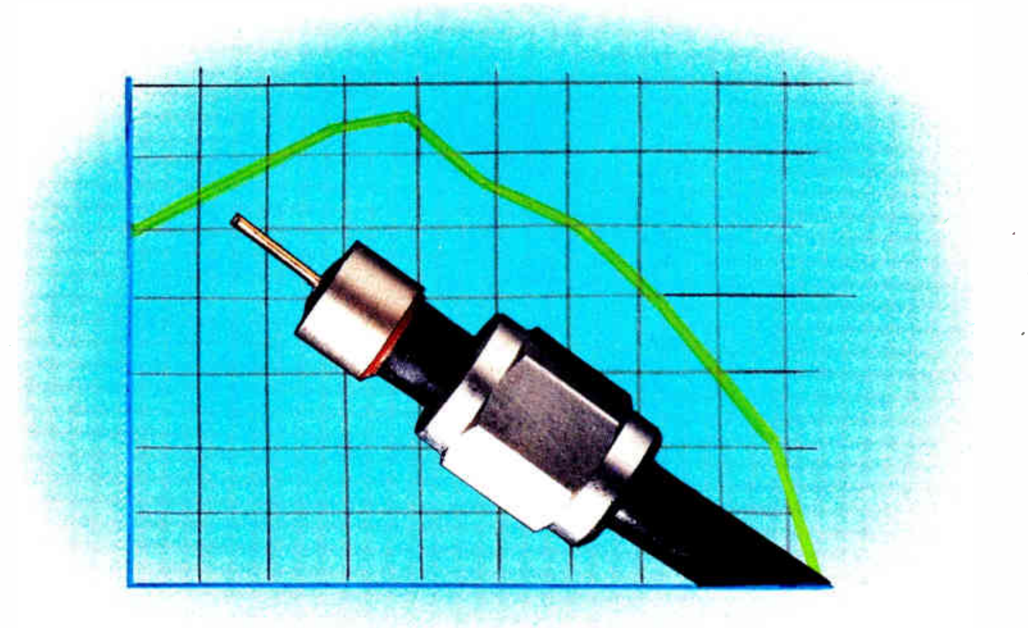
Reduce maintenance budgets with the EZF™ Connector System...



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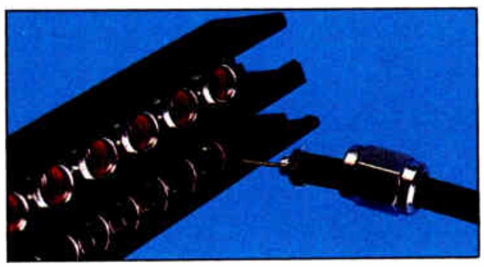

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