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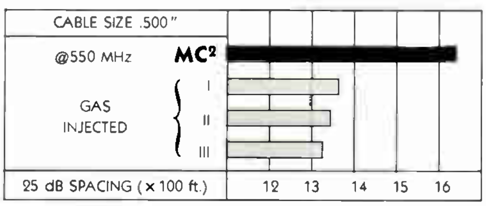

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April 1988 Volume 14, Number 4

INTERNATIONAL THOMSON COMMUNICATIONS INC.

CED. (USPS 300-510) (ISSN 0191-5428) is published monthly by International Thomson Communications Inc., 600 Grant St., Denver, CO 80203. ©April 1988, Volume 14, Number 4. Subscriptions free to qualified industry readers. All other one-year subscriptions are $26, prepaid in U.S. funds only. Second-class postage paid at Cleveland, OH. and additional mailing offices. CED is published on behalf of the cable television and broadband communications industries. POSTMASTER: Please send address changes to 600 Grant St., Suite 600 Denver, CO 80203. MEMBERS OF THE BPA.

CLASSICS

Birds in the antenna path: "Watt" effect do they have? **16**

This long-lost article by Thomas Haskett of Radio-Electronics describes the effects of birds on TV antennas. Entitled "Imbirdance Measurement for CATV Antennas," the piece covers a serious topic with just a bit of tongue-in-cheek.

Advances in research making AM transmission a reality **20**

As recently as a few years ago it was considered an impossible task to deliver 40 channels of video over a single fiber utilizing AM transmission techniques. That day is now just around the corner, says Dr. Larry Stark of Ortel.

Construction marketplace fueled by rebuilds **36**

With tens of thousands of miles slated for newbuild, rebuild and upgrading, its apparent the industry will experience one of its busiest years ever. With the focus on rebuilds, this piece also looks at how to get rid of the wrecked-out cable.

Will Ku-band technology work during the rainy season? **40**

That's the question a number of operators along the Gulf Coast are asking each other. J. Richard Kirn of the Florida Chapter of the SCTE—the only organized group testing the technology—outlines the test procedure being used to get some hard and fast data.

BROADBAND LAN

Lockheed blasts off **44**

Faced with ever higher telecommunication costs, Lockheed Missiles and Space made the choice of broadband technology to tie its facilities together. This article by Editor Gary Kim tells you how and why.

De-addressing for success **48**

Stuck with a low penetration rate and high consumer dissatisfaction, Mile Hi Cablevision of Denver decided to unscramble its channels and de-address a large portion of its subscribers. How the system went about doing it and the effect it had is the focus of this article.

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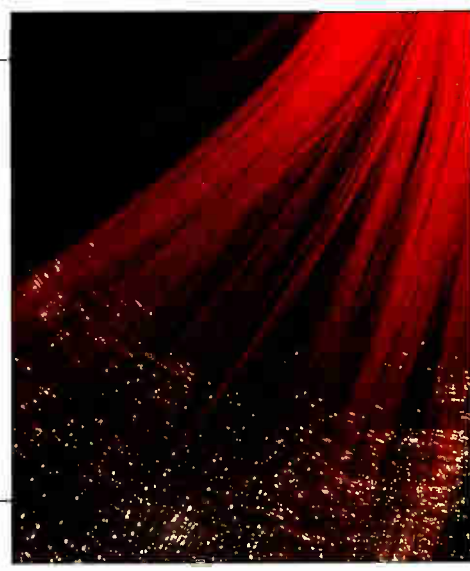
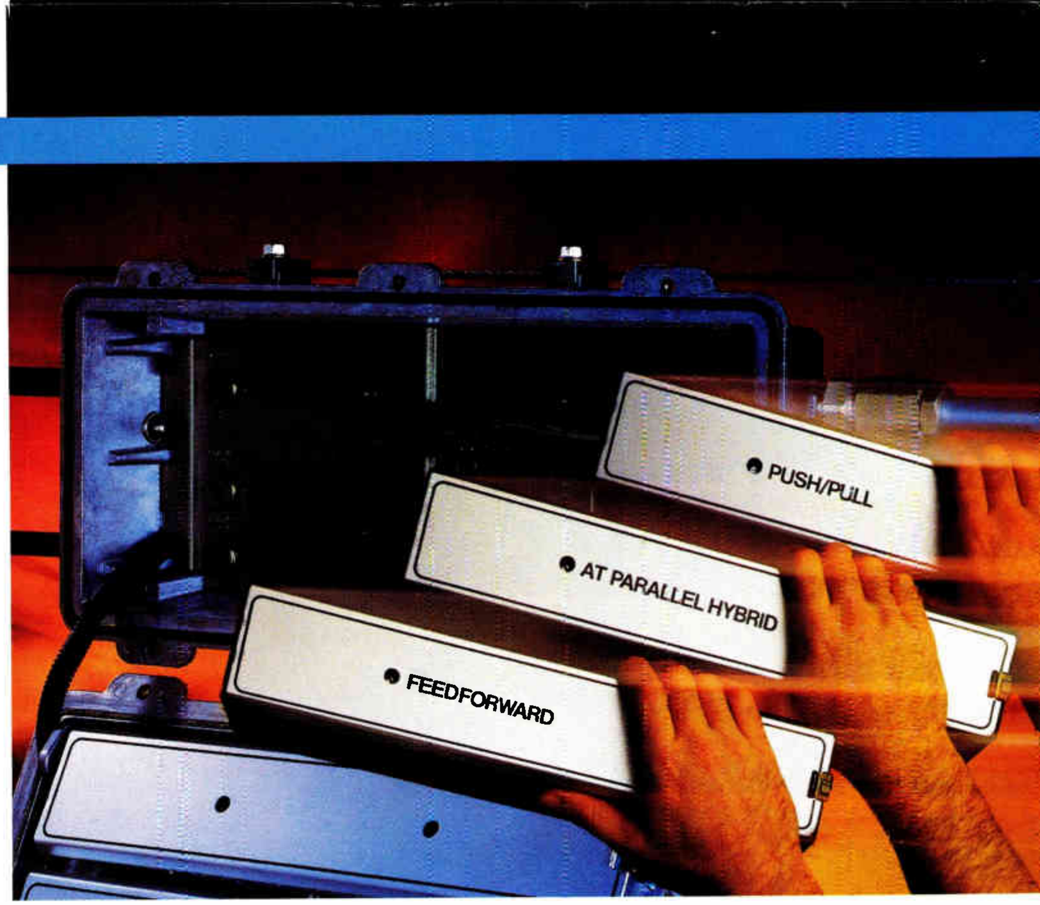


About the Cover:
Fiber optics. The technology will no doubt be important to CATV's future, but, according to the cover story, the future may be here sooner than originally thought. Photo by Ken Cooper, The Image Bank.



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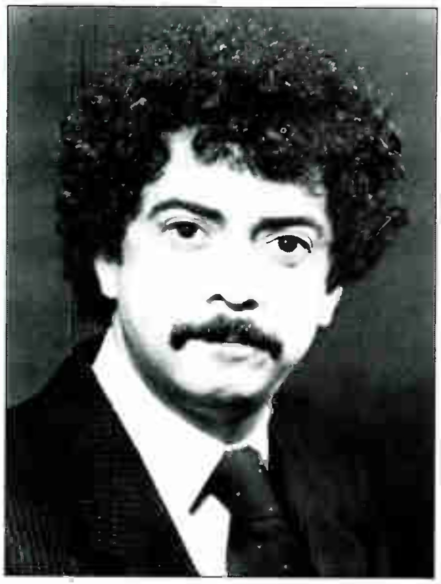


Paul Perez

Early days gave Perez experience he needs today

The cable television industry is at a crossroads. With competition soon to appear from the Japanese in the form of high definition television, cable must respond by embracing new and better technologies or risk being run over by a vastly superior form of signal transmission.

That's the message Paul Perez brings to industry engineers over and over again. As director of marketing at Recoton Corp., where he also gets involved in product development, Perez has his finger on the pulse of the consumer electronics industry. What he sees for the future is fascinating; incredibly detailed pictures over the television. And cable has to keep up or risk its health.

Perez has seen a lot of products come and go during his 18 years buying, selling and marketing audio and video products. He's seen the transitions from tubes to transistors, from open reels to compact disks, from Beta to Super-VHS. During that time, he's also witnessed the rise of the Japanese and the fall of the American electronics manufacturers.

Perez started at Henry's Camera, a store in Los Angeles that sold literally everything from Instamatics to top-line cameras. The store's environment was so competitive, the salesmen literally climbed over one another to write up orders. "If you wrote three receipts in a row without accessories, you were fired," remembers Perez. It was a tough place, but Perez thrived. To this day, many of the lessons he learned there remain with him.

After that, in 1974, he went to Music and Sound of California, a high-end audiophile salon that catered to people who routinely spent $20,000 for audio speakers. "Everybody from Carroll O'Connor to Frankie Avalon were my customers," says Perez. He was regularly honored as the top salesman nationally by such speaker manufacturers as JBL, Infinity and Bose.

"I learned what golden ears could hear," he says. With products at that level of sophistication, subtle changes in environment or technology became apparent. He learned to listen for them.

Perez then went on to form The Video Center chain of retail outlets with some other partners, including an heir to the Pepsi fortune. It was the first video retail chain in the U.S., grew to seven stores and "was very successful."

He went on to bigger things in 1976 as the first audio/video merchandise manager ever hired by The Federated Group. While there he saw the first VHS tape machine (he provided RCA with its first big purchase order and later became RCA's third-largest dealer); became Sony's largest Betamax dealer and helped the company grow from $40 million in sales to $100 million in just 18 months.

But he was also exposed to a wider slice of the American consumer. He learned what they could see and hear and—more importantly—what they would pay for it. He had to because in retail, if people aren't satisfied, they bring things back. "Negative reinforcement was immediate if you were wrong," says Perez.

In 1979 he started up The Cable Works with an old friend he had met while at Henry's. The company specialized in supplying video accessories to Sears, Pacific Stereo and others. In fact, if you needed a video cable, you probably got it from The Cable Works. The business went out of the garage to $4.5 million in sales in 30 months. "Those were heady days," Perez says. And he made a lot of money.

In 1982, Bob Borchardt, the president of Recoton, approached Paul and asked him to join his company. Perez resisted three offers, then finally relented when the offer was right. Borchardt wanted Perez's expertise to help Recoton take advantage of emerging technologies and take it from a passive supplier of accessories to an industry innovator.

Since that time, the FRED series of stereo decoders has been introduced and Perez has been instrumental in bringing stereo to a wide audience. He did the first cablecast of stereo over the local cable system in Las Vegas to feed a Consumer Electronics Show and he was in on the first install of BTSC encoders at ATC's Manhattan system.

Obviously, Perez's crystal ball is clearer than most. The man moves at lightning speed (he has to in order to keep up with an industry that routinely introduces new products twice a year), makes quick, sound decisions and has a feel for whether or not emerging technologies will find a niche in American society. He's been responsible for bringing Super-VHS, Apple co-founder Steve Wozniak, video engineer Yves Faroudja and other cutting-edge products and people in front of the NCTA Engineering Committee. And he's a vital force on the Super Cable subcommittee that is committed to exploring new technologies and putting them in front of the consumer via cable. He's organized a trip to the David Sarnoff Research Institute, where this country's top cable-TV engineers can get a feel for the proposed enhanced television transmission system.

Cable has to respond to the gauntlet thrown down by the Japanese in the form of HDTV, says Perez. "I remember when people laughed at the Japanese. Who's laughing now?" Perez asks. "This is the greatest opportunity and challenge I have ever seen for an industry. It is also the moment of its decision. This could be the greatest thing to ever happen to cable—or its eclipse.

—Roger Brown

Cable can't afford to lose any more top statesmen

I recently attended a seminar in which one of the top brokers of cable television systems in this country gave a very private and very informative overview of how one goes about putting together a deal for a cable television system. I'm sure many of you reading this article, in fact, know a lot of those details and, indeed, you may have been fortunate enough to attend seminars of this type yourself.

I was struck by several things, not the least of which is that the overwhelming view of people in the know is that this industry is very attractive to the financial community. It's attractive because when they apply all of the measures of financial judgment as well as their perceptions of whether or not this is a "good business" providing a "desirable" service the answers come out to be very favorable.

After the seminar I had occasion to talk with the presenter privately in my office and I asked a couple of questions. I asked questions about how the formulas and representative indices he had talked about in the meeting took into account such issues as the possibility of high definition television; the possibility of fiber optics; the loss of remote control revenue (as consumer compatibility issues develop); and the issues of improved television signals necessary to continually attract customers in the face of improved recording media such as Super VHS.

Since this person is the ultimate professional, and obviously not as successful as he is because of guesswork, I found he had already considered these issues and their time frame on all of the formulas and index criteria he had talked about so smoothly. He said to me that one of the most vital things he had learned about the changing technology in our industry was that it does have an impact on the viability of the business and it's good that there are senior level technical personnel in the cable industry who are as much businessmen as they are scientists and engineers. He also bemoaned the fact that there seemed to be fewer of these in the major companies than are needed.

Shortly after this conversation, I began to reflect on the state of affairs in this particular area of concern—the senior level statesmen like chief technical officers in our major companies. If you look at any major MSO that is successful, which has desirable properties and is looked at as a leader in the business, if you look at any major equipment manufacturer that has a reputation for quality and performance, you will see that in every case you can identify a person of the type talked about by my friend. A technical person so versed in the multiplicity of disciplines necessary to make a rational decision on technology and yet well tempered by an understanding of the needs of the business, and in particular the needs of his or her company in the competitive arena. Invariably you also find that these people have a great deal of energy and interest and use that energy to work tirelessly on behalf of the industry at large as well as their company. These people work with the NCTA, the SCTE, they write articles, they seek to bring enlightenment on a wide variety of issues to people in all segments of the industry, both management and technical. In the entire industry there are probably fewer than 100 people with the expertise and experience in these twin disciplines to make a significant difference.

I find it alarming, therefore, to reflect on recent events and find that several of these senior level people have changed jobs in the very recent past. More important is that several others are contemplating doing the same and I'll be blunt here: changing jobs is a euphemism for looking for another job either voluntarily or involuntarily.

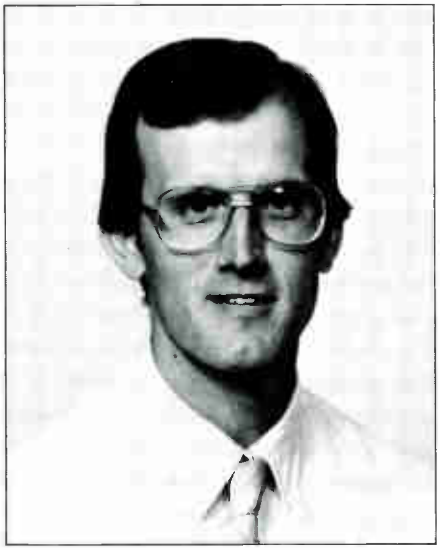
In the last two years, those people that I have put in this category of the top 100 personnel who have changed jobs have done so rather quickly and have, for the most part, stayed in the industry and continued to be a credit to their company as well as to the industry at large. That outcome is less certain as we talk today.

I see the possibility that several people who I think are unparalleled in their selflessness, in imparting their knowledge and wisdom to our industry, are at significant risk.

With the aforementioned issues of high definition television and what that means to our requirements for bandwidth and system performance, with fiber optics and what that means to our general architectural design situations as well what other services can be implemented from a change in the basic structure of our systems, fiber optics and other problems still have to be overcome before cable can take advantage of major new technologies. All of these issues come at a time when the senior statesmen of the engineering community seem to be both hard to hold and hard to attract.

Short-sighted thinking at this time can lead to a scramble in the not too distant future to try to find or develop people with the appropriate talent to help us meet these challenges in the future. A careful analysis of the importance of this group to our future health is called for by all in a position to make a difference. This is too good a business to give away.

By Wendell Bailey, Vice President Science and Technology, NCTA



NTSC artifacts: a thing of the past?

NTSC artifacts sound like something you might find at an archaeological dig. In fact, that might not be too far from the truth. With the way TV technology is progressing, and given that high definition television is on the horizon, NTSC artifacts may very soon be a thing of the past. Since HDTV is becoming such an important industry topic, and since the elimination of NTSC artifacts seems to be one of the goals of proposed HDTV or EDTV (extended definition) systems, I thought it would be worthwhile to review the origin of a couple of the more noticeable video artifacts: cross-color and cross-luminance.

In 1953, the National Television System Committee had as one of its goals the production of a new color television standard that would be compatible with the black-and-white TVs that were already on the market. In retrospect, the NTSC should be commended for its efforts. The color system, as it was defined by the NTSC, turned out to be a remarkably rugged system. Advances in both picture-tube technology and semiconductor physics have combined to produce remarkably good pictures in a short period of time.

By Chris Bowick, Engineering Dept. Manager, Scientific-Atlanta

In order to produce a color TV standard which would be compatible with the existing black-and-white TV sets, the NTSC had to find a way to insert the color information into the luminance spectrum in such a manner that black-and-white sets would ignore the information while color sets would process both the color and luminance with a minimum amount of crosstalk between the two. This was accomplished through a process known as "frequency interleaving."

The color subcarrier (3.579545 MHz) was chosen as the 455th harmonic of one-half of the line frequency (455 × 15,734.264/2). It was placed at this specific point in the luminance spectrum in order to minimize the interaction between the luminance and chrominance information while still maintaining adequate room at the upper-end of the baseband spectrum for the double-sideband suppressed-carrier chrominance signal. This can be better understood by analyzing the video carrier's spectrum as it is modulated by a 15,734 Hz synchronizing signal and its associated luminance spectrum. Close examination will reveal that there is a spectral null in luminance information at every odd harmonic of 7,867 Hz (15,734/2). It is in these spectral "nulls" of luminance information that the chrominance information is "interleaved" by such a judicious choice of subcarrier frequency.

Inevitably there is some amount of crosstalk between the luminance and chrominance information. It is this crosstalk, otherwise known as cross-chrominance and cross-luminance, which has been widely called an NTSC artifact.

Cross-chrominance or cross-color is the contamination of chrominance information by high-frequency luminance information. It can be observed in pictures which have a lot of high-frequency detail such as a tweed coat, multiburst or a very detailed striped shirt, and shows up as a very "busy" rainbow type pattern that seems to be flashing at a 15 Hz rate. The classical example is the talk-show host with a "loud" sports coat that seems to want to jump off the screen.

If the picture contains a lot of vertical detail (horizontal lines on the screen), then it is made up of information relatively low in frequency since the same horizontal line can be retraced only once per frame. For that reason, it would not have the opportunity to mix with the chrominance information at 3.58 MHz, and would therefore not cause a cross-color problem. However, if the picture contains high frequency horizontal detail (vertical lines on the screen) with luminance information that extends out to 3.58 MHz and beyond, then there is a chance, in an NTSC receiver (unless it has comb filters), that the luminance information will fall within the chroma bandpass filter to create the cross-color effect.

Cross-luminance, which results in a phenomenon known as "dot-crawl," is the contamination of the luminance channel with chrominance information. It shows up in the picture as extremely small, high frequency (3.58 MHz) dots or cycles of alternating dark and light luminance, which, because of the interlace type of line-scan structure, appear to move. If you're familiar with standard color bars, you may have noticed the dot structure at the junction between any two of the colors. Instead of a neatly defined instantaneous transition between any two of the colors, you will find the transition to be poorly defined and "crawling" with dark and lightly shaded dots of luminance. With active video, the effect is more difficult to see, and not quite as objectionable as the cross-color artifact.

Many of today's advances in TV technology are aimed at the elimination of these NTSC artifacts. One- and two-line comb filters, which are making their way into many of the medium- to high-priced TV sets, are specifically aimed at reducing the crosstalk between chrominance and luminance. Super-VHS VCRs, with their separate chrominance and luminance outputs (Y/C), never even combine the two signals, thereby eliminating crosstalk.

What does the future hold for HDTV? At this point, I would hate to speculate. But one thing is almost certain: NTSC artifacts are an endangered species. Maybe, if I bury my TV set now, a future archaeological expedition just might .... ■

return path

Whoa!

In reference to your November 1987 "Spotlight" on Sally Kinsman, my eye was drawn to the middle of the article where she states that "a good designer should be able to do two miles an hour." I have been designing for over six years now and have known many designers and have never heard of anyone approaching even half that speed on a modern urban design job. In fact, the only ones that come close to that rate design by the "guesstimation method" with no calculations and no drafting of the design. At that rate, Sally could replace three or four other designers.

Please do not misinterpret this; Sally is definitely an excellent designer who has been influential in the cable industry. She has been helpful to me personally in the past to solve some design problems and she also keeps me on my toes with regards to the quality of my own designs. However, I must wonder if there was a typo in the article or if Sally's design rate needs more defining (i.e., density, frequency, calculations only, etc.).

Thank you for covering the "giants" of our small industry the way you do and for a top notch magazine.

Donald C. Vought
Senior System Designer

More about leakage

Thanks to Steve Raimondi of United Artists Cablesystems for replying to my letter in the January 1988 issue of CED. I appreciate the concern he has expressed over cable television radiation.

My purpose in writing my letter was to sensitize the CATV engineers to the very real problems that confront so many spectrum users operating systems on frequencies used for cable distribution. I wanted to remind them that while the television industry needs millivolts of signal at the antenna, the rest of us use microvolts, or even fractions of a microvolt!

I appreciate that many of the radiation problems occurring are beyond the control of the cable company. I would welcome standards on consumer electronic equipment to prevent it from radiating. These same standards should greatly help reduce the direct cabinet ingress problems which still plague us, even on sets connected to the cable. In my experience, this problem has become much worse over the past few years, even with good brand-name televisions.

Unfortunately, such standards are not going to control interconnecting coaxial cables which may carry augmented channel signals and radiate. They will not control how the consumer connects his equipment. They will not prevent the consumer from doing his own inside wiring and causing additional radiation.

Given that so many problems are beyond the control of the cable company, Mr. Raimondi has helped reinforce my point that some other distribution technology must be used. It seems to me that, as he suggested, light must be brought inside the customer's home and terminated in a converter which will produce an RF output on an ordinary broadcast channel—not an augmented channel.

Unfortunately, until this day arrives, we have to make the best of present coaxial systems. In my view, the cable companies can do a lot to protect the "sacred trust" they have to prevent interference to licensed spectrum users by ensuring that all their craftspeople are well trained on both how a cable system works and the steps to be followed to prevent excessive radiation. I need look no further than my own home to illustrate my point.

A few years ago, my cable drop had to be spliced. The craftsman installed the connector incorrectly so that there was no contact made to the shield. I noticed terrible reception on the "impaired" channels (those cable channels which are also used for local TV broadcasting) and radiation in the FM broadcast band. I quickly discovered the bad connector and made a temporary connection to the shield with a piece of wire and a clip.

I called the local cable company and they promptly dispatched a technician. I explained the problem and showed him my temporary fix. Well, he looked at me as if I was really giving him a line! Contact to the shield? What for? He thought I had caused the problem by the small nick I made in the outer jacket of the coax to connect my clip to the shield!

It was bad enough that some kind of shield continuity check (such as a loop check) wasn't routinely done. But it was intolerable to have anyone working on the system who didn't even understand the importance of shield continuity.

Finally, I would like to illustrate how bad the radiation is from many cable systems. My home is located in a newer area served by underground plant. However, the area is surrounded by older homes served by aerial cable. I have no reason to doubt that the system meets current radiation specifications. In my area, the 145.250 MHz signal is barely detectable on a handheld unit using a small flexible antenna. The signal on my mobile is a little stronger in my area, and it gets much stronger when I drive in the older area served by aerial plant.

However, I also have a good antenna system (2-19 element Cushcraft Boomers, horizontally polarized) at my home for my weak-signal activities. While it is true that this antenna system has much higher gain than a typical commercial land mobile system, the antennas are obviously not omni-directional. While signals in the main lobe are certainly enhanced, the rest of the signals are attenuated.

When I connected a spectrum analyzer to my antenna, I noted that the 145.250 MHz cable signal was typically −90 dBm (7uV), and it never dipped below −100 dBm as I rotated the antenna through 360 degrees. A typical weak-signal amateur can copy a Morse Code signal at around −145 dBm, so the cable signal is more than 50 dB above my threshold. A typical commercial FM base station routinely uses signals as low as −113 dBm, or more than 20 dB weaker than the radiated signal from the cable system!

Raymond W. Perrin
Director—Ontario VE3FN
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Imbirdance measurement for CATV antennas

Ever since the first cable TV pioneer put his TV antennas up on a high hill and ran his cables down into town to make history's first CATV system, birds have perched on TV antennas. In early days their presence was hardly noticed, unless a large number of them overloaded a tower and caused it to collapse. In recent years, however, increasing emphasis on picture quality and efforts at reception over longer distances has brought increasing emphasis on lesser known aspects of TV reception. Many engineers and technicians have wondered about the bird phenomenon. One man did something about it.

Ward Watt is a man with many years' experience in electronic and radio engineering. He holds an MSEE degree from Vassar and has been professor of electronic engineering at Union Theological Seminary. Long a ham operator and hi-fi addict, he worked at commercial broadcast stations for some years and still has his FCC Radiotelephone First Class License.

Watt's theory

Having long wondered what effects birds perched on antennas had on RF signals, three years ago Watt began to investigate the situation. He outlined his theory for me when I talked with him recently. The problem, he explained, is much the same whether a bird is perched on a transmitting or receiving antenna. The only reàl difference is that on a transmitting antenna, the RF power level may be high enough to injure the bird. But the presence of the bird disrupts the transmitted or received wave.

In the immediate vicinity of an antenna there exist two fields, each having two components. They are:

1. The radiation field: (a) its electrostatic component, and (b) its electromagnetic component.
2. The induction field: (a) its electrostatic component, and (b) its electromagnetic component.

Thomas R. Haskett, formerly with Radio-Electronics, New York City

This article first appeared in the Broadcast Journal *magazine.*

The development of the concept of imbirdance and the device for its measurement will contribute significantly to the advance of the cable TV industry.

RF communication is nearly always conducted by means of the radiation field, for the induction field diminishes rapidly with distance from the transmitting antenna. Thus, most receivers make use of the radiation field to pick up the signal from the transmitting station. Furthermore, nearly all receiving antennas are designed to respond primarily to the electrostatic component, rather than to the electromagnetic.

This means that most RF communication—whether TV, two-way radio, or amateur CW—is conducted by means of the electrostatic component of the radiation field emanating from the transmitting antenna. A sufficiently large object placed between the transmitter and the receiver impairs communication. On occasion, so do birds.

From this first theory, Watt began developing ideas. The proper function of an antenna is impaired by the presence of a bird (or birds). He called this parameter *imbirdance* (represented by the symbol *Ib*). He found that this quantity depends on a number of factors: A bird near an antenna has more effect on the signal than one some distance away. Larger birds cause more interference than smaller birds. Finally, the wavelength of the RF signal and the directional pattern of the antenna affects the degree of imbirdance.

Formula for imbirdance

It soon became obvious to Watt that Ib is directly proportional to the square of the distance between the bird and the antenna. The size of the bird is much more complex, and Watt found that Ib was directly proportional to the cube root of the volume of the bird. Wavelength was an inverse factor, since a bird of a given size would cause greater imbirdance as the wavelength decreased. It turned out that interference increases with frequency, the bird size remaining constant. What happens is simply that the capture area of the antenna decreases as frequency increases.

One factor remained which determined imbirdance. By a thorough series of experiments, Watt determined the effect of varying the orientation of a bird with respect to the directional pattern of the antenna. He used the symbol Δ to represent this factor. Figure 1 shows various values of Δ for a simple dipole antenna.

Computations and field tests have been made by Watt and his co-workers which recorded bird-orientation effects on several types of antennas in common use today. (This information is available from Watt, as will be mentioned later.) It is therefore unnecessary to refer to the physical construction of many types of antennae to compute imbirdance. The value of Δ includes antenna length in λ, number of elements, spacing and capture area.

At this point, Watt was ready to write a formula to describe the phenomenon he had so painstakingly researched. As the unit of imbirdance, he chose the term *avis* (Latin for bird; abbreviated *Av*): His formula:

Classics

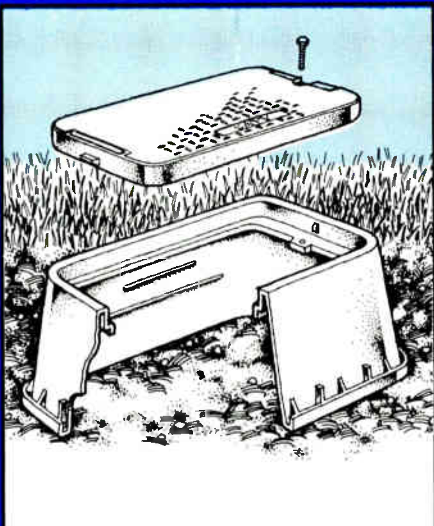
Of all the phenomena affecting over-the-air reception of television signals for distribution in cable, it is possible that the impairment effect of birds is one of the least well understood.

Many cable engineers may have missed this thoroughly researched article on the subject when it was first published. The author, Thomas Haskett, provides an excellent theoretical basis for his treatment of the calibration and use of equipment for the measurement of imbirdance. Those familiar with a remotely related instrument called the "Bird Wattmeter" will read this article with special interest.

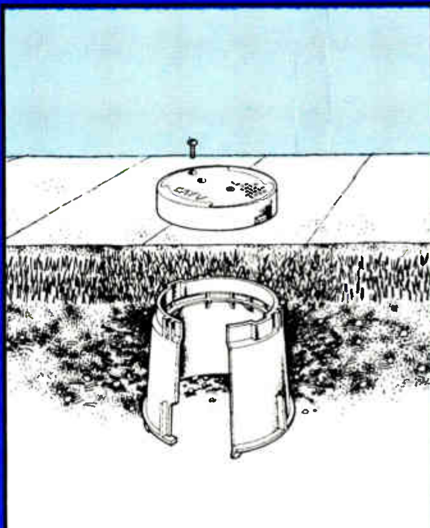
I'm indebted to Joe Van Loan for finding this article.

Graham Stubbs
Consulting Engineer

Carson Grade Level Boxes...



GLB-1320-12B



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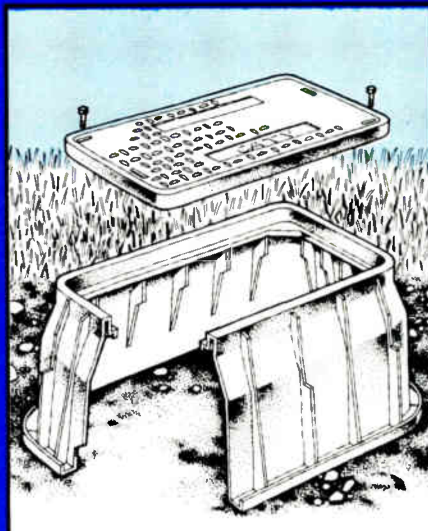

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Reader Service Number 8

Watt's experiments were conducted chiefly with the common starling, *sturnus vulgaris*.

$$Ib = \frac{\phi d^2 \sqrt[3]{V}}{\lambda}$$

Where Ib = imbirdance in avis,
Δ = orientation factor of bird with respect to directional pattern of antenna,
d = distance in inches between center of bird and
V = volume in cubic inches of bird, and λ = wavelength in inches of center frequency of transmitted or received signal.

Watt's experiments were conducted chiefly with the common starling, *sturnus vulgaris*, that species being most prevalent near his laboratory. He did, however, record data concerning several other species.

Using the formula

One series of experiments which Watt conducted shows how bird interference increases with frequency. He placed an adult male starling (volume, 18.2 cu. in.) on four antennas, one after another. Since the bird perched on the antenna (each was horizontally polarized) the center of its mass was 3.0 inches from the center of the antenna. The bird was placed in the major lobe of each antenna, which was a standard bir-directional dipole. Thus Δ was equal to 6.0, d was equal to 3.0, and V was equal to 18.2. The only factor which was varied was wavelength. The results follow:

UHF TV antenna, $f_0 = 700$ MHz

$$Ib = \frac{6x9x18.2}{16.8} = \frac{54x2.63}{16.8} = \frac{142}{16.8}$$
$$= 8.46 \text{ Av}$$

Low-band VHF TV antenna, $f_0 = 57$ MHz

$$Ib = \frac{142}{207} = 0.685 \text{ or } 685 \text{ mAv}$$

Amateur 75-meter antenna, $f_0 = 3.8$ MHz

$$Ib = \frac{142}{3{,}080} = 0.0461 \text{ or } 46.1 \text{ mAv}$$

Broadcast-band antenna, $f_0 = 1{,}000$ kHz

$$Ib = \frac{142}{11{,}800} = 0.0120 \text{ or } 12.0 \text{ mAv}$$

To determine the effect of a bird in the lobe or in the null of an antenna pattern, Watt next varied the bird's position with respect to the antenna. In the following example, worked on the dipole of Figure 1, volume (18.2), distance (3.0) and wavelength (16.8 or 700 MHz) remain constant. Only Δ, or the orientation of the bird, changes:

0°, Δ = 0.80, Ib = 1.13 Av
40°, Δ = 3.92, Ib = 5.53 Av
90°, Δ = 6.00, Ib = 8.46 Av

When Watt began placing two, three and even more birds on an antenna he discovered that flocks of birds can flock up the calculations.

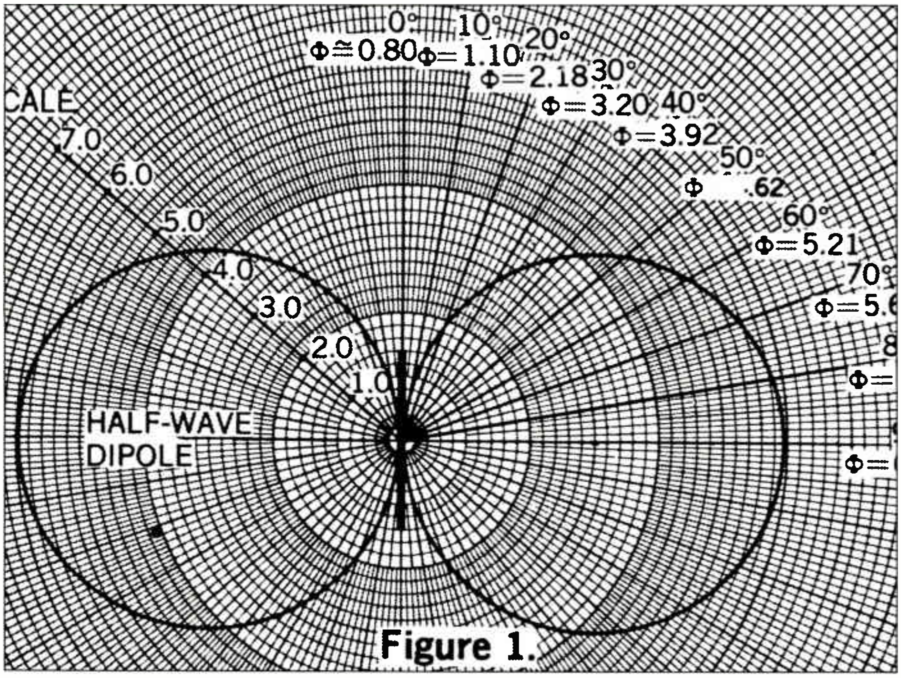


Figure 1.

From these and other experiments, Watt determined that when the volume of a bird was large, near and in a directional lobe with respect to the capture area of the antenna, signal transmission or reception was impaired. Generally speaking, imbirdance of the order of 0.5 avis and up causes serious disturbance to reception and/or transmission. Below 0.5 avis (500 mAv) signal impairment is slight. Below 100 mAv the bird is electrically invisible.

Measuring imbirdance directly

When Watt began placing two, three and even more birds on an antenna to measure their effect, he discovered that flocks of birds can flock up the calculations. You have to haul out integral calculus, and keeping the birds in position long enough to compute imbirdance was a task. It became obvious that the tedious process of observing the birds perched on an antenna, determining their species, sex, age and health, then consulting tables giving mean volume, and finally computing imbirdance according to Watt's formula, was a waste of valuable time by many radio engineers and technicians. What was needed was an instrument which would determine imbirdance electronically, and which would be read directly in avis.

Watt knew that a bird had to be relatively close to the antenna—in terms of wavelength—to cause serious impairment to reception. He observed that if a bird was close enough to disrupt communication, it was within the induction field. That was the basis for the invention of the Watt Birdmeter.

As originally conceived, the birdmeter consisted of a simple low-powered transmitter which emitted a continuous-wave signal that matched the f_0 of the antenna under test. A separate receiver fed from an induction loop intercepted the returning induction field. After much effort, Watt calibrated his prototype birdmeter for various species and wavelengths. But something was lacking. How could you measure imbirdance during the transmission or reception of a program without interfering with that program?

His next step was to employ a keyed or pulsed transmitter. Since he couldn't transmit a CW signal of carrier frequency through a TV transmitting antenna during normal program time, he keyed his instrument on during vertical sync interval, when it would be unnoticed by home viewers. This seemed to work satisfactorily, and he developed a similar technique for FM. The birdmeter generator was multiplexed into the main FM transmitter.

Future of imbirdance

Today Ward Watt is president of the Watt Electronic Corp., located in Savant, Ohio, a pleasantly bird-infested suburb of Cleveland. His original work relating birds to TV interference (which cable TV technicians call TVI) has given way to efforts to prevent such interference. It would be simple to electrify the antennas and shock them off, but Watt is a lover of nature and dislikes harming our feathered friends. He is currently working on ways of gently nudging them off antennas.

I recently stopped out at a cable TV headend to watch Watt at work.

"Strange as it may seem," he said, "there are some combinations of antennas, frequencies and even programs, that attract birds. For instance, this cable system uses log-periodic cantilevered quad arrays for the high band channels. Right now, as you can see, we're watching Lawrence Welk on ABC, and I'm reading 2.5 Avis. Maybe they don't like good music."

As I left, Watt told me of his newest invention, the Disimbirder—a device which would remove birds from an antenna gently. "It uses," he said, "a soft unclamp, to induce them to remove their claws from the antenna elements." ■

AM transmission on fiber

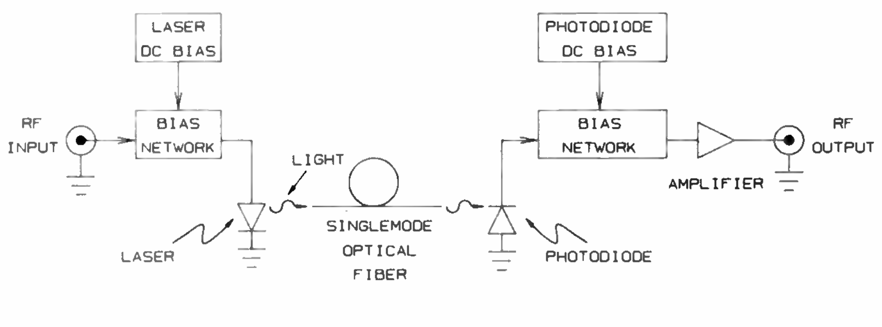
Myth or reality?

Fiber optic links that transmit distribution quality AM signals will radically change the way CATV systems are designed. The CATV industry will be able to incorporate fiber optic technology in affordable systems that penetrate deep into the subscriber network. These links will cost less and be more reliable than equivalent coaxial distribution systems. Subscribers will receive better quality signals and suffer fewer interruptions because of the fiber optic links.

Principles of transmission

Figure 1 shows a schematic of an AM fiber optic link. For communications specialists, the easiest way to understand the link is to think of the laser as an AM modulator and the photodetector as an AM detector. The input RF current modulates the light output of a semiconductor laser diode operating in the invisible 1300 nm range. Optical fiber captures the emitted light and transmits it to the photodiode with negligible attenuation and distortion. The photodiode faithfully reconverts the light back to current, recreating the original signal.

FIGURE 1



Semiconductor lasers are specially constructed PN diodes that emit coherent light when the diodes are forward biased above a threshold current. Above threshold, the diodes convert current to light with remarkable linearity. If the lasers are made carefully, the intensity of the emitted optical beam will be linearly proportional to the instantaneous diode current with bandwidths well into the microwave frequency range.

In signal processing terms, the input of the laser is an RF signal, more specifically the RF current. The output is an amplitude modulated optical signal. The ratio between optical power and input current is known as the modulation gain, which is the slope of the laser's LI (light vs. current) curve. This has dimensions of mW/mA. Figure 2 shows this curve and an example of how the RF current modulates the optical output.

A practical laser module consists of a laser chip in a suitable package with optical fiber directly coupled to the output of the laser. Lasers exhibit considerable dependence on the ambient temperature, so most module designs incorporate a thermoelectric cooler into the package for temperature control of the chip. Usually an internal photodiode is also included to provide ALC of the laser output. The photocurrent is compared to a reference to set the laser current and control the DC operating point. A complete optical transmitter consists of the laser module and the additional electronics required to operate the optical ALC circuit and the temperature control circuit. There may be signal conditioning circuits as well, such as an amplifier or a filter.

A photograph of a practical laser package and the internal schematic are shown in Figures 3 and 4. The coaxial input connector is particularly useful in high frequency analog systems. Also very important is an internal matching resistor to build the laser dynamic resistance up to 50 or 75 ohms, depending on the application.

By Dr. Larry Stark,
Ortel Corp.

Optical reflections

One cannot mention semiconductor lasers used in fiber optic networks without mentioning their susceptibility to reflected optical signals. Reflections from system components, particularly connectors, will produce frequency hopping, increased noise, distortion and nonlinear tuning effects. Thus, it is essential to provide well designed optical networks to realize the best performance from these lasers.

Fortunately, these problems can be solved. High performance connectors are available that have negligible reflections. By using these connectors and using good design techniques in the laser module itself, it is possible to keep discrete reflections to the laser low enough to obtain very low noise performance, low enough to operate in CATV links.

Fabry-Perot and DFB

Two principle types of laser designs are found in use today. They are designated Fabry-Perot (FP) and Distributed Feedback (DFB). They differ primarily in the optical spectrum of the light they emit. In general, the laser operating wavelength is determined by two factors: the band gap of the semiconductor used in the active region, and the optical characteristics of the laser cavity. At 1300 nm, standard cavity designs (FP) resonate at several closely spaced wavelengths within the operating range of the semiconductor material. Thus, the laser operates at more than one frequency. Typical lasers actually have four or five operating frequencies, or modes.

DFB lasers are built with an internal grating in the optical cavity that limits the operating wavelength to a single value. The grating acts as a miniature bandpass filter that restricts the laser oscillation to one wavelength. The significance of DFB lasers' single operating wavelength is that dispersion is reduced to an absolute minimum. Dispersion is caused by slight differences in the propagation velocities of light as a function of wavelength. Over

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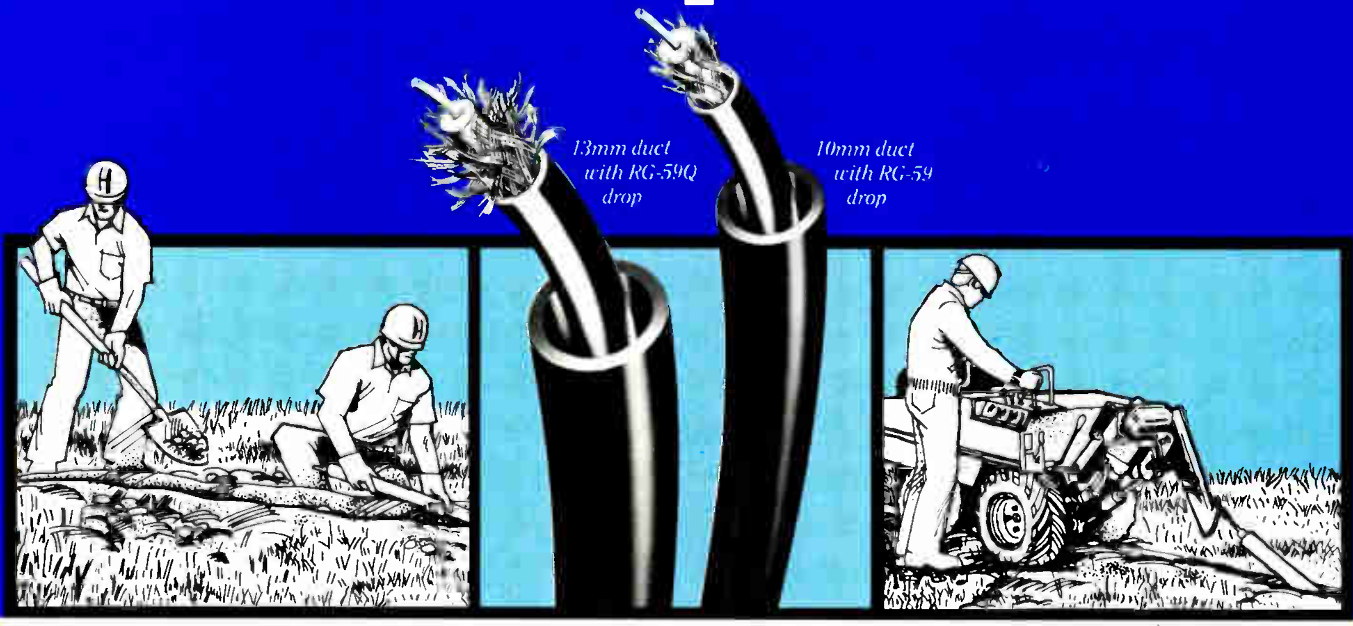

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Reel sizes available: 1,000 ft. and 2,000 ft.
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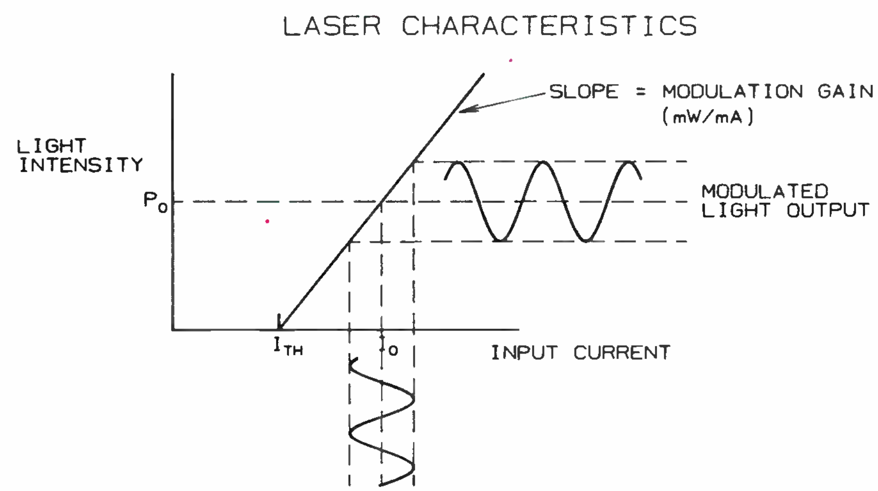
Reader Service Number 12

Considerable study is underway to determine if DFBs offer any significant operating advantage for CATV networks.

FIGURE 2



very long optical links operating at high frequencies, different wavelength components of an optical signal will arrive at the detector at slightly different times, thus causing distortion of the received signal. DFBs minimize this problem since only one wavelength is transmitted.

Fabry-Perot lasers are not without some advantages of their own. Their operating characteristics make them very easy to use compared to DFB lasers. In particular, they appear to be more resistant to the effects of reflections from the fiber. Considerable study is underway to determine if DFBs offer any significant operating advantage for CATV networks. Recent practical demonstrations of operating links transmitting in excess of 40 channels of subsacriber signals have used FP lasers. Results in the R&D lab indicate that even better performance is possible with FP lasers.

The photodiode

Considerable attention has been paid to the laser portion of fiber optic links, with little attention paid to the photodiode. It may seem that the laser is the key to these networks, but the photodiode cannot be taken for granted.

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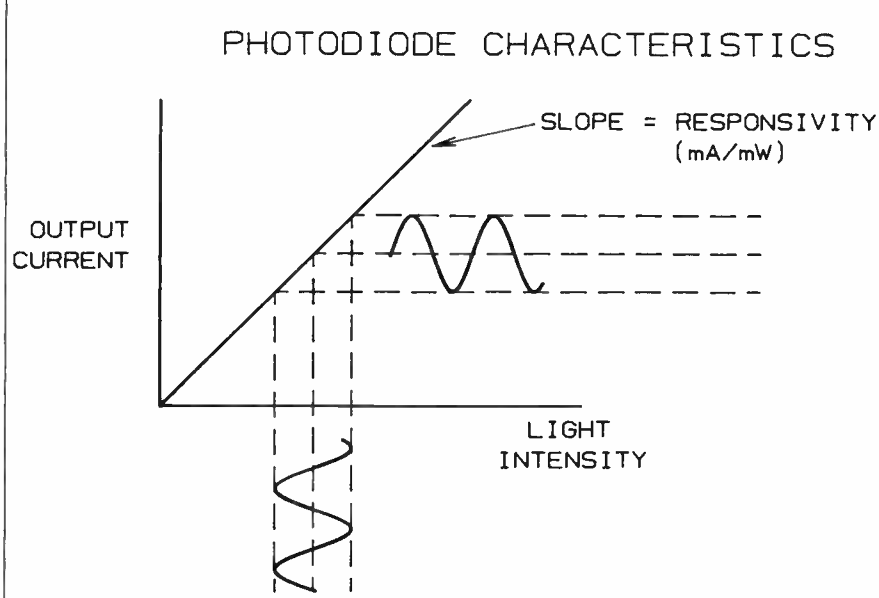
Specifications:

Bandwidth:	5-550 MHz	**Tap loss:**	1 db of assigned value
Tap-to-Tap isolation:	30 db	**Impedance:**	75 OHMS
Return loss:	20 db minimum all ports	**RFI:**	−100 db
	18 db 5 MHz tap port	**Input/Output ports:**	5/8 female
Power passing:	6 Amp AC/DC	**Subscriber ports:**	F-Type female (brass)

Fundamentally, a photodiode converts photons (light) into electrons (current) with excellent linearity and virtually no excess noise.

FIGURE 3



Fundamentally, a photodiode converts photons (light) into electrons (current) with excellent linearity and virtually no excess noise. Figure 3 shows the process by which analog signals are generated from an input optical signal.

There are three types generally in use: the PIN, the PINFET and the APD. Of the three, APDs are the noisiest and PINs are the quietest. On the other hand, APDs provide the most signal gain while PINs need special amplifiers to achieve the best signal gain.

The key to achieving 40-channel transmission performance over long links (more than 10 km) is minimizing the receiver noise and maximizing the signal gain. This can be done by utilizing the property that photodiodes behave like a current source. The actual output RF signal power is given by $I_{rf}^2 R_L$, so higher output power can be obtained by increasing the load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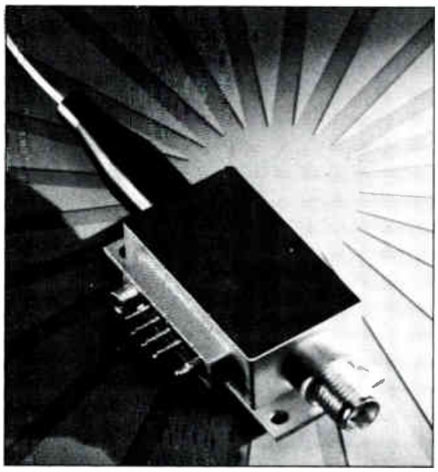
An often neglected aspect of the photodiode design is the care given to the termination of the optical fiber at the photodiode.

resistance. To achieve this performance, devices called "transimpedance amplifiers" are used. These amplifiers use feedback to raise the input impedance to a high value. This results in the maximum signal power for a given amount of receiver noise.

An often neglected aspect of the photodiode design is the care given to the termination of the optical fiber at the photodiode. Improperly terminated fibers will reflect a considerable amount of power back into the system. Reflections from a cleaved fiber are only 14 dB down from the incident signal. Such a high reflection could ruin an otherwise carefully designed fiber optic network with respect to the control of reflections.

Ortel has recently developed a proprietary process for controlling the reflections from the photodiode. Reflections are specified at <-45 dBc, and are typically unmeasureable. This is an important aspect of overall the CATV

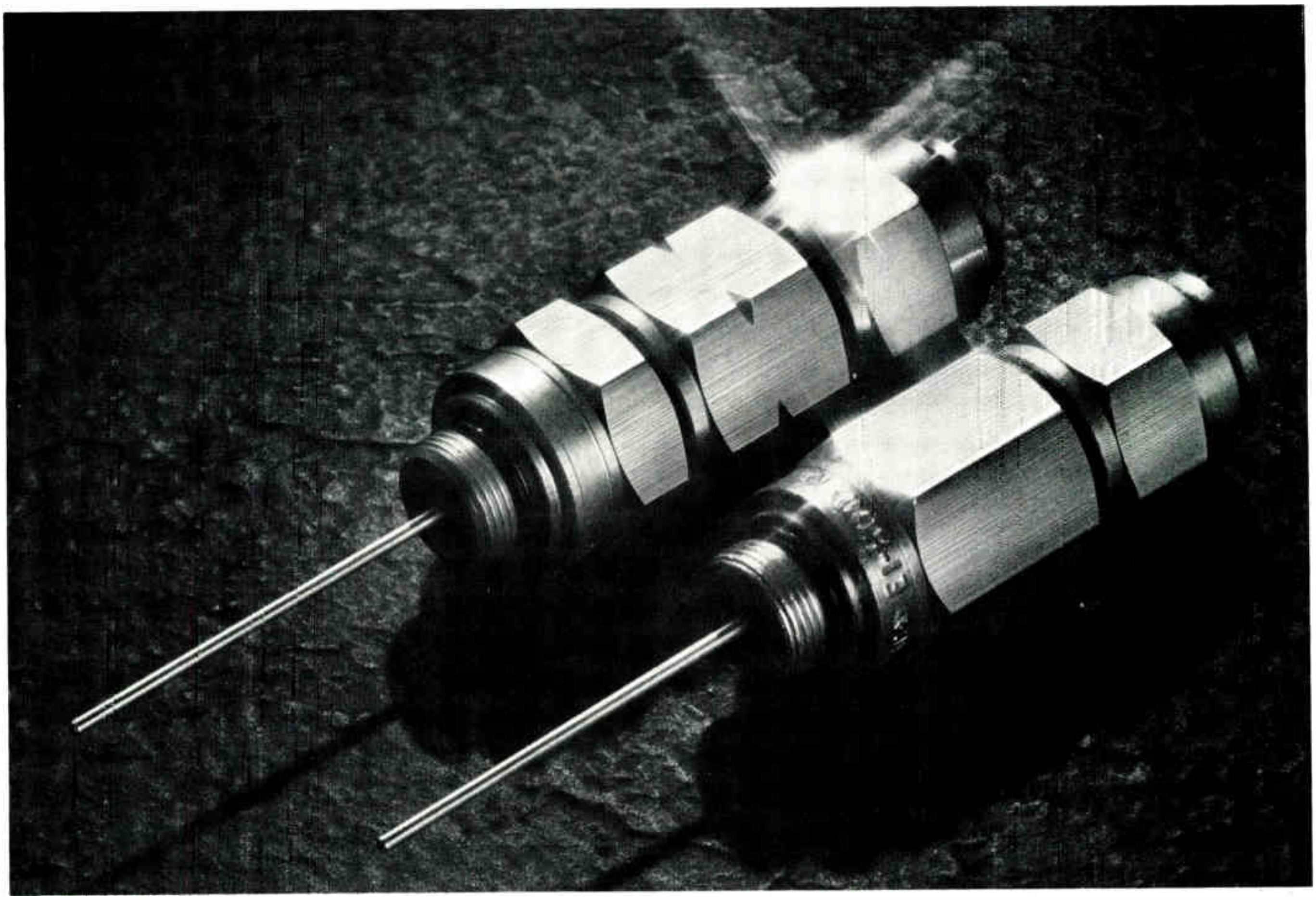


fiber optic system design.

Optical fiber

Modern optical fiber for 1300 nm systems is now available from several vendors at reasonable prices. The remarkable properties of optical fiber are well known. Most remarkable is the nearly negligible attenuation of the optical signal. Coaxial cable losses are measured in dB/meter, while optical fiber is measured in fractions of a dB/km, presenting the prospect of repeaterless links stretching for many tens of kilometers. Another important property of fiber is its bandwidth. Signals transmitted over fiber optic cables do not need equalization, as is often the case with coaxial systems. In fact, the bandwidth of singlemode fiber extends to many tens of GHz.

At 1300 nm, fiber is readily available with losses <0.4 dB/km. Even at these low losses, the practical limit for transmission distances in AM systems is 15 to 20 km. For even longer distances, fiber optic system designers are looking toward 1550 nm systems, where fiber loss is <0.2 dB/km. Today, systems operating at 1550 nm are not widespread in telecommunications net-



These systems can benefit from the use of fiber optic transmission just as the telecommunications world can.

works. The majority of advances in reliability improvement and cost reduction have occurred at 1300 nm wavelengths.

Performance advances

In the last several months, there has been considerable publicity about analog fiber optic systems for transmitting VSB-AM signals in the CATV network. Only a few years ago, such systems were considered impossible. Where has such improved performance come from? What is so different about today's lasers and photodiodes compared to those that were available before?

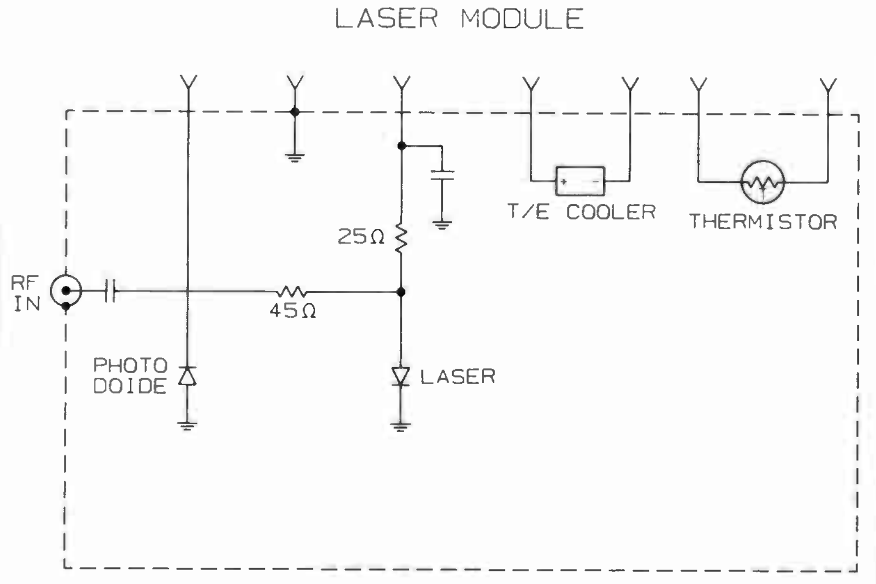
The difference is that recent improvements in laser and photodiode design have come about because of the growth of fiber optic links in microwave analog links. These links present far more stringent demands for performance than the digital links that preceded them.

Growth of digital systems

Fiber optic systems, praticularly those at 1300 nm, grew in response to developments of digital transmission systems used in telecommunications networks. The low loss of optical fiber made possible repeaterless transmission lengths of many dozens of kilometers. Telephone companies could install links between central offices with no repeaters, thus enormously simplifying their construction and maintenance costs. As applications grew, performance advanced, creating new applications. Today, routine systems achieve 565 Mb/s transmission speeds, with new products being announced at rates exceeding 1,000 Mb/s.

Impressive as they are, these bit rates can be achieved with components whose bandwidths are relatively low in the analog world. The growth of RF and microwave technology has resulted in an explosive growth of carrier transmission systems operating in the microwave region. Today, the average consumer can buy microwave receivers operating at 4 GHz (C-band) in TVRO satellite reception systems. The cost of these systems is extremely low. In fact the primary cost is for the mechanical part of the system, the antenna. Improved device design and mass production has lowered the cost of the microwave portion of the system to less than $100. And in Europe, DBS systems operating at 12 GHz (Ku-band) are a growing consumer market. Radar systems routinely operate in X-band (10 GHz) and a host of other systems, both commercial and military, use microwave technology.

FIGURE 5



These systems can benefit from the use of fiber optic transmission just as the telecommunications world can. But to meet these needs, much higher performance lasers and photodiodes were needed than were available for existing digital systems. Besides the higher frequencies needed for microwave systems, laser noise and distortion, relatively unimportant in digital systems, were also important. This required laser designers to measure these quantities and learn how to minimize them.

Analog requirements

Today, lasers are available that are optimized for analog transmission parameters. Of particular importance are:

- input impedance
- connector type (coaxial)
- flat frequency response
- low noise
- low distortion.

By contrast, these parameters were relatively unimportant in the digital applications. In the digital applications,

- Input impedance was less important than using a suitable laser driver that would accept ECL level signals and convert them to suitable current drive pulses.
- To be compatible with other components, lasers were packaged in multipin DIP packages that could be soldered onto circuit boards, next to other digital components.
- Frequency response was not measured. More important was pulse rise and fall time.
- In digital systems, the required signal-to-noise ratio is much less than in an analog system. So, laser noise is much less of an issue for analog system.
- Since the signal is digital, distortion is much less important a parameter than in an analog system.

The result of concentrated efforts to improve performance in these areas has been a new family of lasers and photodiodes that offer substantially better performance than many workers felt was possible.

CATV requirements

CATV system designers specify their requirements in terms that are unfa-

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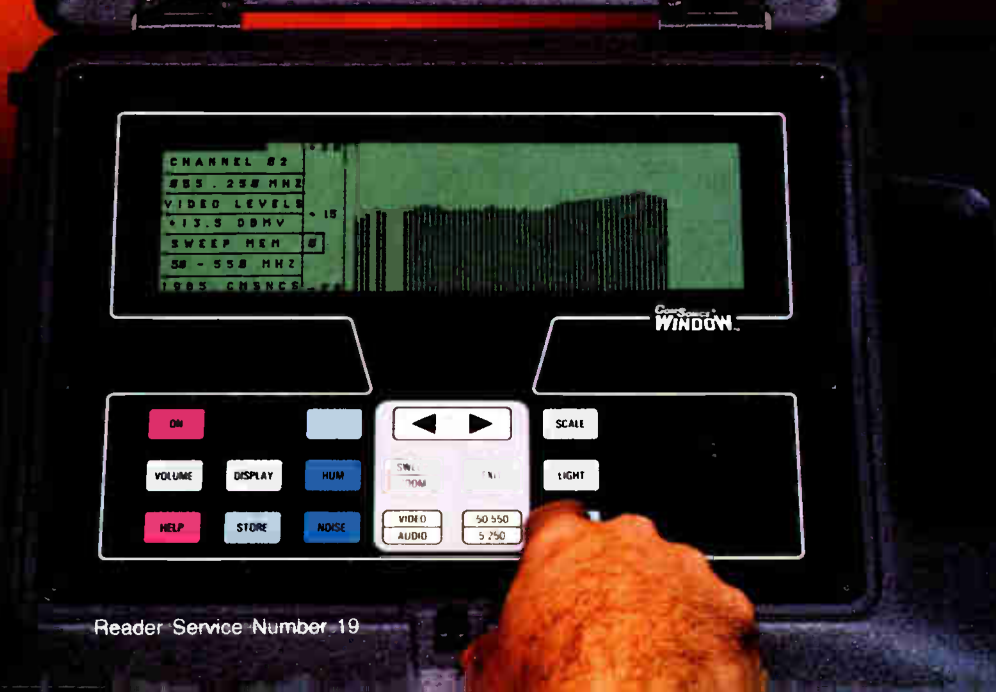

Reader Service Number 19

Intercept points can be directly measured on a short fiber optic link using a signal generator and spectrum analyzer.

miliar to fiber optic component designers. Yet there are definite relationships between the design parameters of lasers and photodiodes and the link parameters that define the video transmission performance. From the standpoint of a broadband fiber optic transmission link, it only takes four or five parameters to completely describe the requirements of the link. They are:

- number of channels
- transmission distance
- channel SNR
- third order distortion (CTB)
- and second harmonic distortion (CSO).

For a given transmission channel, changing any of these parameters affects the remaining ones. For example reducing the number of channels lowers the total signal power in the link, thus reducing the distortion levels. Transmission over a shorter distance reduces the path loss and raises the power to the receiver, thus improving SNR. Raising the power per carrier improves SNR but degrades the distortion performance. In practical terms, achieving a given level of performance defined by SNR and distortion levels requires a trade-off between the number of channels and the transmission distance.

The laser

The properties of the laser are best described in terms of the average output power (optical), the equivalent input noise (EIN), and the intercept points for two-tone second and third order distortion products. These parameters, combined with the input power channel, ultimately determine the CNR per channel, the CTB and the CSO levels.

The laser output power is determined by how far above threshold the laser is biased, and the laser to fiber coupling efficiency. Naturally, higher coupling efficiency increases the output power, but can actually work against good performance by increasing the laser susceptibility to reflections. There will be an optimum value of coupling efficiency that results in the highest link signal-to-noise ratio.

The laser noise originates from the intensity fluctuations of the laser's optical output. The EIN is the amount of noise at the input of the laser that would exactly produce the actual output noise. It is a useful parameter because it is easy to measure and can be easily used to predict link CNR values.

Intercept points are specified in terms of input power levels per channel. They can be directly measured on a short fiber optic link using a signal generator and spectrum analyzer.

A common misconception is that these distortion products can be predicted from the measured light-vs.-current curve of the laser. This curve generally shows some curvature, but

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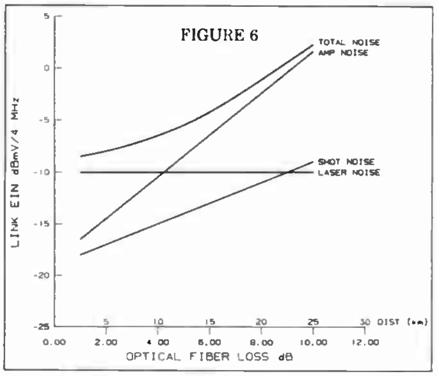
A more subtle source of reflections is backscattering of the light from impurities within the fiber itself.

the curvature is normally due entirely to self-heating. Current fluctuations above a few kHz will not change the average temperature of the laser, so the AC loadline is not related to the measured DC curve. In fact, the measured distortion products of advanced laser designs are considerably better than would be predicted from the DC curves.

The receiver

The two most important parameters for the receiver are the photodiode responsivity and the noise contributed by the amplifier following the photodiode. Needless to say, the responsivity should be as high as possible, and the amplifier should contribute as little noise as possible. Transimpedance amplifiers will contribute relatively low levels of noise, because the high input impedance minimizes the equivalent noise current at the input of the amplifier.

In addition to the amplifier, there is an additional source of noise in the receiver. The DC portion of the input



optical signal produces a DC photocurrent that has an accompanying shot noise. Paradoxically, proper system design favors high received optical power to minimize the effects of shot noise. Although this actually increases the absolute amount of the shot noise, the signal power is increased even more, thus improving the overall C/N ratio.

The optical fiber

The transmission medium itself is the optical fiber and associated connectors. The parameters of interest are the overall loss and the level of reflections caused by connectors and splices. To achieve the highest level of performance from the link, system designers should build fiber links with reflections less than −45 dBc. Fusion splices have unmeasureable reflections, so the net result is a fiber network with the desired quality. A more subtle source of reflections is backscattering of the light from impurities within the fiber itself.

The complete link

Figure 5 shows the calculated input noise of a complete link achievable

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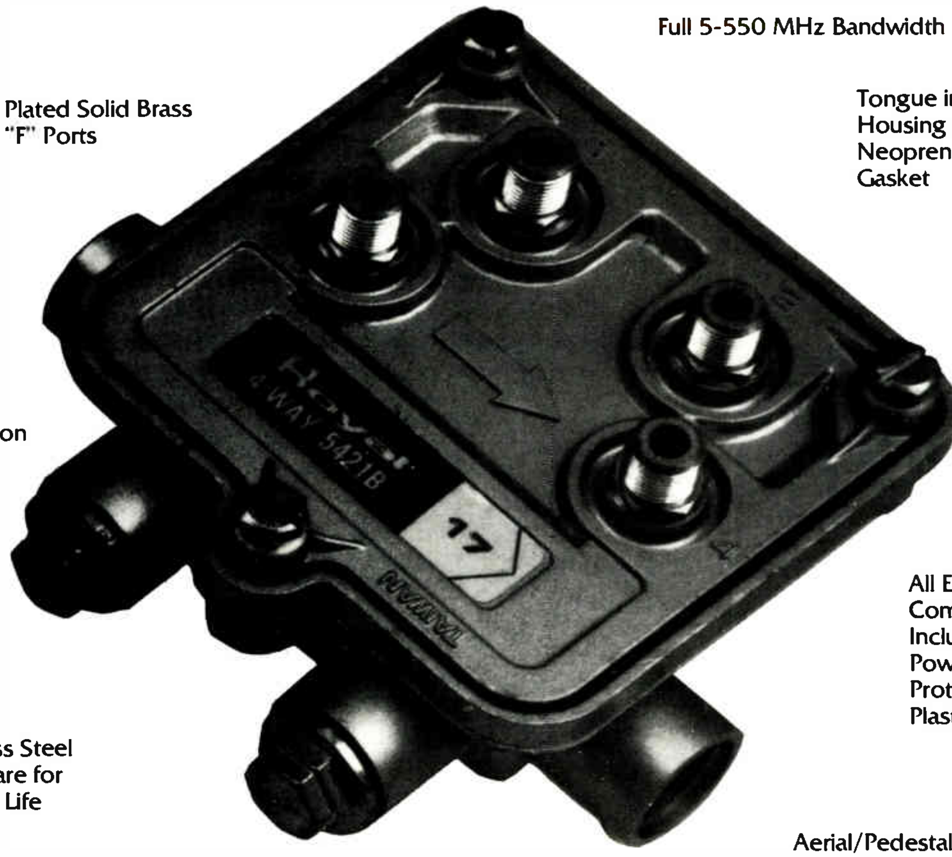

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Continued improvements in laser design will result in lower laser noise, with improvements perhaps of a further 10 dB.

with available components today. It shows the three different sources of noise, which are laser noise, shot noise and receiver amplifier noise. The horizontal axis is given in optical loss and transmission distance. The three noise sources are added together to show the total link noise. Since this plot shows equivalent input noise, the laser noise is independent of link length, as would be expected.

Of the two receiver noise sources, the amplifier noise increases the fastest with optical loss. This is because the RF attenuation of the link actually increases 2 dB for every 1 dB increase of optical loss. This strange behavior is due to the property of the photodiode which converts optical power into electrical current. Since electrical power is proportional to current squared, the dB relationship between electrical power and optical power goes as 2 to 1. The shot noise only increases as 1 to 1 since the receiver shot noise is directly proportional to the received optical power.

The link shown in Figure 5 could transmit 20 channels of AM signals with CNR = 50 dB and CTB = 60 dB for distances of 10 km. Although this performance could be very useful in many transmission applications, one asks what more can be achieved. At 10 km distance, the receiver contributes as much noise as the laser. This example assumes no noise improvement due to transimpedance amplifiers. Therefore, we would improve the link by increasing the receiver sensitivity. Reducing the receiver noise by 10 dB would improve the overall link noise by nearly 3 dB, allowing 40 channel transmission with the same overall performance.

Continued improvements in laser design will result in lower laser noise, with improvements perhaps of a further 10 dB. This would result in receivers that are shot noise limited, placing a premium on increasing the laser transmit power.

Nevertheless, with careful control of all the elements of the complete system, it today appears highly likely that practical systems can be designed with the following characteristics:

Number of channels	40
CNR	55 dB
CTB	65 dB
CSO	65 dB
Transmission distance	15 km
Performance margin (optical)	3 dB

There is no single set of device performance parameters that will yield this performance. Failure to achieve targets in one value can be compensated by better than expected performance in another. ■

Construction surge fueled by rebuilds

Depending upon which article you read, the cable television industry will build, rebuild or upgrade approximately 85,000 miles of plant in 1988, (according to *CableVision* magazine's annual construction survey). That represents a capital outlay of at least $1.4 billion on plant construction.

Perhaps the largest slice of that pie is in rebuilds (according to Paul Kagan, some 37,000 miles of plant will be replaced in 1988) as operators plan to wreck out old plant that has reached its intended design life or are forced to start all over again and add channels or enhance picture quality in this ever-increasingly competitive environment. All in all, this year could be the best year for cable construction since the heady days of 1983, when the industry was in the midst of franchising.

Increasingly the once-never-uttered word "overbuild" is generating the increased rebuild activity. A number of MSOs are facing overbuild threats and are investing in new plant to get more channels and better pictures to appease both subscribers and franchise authorities.

But one question remains: what happens to the miles and tons of coaxial cable, sheath and lashing wire that is pulled off the poles? Typically, a trash hauler is brought in and paid to get rid the mess. But more and more, trash dealers are reluctant to take the entire tangle. And landfills refuse to deal with it all because the myriad pieces of scrap are a nightmare to separate.

Slowly, a number of MSOs are realizing they are literally throwing away money. In the jumble of wreck-out lies a significant amount of salvageable plastic, aluminum and steel, among other things. Those MSOs who are progressive enough to see that are turning to scrap dealers who promise to come in, remove the entire wad of wreck-out and *pay* the operator a small sum for the privilege of doing it. With bottom-line considerations all the more important these days because of the huge debt many companies operate under, this may become a significant consideration.

"It's found money," says Tom Kruger, contract and project engineer for Denver-based United Cable Television, of the checks he's been receiving for scrap hauled away from United rebuild sites. "If you negotiate your contract well, you don't have to do any work at all and they pay you for it."

But what do you do with the waste?

Resource Recovery Systems, based in San Antonio, Texas, and Midwest Cable Services of Plymouth, Ind., are two of the most recognizable national

scrap dealers who are geared toward the special needs of cable television. Each company operates differently but each has its fans.

Resource Recovery boasts that it has been around the longest—about four years—and can accommodate more systems in more states than anyone else. According to Tom Wood Jr., accounts manager at RRS, he is currently servicing systems in 35 states. But above all, he rates his service and honesty as the most important attributes he has to offer. Yet he says most MSOs are missing the boat.

"We're fighting an uphill battle against the MSOs," says Wood. "Most MSOs don't care (what happens to the scrap) at the corporate level. They won't send out a memo to let the system personnel know that we exist. Those decisions are often made too far down the line" where turnover is high.

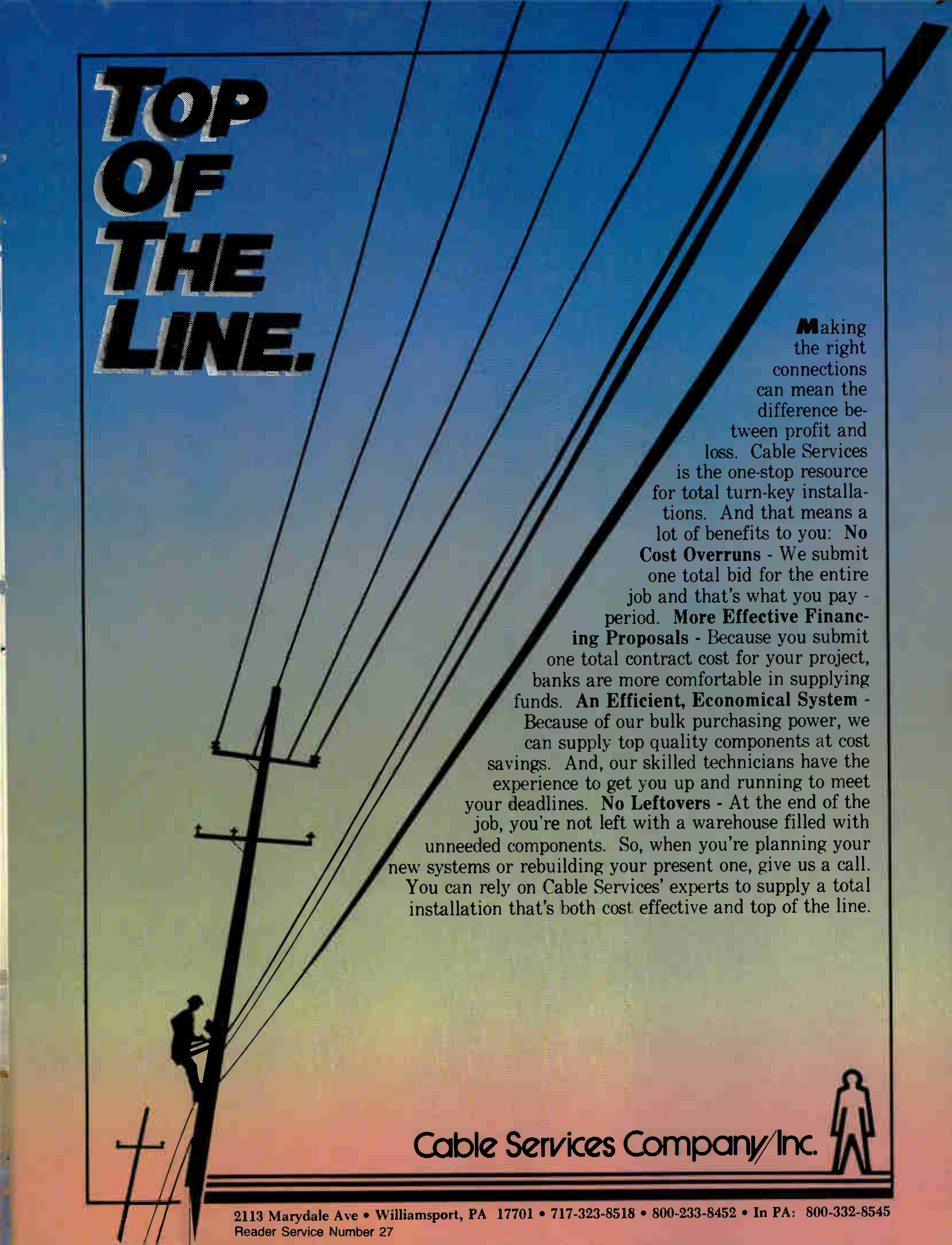
Wood should know. He has traveled in person to meet with a number of MSOs at their corporate headquarters only to be put off or told that his services aren't really needed. But, at long last, he's been getting some heads to turn, says the exasperated Wood. "It's not quite as bad as it used to be; we're getting some more recognition."

Wood spends most of his time on the telephone coordinating local contractors to be in specific locations when they are needed. "Almost everything I handle is over the phone," says Wood. That could lead to problems, and sometimes does, but Wood works hard to minimize that prospect. "It's a hassle finding dependable contractors (who will arrive at the proper location at the promised time). It reflects back on us if the contractors let me down. That's why we meet with the people in person and set things up."

All in all, Wood remains frustrated, though. He says operators don't really care if they get paid the full amount they are entitled to, they just want the wreck-out cleared away. That makes it tough on Wood because he works hard to do a good job and provide the operator with certified weight tickets. He was also instrumental in getting many of the cable manufacturers to agree to buy empty wooden cable reels back. In the past, system personnel often had to break them up because many scrap dealers wouldn't take them.

At Midwest, two-man crews and portable baling machines trek thousands of miles per month to service systems with scrap waiting to be picked up. According to Ralph Howard, the managing partner at Midwest, his company processed 4.1 million pounds of scrap in 1987, the equivalent of about 4,000 miles of plant.

Utilizing a crane attached to the mobile unit, Midwest crews come to a site and bale the entire mess without help from local cable system personnel. The processed material is weighed, weight tickets are sent to the system (or the MSO, depending upon the agreement worked out) and the machine moves to the next site. This way, if the load is less than the amount needed to fill a semi-trailer, scrap from the next site is added to make a full load.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Because so much rebuild activity is planned by all the MSOs in 1988, more and more people are getting into the business.

As containers are filled, they are shipped to the nearest seaport and exported overseas, typically to Taiwan. There the scrap is separated and processed and new products are made from the scrap. Last year Midwest shipped 110 containers averaging about 39,000 pounds in weight.

"The issue of scrap has always been small, but it becomes a big one when the time comes," says Howard. He, too, has noticed an increase in business from operators who are becoming aware that services like his exist. "Last year was a good year; we stayed busy the whole year," he says. "December, January and February are usually slow, but January (1988) was our busiest month ever. We're looking ahead, knowing we'll have to add more equipment."

Midwest's ability to operate without help from system personnel has impressed Cecil Monson, corporate construction manager at Cablevision Industries. "I've been in this business for over 20 years," he says. "In that time I've seen a lot of scrap dealers come and go. (Midwest) is the only scrap dealer I've ever met who has fulfilled his promises and is able to handle all our business without inconveniences on our part."

Monson says that's important because he has more than 2,000 miles of rebuild planned for 1988, so "scrap is a problem that has to be dealt with."

Because so much rebuild activity is planned by all the MSOs in 1988, more and more people are getting into the business, says RRS' Wood. Operators need to beware the fly-by-night dealers who might offer an extra penny or two per pound because the unscrupulous dealer may not pay the MSO for every pound removed, Wood says.

Even when the scrap market is good, operators need to realize they're not going to get rich by recycling their waste. Resource Recovery and Midwest both pay about 1 cent to 3 cents per pound, depending upon market prices, type of scrap, season, shipping costs, competition and location.

"Nobody's going to make a whole lot of money on scrap," says Howard. "We have our limits on what we can pay for it. But it's better to get $3,000 (from a scrap dealer) than pay $4,000 (to have a trash hauler remove it)."

Wood agrees. "We provide a unique service to the cable operator. In order to perform that service, we pay what we can," he says.

Besides the cable, sheath and strand, both firms also will buy salvageable electronics. Wood's firm has been doing it for years while Howard says Midwest is "really getting into that" now.

Although the total an operator might get for his wrecked-out cable wouldn't make a dent in the budget, the "extra" money can be put to good use, says United's Kruger, who turns over the checks he gets to the local operator to use as he pleases. "It might be enough for a company party or an employee picnic," he says. And that might help boost morale. "With rebuilds being the focus of the construction business this year, the whole issue of scrap is something the MSOs should be aware of," concludes Kruger.

—Roger Brown

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Reader Service Number 28

Testing Ku-band's reliability

The Florida Chapter of the SCTE has sponsored a Ku-band test program.

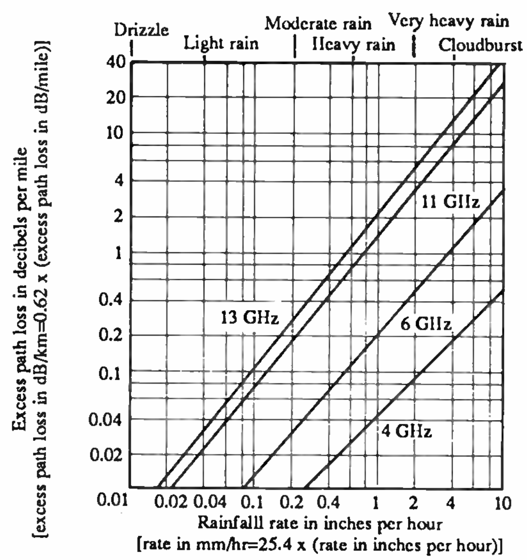
The experience with frequent rain fades on AML links, far above that predicted by mathematical modes, produced a fair amount of skepticism with many operators over the feasibility of operating Ku-band receive sites in the state of Florida. This skepticism was reinforced by preliminary experience with Ku-band receive sites. With that in mind, the Florida SCTE Chapter formed a committee, chaired by Jim Haworth of Cablevision of Central Florida, to review what information was available and recommend an initial program. Rain Rate data and thundershowers show that potential serious conditions affect not only Florida but also part of South Carolina, Georgia, Mississippi, Alabama, Louisiana and Texas. Other areas of the country may have problems of a lesser extent.

Published Path Loss vs. Rain Rate data, Figures 1 and 2, confirmed that very deep fades were probable. Rain rates in the four to six inches per hour range are not unusual in Florida and produce losses of 10 to 20 dB per mile of path.

With thunderheads reaching heights of 30,000 to 50,000 feet (nine miles), looking through three miles of rain would not be an unreasonable assumption. This would result in fades on the order of 30 to 60 dB—a serious problem.

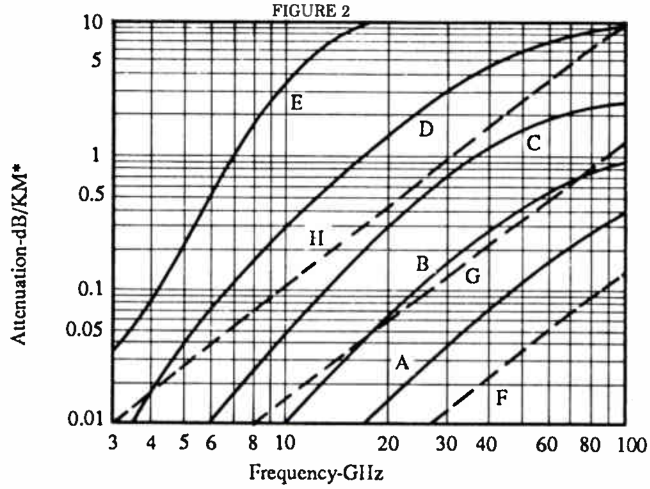
In addition to excessive path loss attenuation, at least two other potential problems are presented by high rain rates. Water sheeting on the surface of the antenna produces several effects. Part of the incident energy falls on the antenna is reflected and dispersed by the flowing water surface and will not be focused properly (Figure 3). This effect would be much more pronounced in the Ku-band with its much smaller wavelength than in the C-band. The energy not reflected from the surface must travel through the water film twice (Figure 4), where it will be attenuated.

FIGURE 1



Rain attenuation vs rainfall rate (Theoretical, after Ryde and Ryde)

FIGURE 2



Attenuation due to precipitation (after CCIR)

——— Attenuation in rainfall intensity of: A, 0.25 mm/hr (drizzle) - .01 in/hr; B, 1.0 mm/hr (light rain) - .04 in/hr; C, 4.0 mm/hr (moderate rain) - .16 in/hr; D, 16 mm/hr (heavy rain) - .64 in/hr; E, 100 mm/hr (very heavy rain) - 4.0 in/hr

— — — Attenuation in fog or cloud: F, 0.032 gm/m³ (visibility greater than 600 meters); G, 0.32 gm/m³ (visibility about 120 meters); H, 2.3 gm/m³ (visibility about 30 meters)

*Attn-dB/mile=1.61 x (Attn in dB/km)

The second effect of high rain rates is substantial water buildup in the antenna at high look angles. Even with a drain hole in the antenna, when the rain rate exceeds the drain rate the antenna resembles a bathtub, or a bird bath (i.e., a portion of the reflector surface is lost totally because the signal is reflected from the water surface and the weight of the standing water may distort the antenna structure, producing additional reductions in antenna gain).

After some preliminary experimenting with chart recorders and rain bucket scalers, the committee determined that in order to obtain sufficient resolution to record high rain rates and short outages, a relatively high chart speed is required (three to four inches per hour). With the likelihood of data being collected 24 hours a day over perhaps a year's time, the committee turned toward the use of a computer to eliminate the miles of chart paper that would be produced.

Roy Tucker, with Advanced Technical Products Inc., a designer and manufacturer of specialized CATV test equipment, was asked to produce a computer program and the associated interface equipment necessary for recording the data. The basic concept selected for measuring the Ku-band signal consisted of calibrating the receiver AGC voltage in terms of received signal utilizing a spectrum analyzer at the input of the receiver, (Figure 5). This procedure establishes the margin between threshold and

By J. Richard Kirn, Florida Chapter of the SCTE

Be sure to record the number on the computer screen and the receiver's front panel after each step.

normal signal level for clear sky conditions. According to published data, the sky noise comes up about 3 dB for rain fades within the 8 to 25 dB range. This effectively says that the system margin is 3 dB less than the signal to threshold margin as determined in this procedure.

Following is a list of the equipment used to set-up and measure rain fade effects at Ku-band receive sites:

- Tektronix spectrum analyzer, Model #7L12
- Micronta digital voltmeter, Model # 22-191
- Advanced Technical Product Computer Interface
- Advanced Technical Product Computer Software
- Tandy color computer 2
- Tandy dot matrix printer, Model DMP 106
- Tandy computer cassette data tape, C-10
- Tandy computer cassette recorder, Model # CCR-81
- Texas Electronic rain bucket, Model # 525
- Four-way power divider, 900 to 1500 MHz
- Computer or video monitor
- Sony receiver, Model # FSR-2000

1. The AGC voltage reached saturation before peak signal level, requiring attenuation to be inserted between the antenna and the receiver to bring the AGC into a working window.
2. Tandy's Co-CO2 joystick ports each have two 6-bit, 1 to + 5 volt D.C., A to D converters, and one input port for sensing key closures. For this application, only one A to D port and one key closure port are used. AGC voltage must be '+' only.
3. VideoCipher must be authorized.
4. For a Sony receiver, the impedance of the AGC measuring device must be 15 K ohm or greater.

Be sure to record the number on the computer screen and the receiver's front panel after each step. Beginning with Step 12, after *each* step, also record VideoCipher and TV picture sync loss.

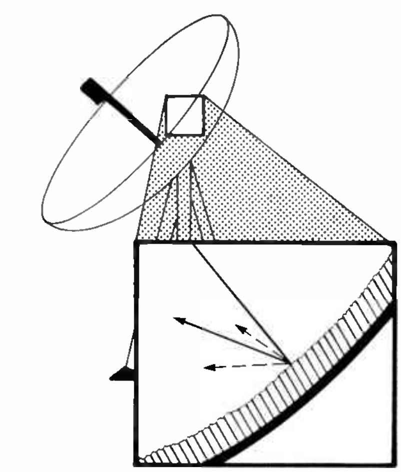
1. Set up Tandy's computer/printer/cassette deck according to the instruction manuals. Set the printer's switches (rear), as follows: switches 1, 3 & 4—'off;' switch 2—'on.'
2. Turn off power. Insert plug from the ATP computer interface into the computer's right joystick port. See attached diagram.
3. Connect the AGC + and AGC-leads from the receiver terminals respectively to the interface terminals marked AGC + (1) and GND (5). Do not reverse these leads, or damage to the computer may occur.
4. Connect the leads from the rain

To center pots, turn both clockwise 15 turns or until a clicking sound is heard. The pots are centered.

bucket to the interface terminals marked rain bucket (5 & 6). Connections are not polarity sensitive.

5. Turn on computer. Type CLOAD 'HBO' Type ' ' around the word HBO only. Type RUN and press the Enter key to begin.
6. Press the #1 key to enter the 'Begin Monitoring' mode. The A/D designation should have a number between 0 and 63. If no number for this designation, begin again.
7. Using the spectrum analyzer, repeak the antenna for maximum signal. Record the level reading from the spectrum analyzer. If you are not using a Sony receiver, proceed to Step 10.
8. Using a digital voltmeter, measure the AGC voltage on the receiver. More than likely the voltage will read around 6.5 volts D.C., and will be driven into saturation due to the level of the incoming signal. Record the voltage reading.
9. Install a selected value of attenuation between the antenna and the receiver, increasing the value until the AGC voltage decreases .2 volts below the maximum voltage noted in Step 8.

FIGURE 3



10. The ATP interface has two controls (Pots A & B). Each is a 15-turn pot, connected to form a voltage divider. Adjust these pots until # 50 appears at the A/D designation on the computer screen, beginning with Pot A. Adjust Pot B only if the # 50 is not reached with Pot A. The ATP interface has been preset for the Sony receiver and should require only slight adjustment to obtain the # 50 reading.

For other receivers, the following procedure is recommended:

To center pots, turn both clockwise 15 turns or until a clicking sound is heard. The pots are centered. Observe the number on the computer screen. If higher than 50, turn Pot A clockwise and Pot B counterclockwise in one-turn increments. If the number is lower, reverse pot rotation. If the AGC voltage is lower than 3.9 volts when antenna is peaked on the receiver, turn pots the number on the screen—up to 50. Record the number on the screen and the

Slowly, move antenna off peak in 3 dB increments until impulse noise level is reached.

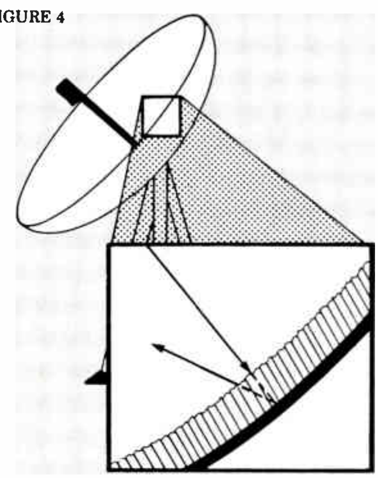
receiver's front panel.

In case the unit will not adjust to the receiver, remove the 5K ohm jumper located in the rear of the ATP interface, between terminals 1 and 2, and replace with the required resistance value for additional AGC voltage attenuation.

The sets of numbers are then recorded in a table.

11. Tune off antenna peak approximately 3 degrees. Set spectrum analyzer for maximum sensitivity. It should not have a signal. The computer screen readout should have dropped by approximately 25 steps (i.e., range from 50 to 25, 23). Record the A/D number on the computer screen: It is the no signal noise floor. Record the reference level number from the receiver's front panel. Move antenna toward peak until the A/D number increases one digit. Move antenna away from peak until the A/D number decreases one digit. Record level reading from the spectrum analyzer: Insert as DB reading for column 'H' in the recording table.

FIGURE 4



12. Repeak the antenna for maximum signal level, as recorded earlier in Step 7. Record both the reference level number from the receiver's front panel and the A/D number from the computer screen. These numbers are usable to verify future system integrity, and are the 0 dB reference.
13. Slowly, move antenna off peak in 3 dB increments until impulse noise level is reached. When the impulse noise level is reached, rapid picture degradation begins. At this point, shift to 1 dB increments and check for TV monitor picture and associated Video Cipher sync loss. Proceed until the no signal noise floor numbers recorded in Step 11 are reached. Remember to record the A/D num-

Continued on page 62

Lockheed makes its choice

Like other companies faced with high telecommunications costs, Lockheed Missiles & Space Co. in Sunnyvale, Calif., recently had to undertake the mission of gaining control of its telecommunications destiny.

The Communications Network Utility (CNU), initially intended to link about 19 buildings on a one-square-mile parcel of land (another 10 buildings will be added eventually), is Lockheed's way of linking computing devices on the campus. It won't be easy. Although the top two vendors are IBM and DEC, "we have one of virtually every computing device ever made," says Jerry Olds, supervisor of network services for LMSC.

Lockheed's computing environment probably is typical of most aerospace companies in that it is heterogeneous, leading-edge, requires frequent device relocation, has a high need for reliability, bandwidth and flexibility. The area to be linked is campus-sized. So why not a system based on fiber optic media? Why broadband? There clearly are fiber proponents at the company.

Simply, the company just couldn't wait any longer. After extensive evaluations, the company chose broadband because it just couldn't get a cost-effective solution any other way. "We just had to bite the bullet on the network," Olds says. "We wanted to move before the users began to scream for a connectivity solution." Also, having decided on a bus topology, the per-port cost of a fiber solution simply was too high. Which isn't to say the company won't use fiber (or infrared, microwave or twisted-pair transmission methods). Indeed, it plans to augment the broadband network in the future with a parallel fiber network with communication between them. Olds predicts that eventually the lower-speed applications will be run on broadband while the higher-speed applications will be run on fiber. The costs he'd like to see for those fiber applications are about five years away.

> The choice is broadband.

The broadband portion of the network will serve as a backbone connecting sub-networks already in place as well as devices connected through Integrated Wiring Centers (IWC) similar in function to telephone patch panels. All active components associated with the telecommunications function of the CNU, such as bridges, amplifiers and taps, are located in the IWCs. One building on the site already is set up with Ethernet and twisted-pair wiring running out of the IWC to users in the building and another is under construction. Olds estimates that device relocation costs will be reduced about 20 percent by moving to the IWC concept.

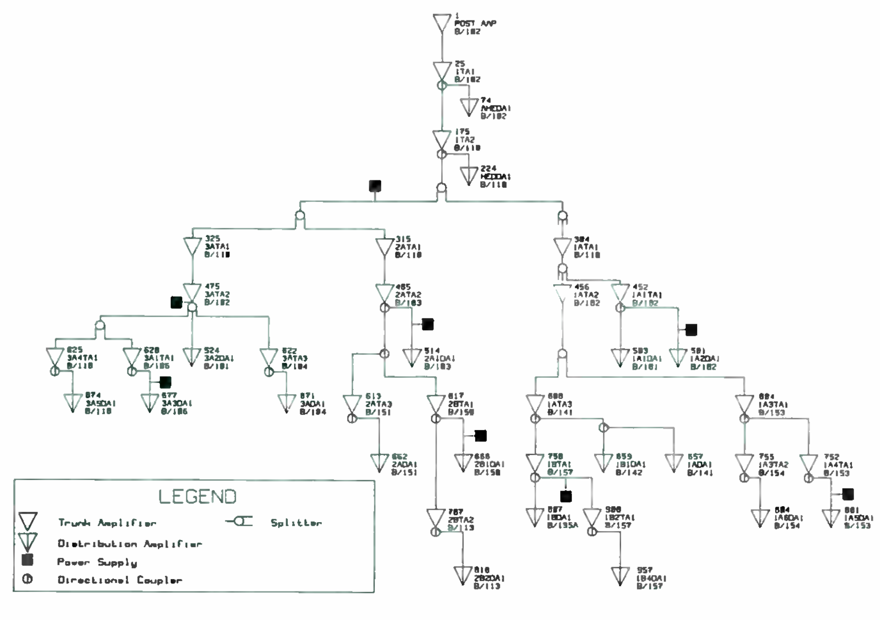
The broadband dual-cable design includes three initial cable legs with a fourth planned. Two headends—a primary and a backup—will be put into place at first. Ultimately, the backup headend will be fully redundant. The global network control and management system as well as device addressing system will be located in the main headend. Backbone network traffic will be controlled from the primary headend to each of the backbone network interfaces. Beyond that, each of the sub-networks will manage its own internal traffic. This makes more effective use of backbone network taps and allows frequency re-use at the sub-network level. It also keeps backbone network spectrum available for internetwork communication and doesn't clog it with intranetwork traffic.

The network design also includes 11 mini-headends containing filters, translators or remodulators and bridges that can isolate traffic from the backbone network. That allows frequency re-use at each of the sub-network sites. Protocol-independent bridges will link each of the mini-headends to the backbone network.

At first, a minimum of 16 ports will be served from each of the IWCs. Some IWCs will have 32 ports. Each building will have between two and four IWCs each. It is envisioned that Lattisnet by AT&T as well as other networks will be connected to the backbone. Lockheed also will likely move many of the 3270 controllers now dispersed around the buildings to centrally-located sites, enabling formerly isolated pockets of users to be reached by the IWCs. Some buildings now have as many as 21 3270 controllers, for example.

The underground, hard-cased network may use the Transmission Control Protocol/Internet Protocol (TCP/IP)

Lockheed's broadband cable system amplifier tree



Lockheed's CNU has, in the past, been the source of intense interest within the company.

for full-network communications. Many of the users are already going with TCP/IP.

The cable network already is in place, as are the initial 38 redundant Jerrold X-2000 trunk amplifiers. "General Instrument's Jerrold division was selected as the vendor," says Mac McComb of RFI Communications, the prime contractor, "because its X-2000 LAN amplifier provides the most cost-effective reliable solution for dual cable local area networks. One important feature is the fact that the X-2000 mainstation amplifies and monitors both cables in a single housing."

Balancing and sweeping as well as system turn-on will occur during the first quarter of 1988. The newest version of Jerrold's Advanced Status Monitoring System is being used, as is Trilogy air-dielectric cable. The backbone is 0.750-inch and one-inch cable in rigid four-inch conduit. All the cable showed 30 dB SRL before and after installation and "not a single length of cable had to be replaced," says McComb. He says MC^2 was chosen for its loss properties and frequency response. "It was flat as a pancake," McComb says.

All the system actives and most of the passives are made by General Instrument. All the taps are 1.5-step values. Each building has AC power standby and a battery-backup system on top of that. The standby supplies, made by Lectro, have been modified so that a headend console knows whenever a supply has gone into standby mode. The headend racks have uninterruptible power supplies made by C-COR Electronics.

Lockheed asked for, and got, firm guarantees from Jerrold on the delivery and quality control standards for network actives. RFI reports no failures of delivered devices.

Why was RFI picked as the prime contractor? "We liked the thoroughness and sophistication of the design. To a certain extent, we also relied on the reputation of the company," says Olds."

Lockheed's CNU has, in the past, been the source of intense interest within the company. And it's a safe bet that other Lockheed units will be watching to see how well it works before they adopt something like it themselves.

They also believe they've made a sound, defensible choice that gets the company the communication system it needs today without compromising migration to future technology and capabilities. Broadband wasn't the only media choice, but it ended up being the most cost-effective solution to Lockheed's requirements that can be implemented today.

—Gary Kim

LANwatch

CommNet show provides flurry of new products

With all the activity at the Communication Networks '88 show, we missed some new product announcements from some of the more familiar vendors. In order to give those concerns "equal time," here are some additions to the new product announcements.

Augat Communications Group unveiled the Melco CDF-21 Modular Cabling System. With this system, according to Augat, one can prewire a cabling system or building now to meet the voice, data and network requirements of the future. The system also accommodates any manufacturer's equipment, the company says. Further, the unique modular design, "lends itself to any equipment and virtually any application." For information call Augat Communications, (206) 223-1110.

Bridge Communications Inc. showed off four new security network products. The new products are all designed to provide security and access control for users and resources in "sensitive or controlled environments." Topping the new product list is the Secure PCS/1 Personal Communications Server, a "broadlevel" TCP/IC-based server providing terminal emulation and file transfer for networked PCs. In addition, Bridge offered three protocol-independent internetwork bridges: the Secure IB/1 (linking Ethernet and Bridge 5 Mbit/second broadband LANs); the Secure IB/2 (connecting multiple Ethernets); and the Secure IB/3 (connecting multiple Ethernets over T1 and other point-to-point communications links). Call Bridge Communications Inc., (415) 969-4400.

From **C-COR Electronics Inc.** comes new monitors, modem and data taps. C-COR's new product releases include a 117V line-powered stand-alone status monitor which complements its line of single- and dual-powered SSMs. The SSM is a subset of the Quick Alert Status Monitor System and monitors distribution equipment. Also introduced at COMNETs was a Power Supply Status Monitor which integrates the monitoring and control of standby and redundant power supplies with the Quick Alert Broadband Network Status Monitor System.

A third product introduced by C-COR was a new series of RF modem for use on broadband LANs in point-to-point or multidrop applications. The modem has an offset frequency of 192.25 MHz and is frequency-agile over seven continuous channels (42 MHz): channels T10 to 4 for the transmitter and J to Q for the receiver.

Finally, C-COR has added a new line of adjustable, split-band data taps and 1.5 dB-step (conventional) data taps to

New from Wegener Communications is the FST 2000 VSAT terminal, which features digitized audit, data, video and facsimile channels.

its broadband product line. The split-band tap is designed specifically for high-performance mid-split and high-split LANs. It allows independent control of both the forward and reverse tap values within 1 dB. The conventional taps are available in 18 different 1.5 dB steps and can be converted to split-band. Contact C-COR Electronics Inc., (814) 238-2641.

New AutoCAD templates are now available from **Cable Technology Group**. The Broadband Cable AutoCAD Template is a software package for AutoCAD (a popular microcomputing drafting package). It is designed to put graphics cabling documentation under the control of a PC XT or AT in the data communications department rather than in the facilities department. As such it serves four primary functions: broadband cabling symbols and rules; infrequent data communication needs; floor plan entry capability and CAD/SUMII (a transfer and cable design knowledge base).

The Ethernet Cable AutoCAD Template is a software package for documenting Ethernet communications LAN cabling, transceivers, controllers, DTE terminals, servers, gateways and bridges. ECAT is said to enable even a novice AutoCAD user to document an Ethernet LAN's cabling and devices. Contact Cable Technology Group, (617) 969-8552.

New from **Wegener Communications** is the FST 2000 VSAT terminal, which features digitized audit, data, video and facsimile channels. The channels are multiplexed into a single data stream (1/2 to 7/8 FEC-encoded prior to modulation). Both BPSK and QPSK modulators are available. The terminal also incorporates PARASYNC, Wegener's proprietary error reduction technique. Contact Wegener Communications Inc., (404) 623-0096.

Zenith introduced its new TCP/IP Interface Software, which performs the necessary communications facilities to enable PCs on a Z-LAN network to communicate with other products also utilizing TCIP/IP protocols. Applications are especially useful in government and educational markets (where TCP/IP software and hardware are currently available). Contact Zenith Electronics Corp., (312) 699-2160.

Finally, unrelated to the show, **ACI Lightwave Products** recently announced its "Super-Performance Biconic" fiber optic cable connnector. The product's insertion loss is 0.35 dB for either single-mode or multimode applications, making them attractive for long-haul networks and where maximum repeater spacing warrants lowest possible light loss. All connectors are compatible with AT&T licensed biconics and meet or exceed all EIA, FOTP and Bellcore requirements. Contact ACI Lightwave Products, (516) 543-5000.

—Greg Packer

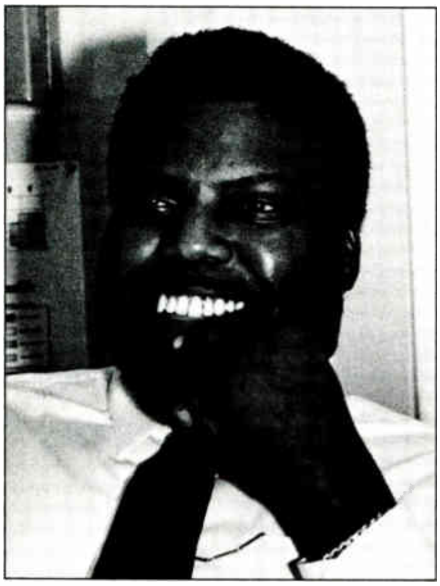
Stepping backward into the future

Everyone is trying to be "consumer-friendly." But just what is the definition of "friendliness?" There are no hard and fast answers because friendliness—especially when it comes to cable television—is a relative term.

Cable operators try to be as "transparent" as possible in their drive to get friendly with consumer electronic devices like TVs and VCRs. The issue has been a real bugaboo ever since VCRs became widely popular and cable-ready televisions flooded the market.

The issue continues to confound engineers and becomes a critical issue when addressability is added to the mix. Addressability requires a set-top converter and although features have been added to the converters to help make them more transparent, it remains a fact that VCRs, cable-ready TVs and cable converters just don't get along.

Those are the issues to contend with when adding addressability to your system. But what are the consequences of taking addressability out of a CATV system? Mile Hi Cablevision of Denver found out recently when it de-addressed and unscrambled its system.



John Dawson

The last time we visited Mile Hi (*CED*, February 1987, p. 36), Vice President of Engineering John Dawson explained the bind the system found itself in; unfriendly to consumer equipment and stuck with a low penetration rate (about 26 percent). He also outlined the options available to him and expressed the most confidence in a hybrid addressable/trapped system as a way to get out from under the predicament.

Mile Hi de-addresses for success.

Since that time, Mile Hi has completely descrambled its basic package of channels and unscrambled three pay channels in favor of traps. But it wasn't easy.

The first decision made was to descramble the entire basic tier of channels because those are the ones most often recorded by subscribers with VCRs, says Dawson. "But what we had to determine was to what degree do we descramble the pay channels?"

In a trapped environment, the system was limited to three traps total. "Once you get over three traps, it becomes (an) unmanageable (situation)," says Dawson. The weight of three traps would force the trunk lines to sag below the local telephone line, an unacceptable situation because it's a National Electrical Code violation.

After limiting the number of traps to three, the next hurdle that had to be cleared was a decision on which of the eight premium services would be trapped and which would continue to be scrambled. The decision was significant because the programmers left scrambled would now be thrust into a situation where they are unfriendly to VCR-equipped subscribers.

However, "the decision was approached from an engineering viewpoint rather than from a marketing concern," says Dawson. "We wanted to install the minimum number of traps possible." By utilizing both positive and negative trapping schemes, that made the decision on which channels to unscramble very simple. The least popular pay service (the one with the fewest subscribers) was trapped positively; the most popular service was negatively trapped. What to do with the third channel was "a coin toss," says Dawson, but since it would also utilize negative traps, the second-highest penetrated channel was chosen.

The logistics of descrambling an operational addressable system proved to be the most challenging difficulty facing Dawson and his crew. "It would have been too labor intensive to change the service and do an audit simultaneously," he says, so instead, the channels that were going to be trapped were duplicated on access channels borrowed from the city of Denver. "In the event an individual (subscriber) elected to change service before we were able to remove or change a trap, we could address that service before putting the trap in," explains Dawson.

Although the city cooperated by allowing Mile Hi to use three channels, it gave the system only 90 days to complete the program. By the time approval was granted and Mile Hi fully implemented the program, only about 70 calendar days remained to audit 210,000 passings.

Combine the rush factor with the fact that as many as 40 percent of the drops were untagged (remember, this was a 100 percent addressable system—who needed tags?), and you can see how this project became an ordeal.

Multiple dwelling units (apartment housings, two- and four-plex homes, etc.) proved to be the toughest facilities to audit. "In some cases what we elected to do was trap all the services in the entire complex and then flush out the services through service calls," says Dawson. "This allowed us to identify each subscriber. But we soon found (that the workload) was unbearable. Had we been able to absorb that workload, we would've found it to be the most effective way of doing an untagged audit on an operating system."

Single residences were easier to manage, but some duplexes presented small problems. Sometimes, installers had set up the second residence (within the same home) as an additional outlet with a splitter on the side of the home. "The concept was a good one, it was fine, it worked" in the past, says Dawson. But after de-addressing and descrambling the second set is forced to receive the same services as the primary residence. "And Murphy says they will not subscribe to the same services," laughs Dawson.

As some of the work was completed

As work was completed, and subscribers began to realize they could hook the cable directly to their TVs, another problem appeared.

and subscribers began to realize they could hook the cable directly to their TVs, another problem appeared. Because Mile Hi had left the data stream operational, the data that would otherwise be eliminated by the converter was appearing at the top of the TV screen.

After the audit was completed and traps were pulled, subscribers were slowly told of the system's new friendliness through carefully worded announcements. Mile Hi avoided making a general, easy-to-understand pronouncement because of the effect it would have on the system. If thousands of people per day returned their converters, long lines of subscribers waiting to turn them in would form. And if it was done all in one month, the revenue lost because of the credits given out (subscribers paid a $25 security deposit for the converter when they first signed up) would have had a devastating effect on the system's bottom line.

The first declaration of compatibility that was included in bill stuffers, said something about the system being consumer friendly and a number of videophiles caught on immediately, said Dawson. Word of mouth began to spread. The second announcement said something like, "Mile Hi is extremely compatible and friendly with TVs and VCRs." The third time, it said "you can connect your cable directly to your cable-compatible TV." Finally, Mile Hi asked its subscribers, "Did you know you don't need your converter?" (provided they met certain criteria).

"We kept shooting lower and lower until we thought the average person would understand what we were saying," says Dawson. "We changed the wording in such a way that depending upon people's awareness and technical interpretation of the wording... we grabbed another segment of our subscribers."

Dawson says the new compatibility was really pushed to prospects and new subscribers so that new converters weren't placed in the field unnecessarily.

Denverites apparently caught on quickly and responded. Over the 12 months prior to the change (1986), the system only increased its subscriber base by 3,000 customers. From April 1 to Dec. 31, 1987 (the time after the de-addressing program was complete), a net gain of 14,000 subscribers was realized. That put the system at about 67,000 subscribers, or about 32 percent penetrated. "We plan to zoom over 70,000 (subs) soon," says Dawson.

American Television and Communications, the managing partner (the system is owned by ATC, Daniels and some local investors) is no doubt pleased to be giving Mile Hi an award for the

In fact, keeping every segment of the system informed of what was going on and when was very important.

best net-subscriber gain of all its systems in 1987. Judging from the response, "we know we did the right thing" by de-addressing, says Dawson.

For those subscribers who wanted to ditch their addressable boxes but did not have full-bandwidth cable-ready TVs, non-addressable converters were installed. Nearly 25,000 plain converters are now in the field, says Dawson.

Although the system is free of its addressable constraints, it still has problems with some subscribers who don't understand that although they may have a "cable-ready" TV, it will only receive 36 channels, not the full 60 offered by the system. So it was up to the system personnel to understand and relay the information to the subscriber from the outset.

In fact, keeping every segment of the system informed of what was going on and when was very important. "We tried to maximize our ability to ensure we used every tool available to us to inform the subscriber of what we were doing," explains Dawson. "The key to that success was information."

For instance, the marketing department had to know what was going on because it was involved in selling the service; finance was brought in to tell them what the financial impact of the program might be; programming was responsible for putting information on character generators and passing it along to the viewers; engineering had to implement the program; converter repair personnel had to make sure the new products (traps and non-addressable converters) were ready for installation; customer service had to make sure it didn't misinform the subscribers; the billing people had to know when to pro-rate the bills after service was changed; and the franchise authority (the City of Denver) had to know so it could "screen" complaints.

Just keeping everyone up-to-date was a chore, but extremely important. "We made a lot of mid-course corrections and communication was the only thing that allowed that," says Dawson.

Although the de-addressing and descrambling stage is over, things are by no means static at Mile Hi. The system was slated to begin implementing stereo audio as of March 1, starting with the off-air signals. Dawson says about 20 channels or roughly one-third of all the signals the system carries, will be in stereo within 60 days.

That project, too, has been a time-consuming task because a 12 MHz FM interconnect to two remote hub sites left Mile Hi without enough spectrum to add stereo. Therefore, the system had to manufacture its own equipment and add it to each channel.

With its sights set squarely on 70,000 subscribers, Mile Hi has finally loosened the logjam that kept it from ever becoming a money-making proposition. Now it seems the sky's the limit.

—Roger Brown

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New vigor for an old idea

Off-premise addressability poised for a comeback?

It is perhaps ironic, but the cable industry has finally come full circle in its approach toward addressability. When it was first introduced in the early part of the decade, addressability was hailed as a great money saver because it would virtually eliminate truck rolls for changes in service levels. As operators gained experience with addressable systems however, a great many of them began to question whether or not those savings really existed. Sales of addressable equipment suffered as huge MSOs like Tele-Communications Inc. and American Television and Communications elected to suspend further launches of addressability.

But the technology is once again gaining favor because of the emergence of pay-per-view as a bonafide revenue generator. System after system is finding out that the provision of an impulse ordering system greatly enhances buy rates and addressability's greatest asset is its impulse capability. Consequently, set-top converter manufacturers are all predicting 1988 addressable sales to go above the levels seen in 1987.

But the consumer interface problems associated with set-tops is still an important consideration that perhaps impedes addressability's universal implementation. The time is ripe, according to many MSOs, for a good, reliable off-premise or other out-of-home addressable system to be developed.

Mike Hayashi

Most manufacturers acknowledge that they indeed have ongoing research programs examining such systems, but few are willing to predict when product may be forthcoming.

Except Pioneer Communications. Mike Hayashi, marketing manager for Pioneer freely admits his company is actively working on a system and that it remains a high priority for them. "We feel it (an off-premise system) is the best way to deal with the never ending issue of consumer interface," says Hayashi. "It's a headache for all of us (manufacturers). You will never win the game (by adding features to set-top converters) because TVs keep adding more features."

So what's the holdup? A number of significant technological hurdles have to be overcome. Not the least of which is finding a way to make it compatible with impulse pay-per-view. "If the objective is to not put any device in the home, there is a conflict (with implementing) impulse ordering," says Hayashi. "But that will be addressed—it will have to."

Hayashi predicts that such systems will again gain popularity and everyone will announce new systems. "It's taking us a little more time (to develop a system) than we wanted. We're currently in the middle of development. But probably within a couple years, all of (the vendors) will be able to deliver product in this category."

One fan of out-of-home broadband delivery of signals is Jim Chiddix, vice president of engineering at ATC. His labs have tested a few prototype systems, but nothing is ready for field trials, he says. Still, he tells manufacturers he's interested in a good, reliable and secure system.

"There have been some intriguing efforts," says Chiddix, "but no real success stories." He acknowledges that vendors like AM Communications and Blonder-Tongue offer product, but sales so far have been limited to small systems.

"There's this wonderful payoff (by implementing an off-premise system)," says Chiddix. "Suddenly, your whole market is addressable so you can do PPV everywhere. You're sending out people only to do audits and new installs. All your changes in service no longer require truck rolls. It's consumer friendly because you don't scramble things anymore. This has tremendous operational savings."

Besides Pioneer, Scientific-Atlanta and Jerrold continue to work on various aspects of the off-premise promise. In fact, several industry sources predict that S-A will announce a new product sometime in the next 12 months. S-A won't comment on that speculation, but Steve Necessary, distribution and subscriber system marketing manager at S-A, said the company remains interested in the idea.

Much of the speculation stems from S-A's work with TCI on the MSO's "on-premise" program, which utilizes positive and negative traps housed in a unit that is attached to the outside of the home to give the subscriber total control of the signals entering his house. Most observers say an addressable version of that product is due soon.

A similar product has already been introduced and a prototype shown by Syrcuits International at the Texas Cable Show in February. The system utilizes common traps but integrates them to addressable modules that can be controlled from the headend. According to David Barany, vice president of engineering at Syrcuits, the system has been shown to TCI, ATC, Jones Intercable and others and "it was received very well," he says.

Interest is also shown by Jerrold, which is presently working with Tom Elliot of TCI to develop components for his system. But nothing is being done with an eye toward a complete system, says Tony Aukstikalnis, vice president and general manager of the subscriber systems division. "We have found that most MSOs are still focused on the set-top converter because it can deliver pay-per-view," said Aukstikalnis. "Beyond TCI and the companies they are affiliated with, I don't detect much interest in off-premise systems."

So, round and round the industry goes. Where and when it will stop is anybody's guess.

—Roger Brown

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Field experience with feedforward amplifiers

The demand for an amplifier that gives a high level of distortion immunity while providing large amounts of amplification has driven the CATV industry over the last three to four years. The introduction of feedforward technology presented a viable solution to this problem. During its infancy, feedforward presented a manufacturing challenge to the CATV suppliers who sought to participate. The development and introduction of the integral feedforward package offered the industry an excellent opportunity to maximize cascade lengths for optimum performance while maintaining superior distortion results.

The first application of feedforward presented itself when two discrete hybrid amplifiers were matched with two delay line circuits and associated tuning circuitry to form a feedforward stage.

This unit presented difficulties not only for the equipment manufacturer in both gain and phase matching, but for the cable operator as well.

No longer was the cable operator allowed the luxury of field replacement of hybrid modules. If one section of a feedforward stage failed, the unit had to be returned for realignment.

The introduction of the integral feedforward package offered many advantages over the discrete approach, several of which are:

- Lower die temperature than standard CATV die
- Better temperature tracking of the four individual sections of the feedforward stage
- Better and more controlled loop cancellation
- Better and more predictable flatness

These features and others are what attracted equipment manufacturers to this concept, which revitalized feedforward. In turn, this allowed the cable operators the flexibility to realize the extra distortion headroom many of today's systems demand. However, many

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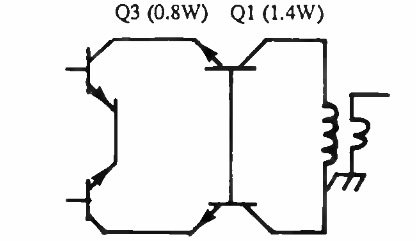
By Mark Adams, Scientific-Atlanta

Where are feedforward amps today and how are they being used?

questions arose during the introduction of the integral feedforward package and in the feedforward concept in general. These questions consist of such concerns as the thermal properties of both the feedforward package and trunk station; how feedforward can be maximized to obtain the optimum performance vs. price; and finally, how are feedforward amplifiers checked for proper operation?

Power dissipation of the output stage transistors



Output stage

65° C Case

Temperature	OjC
Q1 +100° C	25° C/W
Q2 +105° C	29° C/W
Q3 + 89° C	30° C/W
Q4 + 89° C	30° C/W

100° C Case

Temperature	OjC
Q1 +140° C	29° C/W
Q2 +142° C	30° C/W
Q3 +124° C	30° C/W
Q4 +128° C	35° C/W

The integral feedforward package offers a large thermal advantage over the discrete feedforward concept. The entire concept of feedforward operation is based on two RF loop cancellations. These loops consist of both amplitude and phase characteristics and any misalignment may result in reduced distortion cancellation. In the case of discrete feedforward the four individual components (two gain blocks and two delay lines) could all exhibit different thermal expansion over temperature which could cause misalignment.

The integral feedforward package, however, offers thermal compensation to protect the amplitude and phase alignment. Common heat sinking of both amplifiers and delay lines are added insurance that provides the stability for proper cancellation.

With the mounting of all the components of an integral feedforward package to a common heatsink, the question of power dissipation of the transistor dice is brought to bear. See Figure 1.

Two different case temperatures were recorded for transistors Q1-Q4, when the maximum case temperature reaches 100°C and when the die temperature reaches 142°C. In comparison, data was taken on an 18 dB push/pull hybrid utilizing the same transistors as the feedforward unit. See Figure 2.

On an average the thermal resistance of feedforward is 4° C/W lower in feedforward than in a push/pull package and that with similar cast temperatures, feedforward shows a lower die temperature of 14°C over push/pull.

The next consideration that must be given is to provide a path to convey the heat produced by the feedforward package to the external air. As with any active component the reliability is based on the average component operating temperature. Since feedforward results in a larger power dissipation than push/pull circuits, equipment manufacturers had to pay special attention to trunk station thermal design.

In the case of a Scientific-Atlanta trunk station, the feedforward block is mounted to a heatsink located on the amplifier module. This in turn is mounted to the finned outside station housing wall. See Figure 3.

With an outside ambient temperature of 21°C (70°F) the feedforward heatsink temperature will be 52.5°C (126°F). If the assumption is made that a constant temperature difference of 31.2°C (56°F) holds between the outside

Feedforward technology has opened up a new arena for hardware comparisons where distortion parameters are concerned.

ambient air and the inside of the station then the maximum feedforward heat sink temperature will be 91.2°C (196°F) when the outside ambient temperature reaches 60°C (140°F).

Reliability data accumulated over a three-year period shows that with a junction temperature of 105°C the mean time between failures (MTBF) results in a lifetime in excess of 142 years. Since the worst case function temperature seen in a Scientific-Atlanta trunk housing is far less than 105°C excellent reliability can be expected.

The introduction of feedforward technology has opened up a new arena for hardware comparisons where distortion parameters are concerned. The most common distortion limitations are composite triple beat (CTB) and system noise. The feedforward concept offers improvements in the area of CTB, but shows a slight degradation in noise. A trade-off in distortion parameters can be utilized by the cable operator in two ways: first in a supertrunk application where levels can be run higher to make the noise not a limiting factor and second in a combination of feedforward and push/pull amplifiers which provides a good alternative to parallel hybrid amplifiers at lower costs.

In the case of supertrunk applications the operator can choose three different gain combinations of feedforward trunks allowing for higher operating levels which in turn results in a lower number of actives needed. The following example shows a system price vs. end-of-line performance comparison with three different gain feedforward trunks (22, 26 and ·30 dB) in conjuction with three different cable sizes (0.750- 0.875- and 1.000-inch). The desired end-of-line performance is 45 dB C/N and 57 dB CTB.

TABLE 1

Typical Trunk Amplifier Specifications
450 MHz, 62 channel loading

Trunk Amplifier	Gain (dB)	CTB(dB)	NF (dB)
22 dB PP Trk.	22	81	9.1
28 dB PP Trk.	28	82	9.3
22 dB FF Trk.	22	99	12.0
26 dB FF Trk.	26	99	10.0
30 dB FF Trk.	30	99	9.0

Note: Specifications include all losses. Numbers are referenced to 33 dBmV. Distortion numbers are derived from Table 1.

TABLE 2

22 dB gain feedforward (450 MHz)

0.750″
Cable total = 110,880 ft.
Cable cost = $40,000
FF trunk total = 55 (22 dB)
FF trunk cost = $54,000

0.875″
Cable total = 110,880 ft.
Cable cost = $53,000
FF trunk total = 50 (22 dB)
FF trunk cost = $48,000

1.000″
Cable total = 110,880 ft.
Cable cost = $77,000
FF trunk total = 46 (22 dB)
FF trunk cost = $43,000

System cost with 22 dB spacing
0.750″ = $94,000
0.875″ = $101,000
1.000″ = $120,000

TABLE 3

26 dB gain feedforward (450 MHz)

0.750″
Cable total = 110,880 ft.
Cable cost = $40,000
FF trunk total = 48 (26 dB)
FF trunk cost = $48,000

0.875″
Cable total = 110,880 ft.
Cable cost = $53,000
FF trunk total = 42 (26 dB)
FF trunk cost = $42,000

1.000″
Cable total = 110,880 ft.
Cable cost = $77,000
FF trunk total = 38 (26 dB)
FF trunk cost = $38,000

System cost with 26 dB spacing
0.750″ = $88,000
0.875″ = $95,000
1.000″ = $115,000

TABLE 4

30 dB gain feedforward (450 MHz)

0.750″
Cable total = 110,880 ft.
Cable cost = $40,000
FF trunk total = 42 (30 dB)

Feedforward also provides the cable operator the ability to mix and match with push/pull technology.

FF trunk cost = $45,000

0.875"
Cable total = 110,880 ft.
Cable cost = $53,000
FF trunk total = 36 (30 dB)
FF trunk cost = $38,000

1.000"
Cable total = 110,880 ft.
Cable cost = $77,000
FF trunk total = 33 (30 dB)
FF trunk cost = $35,000

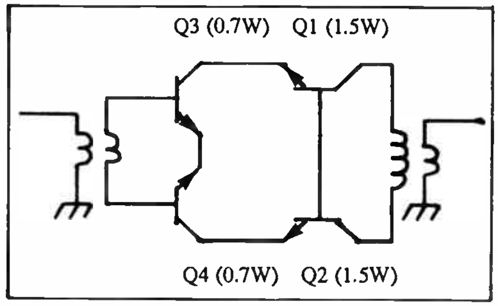
System cost with 30 dB spacing
0.750" = $85,000
0.875" = $91,000
1.000" = $112,000

Table 5 provides a comparison of the price of feedforward vs. end-of-line performance.

TABLE 5

	C/N (dB)	CTB (dB)	Cost
22 dB spacing			
0.750"	44.7	55.9	$ 94,000
0.875"	45.2	57.0	$101,000
1.000"	45.7	57.6	$120,000
26 dB spacing			
0.750"	44.4	55.4	$ 88,000
0.875"	45.0	56.4	$ 95,000
1.000"	45.4	57.4	$115,000
30 dB spacing			
0.750"	43.0	54.5	$ 85,000
0.875"	43.7	55.9	$ 91,000
1.000"	44.0	56.9	$112,000

Power dissipation in standard CATV amplifiers



65° C Case

Temperature	OjC
Q1 +115° C	33° C/W
Q2 +120° C	36° C/W
Q3 + 89° C	34° C/W
Q4 + 85° C	28° C/W

100° C Case

Temperature	OjC
Q1 +151° C	34° C/W
Q2 +159° C	39° C/W
Q3 +125° C	36° C/W
Q4 +120° C	28° C/W

As can be seen from the data, in order to meet the desired 45 dB C/N and 57 dB CTB while maintaining the lowest cost possible, the selection of the 22 dB gain trunk in combination with the 0.875" cable would be the most appropriate.

Feedforward also provides the cable operator the ability to mix and match this technology with push/pull technology to achieve an attractive economic model while still providing quality end-of-line performance. This next example shows how a 40 percent feedforward and 60 percent push/pull cascade provides an end-of-line performance of 43 dB C/N and 61 dB CTB for the total system.

TABLE 6

Feedforward specifications
C/N = 60.2 dB
CTB = 91.0 dB
Output = 37 dBmV

TABLE 7

Push/pull specifications
C/N = 54.9 dB
CTB = 85.9 dB
Output = 31 dBmV

TABLE 8

Cascade analysis
1. Feedforward segment
(8 amplifiers)
CTB(Csc) = (-91.0) + 20 log (8)
= -72.9
C/N (Csc) = (-60.2) + 10 log (8)
= -51.2
2. Push/pull segment (13 amplifiers)
CTB (Csc) = (-88.0) + 20 log (13)
= -65.7

As with any new technology traded-offs must sometimes occur in order to realize the maximum benefits of that technology.

$C/N\ (Csc) = (-54.9) + 10 \log (13)$
$= -43.8$

3. FF (8) and PP (13) combined

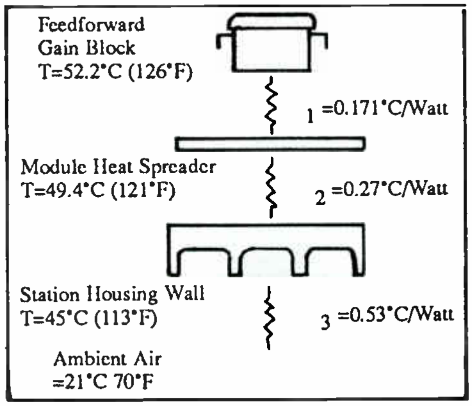
$CTB(Csc) = 20 \log(10^{-72.9/20} + 10^{-65.7/20})$
$= 62.5$ dB

$C/N(Csc) = 10 \log(10^{-51.2/10} + 10^{43.8/10})$
$= 43.1$ dB

TABLE 9

40 percent FF and 60 percent PP

1. Price of FF amplifier = $500/ea.
   Total price of FF = $4,000
2. Price of PP amplifier = $250/ea.
   Total price of PP = $3,250
3. Total price of 21 amplifier cascade = $7,250



As can be seen from the preceding data, the mixture of feedforward and push/pull technologies offers the operator quite an arsenal to optimize his plant for best performances vs. cost.

As with any new technology traded-offs must sometimes occur in order to realize the maximum benefits of that technology. In the case of feedforward the trade-offs are represented in the forms of flatness and in the ability to check the distortion improvement that is offered.

Where flatness is concerned, the combination of two gain blocks within the same circuit, each having its own flatness, creates a unit that cannot match the flatness of the push/pull units that preceded it. When this is introduced into a trunk amplifier module a degraded module flatness specification is realized. When a cascade of these units is combined with the other irregularities of a cable plant the operator is hard pressed to meet the N/10 +1 (N=number of amplifiers in cascade) flatness specification that is generally used in the industry for acceptable flatness. To combat this problem, system trimming is often needed in increased numbers over a push/pull amplifier cascade.

The ability to check distortion improvements provided by feedforward can sometimes be cumbersome. Many operators feel that this level of testing is not necessary and in most cases they are right. Others, however, like to keep tabs on the operation of both gain blocks within the package to truly know if the distortion improvement they paid extra for is really there.

In the case of S-A feedforward amplifiers an external test set can be used to check both the error and main amplifiers of the package. This is accomplished by sampling the RF signal from the output test point while providing a 4 kHz square wave modulation to the feedforward power supply. If the unit is functioning properly, a pass indicator is illuminated on the test set and a fail indication if not. The test set also allows the operator to turn off and on the 24V DC supply to the individual error and main amplifiers within the package in order to see this modulation effect.

While not new, feedforward still confuses many people. Since its early implementation of discrete circuitry, feedforward has made great strides. The integral feedforward package offers excellent performance in terms of: thermal stability and heat transfer, reliability, ease of operation, distortion immunity and economics. There are drawbacks to feedforward, however, including: reduced flatness and larger power consumption. ■

For a list of references, contact Roger Brown, (303) 860-0111.

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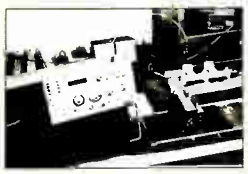

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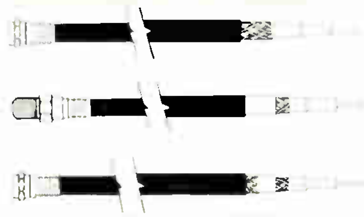

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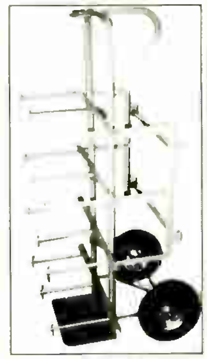

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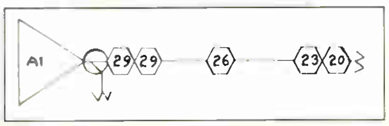

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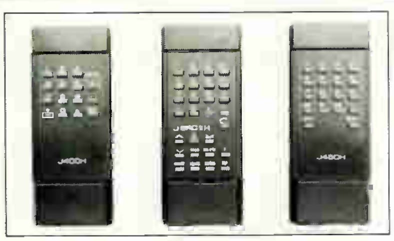

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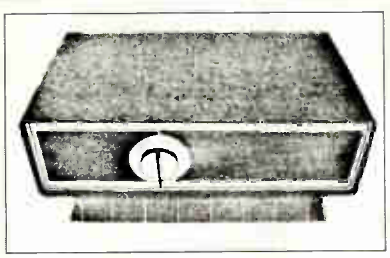

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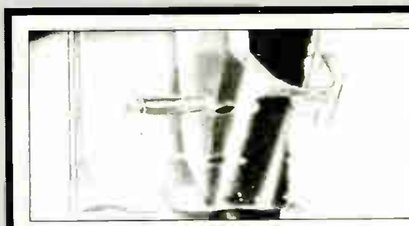

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tific-Atlanta, "Oscillator Phase Noise and its Effects in a CATV System;" Clyde Robbins, GI Jerrold Division, "High Quality Television Delivery System;" and Archer Taylor, Malarkey-Taylor Associates, "Vestigial Sidebands and Improved NTSC."

4:30 to 6 p.m. Room 202

"HDTV and Cable: A Review of the Possibilities." Moderator: Chris Bowick, Scientific-Atlanta. Speakers: Gerald Robinson, Scientific-Atlanta, "Proposed HDTV Systems and Some Technical Implications for Cable;" William Thomas, ATC, "HDTV: Cable's Opportunity for the Future;" Yves Faroudja, Faroudja Laboratories, (title to be determined); and Lex Felker, chief, Mass Media Bureau, FCC.

4:30 to 6 p.m. Room 217B

"Accurate, Usable System Tests and Measurements." Moderator: Henry Cicconi, Sammons Communications. Speakers: Mark Adams, Scientific-Atlanta, "Composite Second Order: Fact or Fantasy?" John Huff, Times Mirror Cable, "Time Selective Sweep Return Loss—A New Look at Coaxial Cable;" David Large, Gill Industries, "Cable Response Testing—The Gillcable True Non-Interfering Sweep System;" Frank McClatchie, FM Systems, "Measuring TV Audio Deviation: How To Measure it, Set it Right and Keep it That Way;" and John Staiger, Magnavox, "Composite Beat Vs. Single Beat Distortion Testing."

Tuesday, May 3

9 to 10:30 a.m. Room 202

"If You Think CLI is a New Pay Service, We're in Big Trouble." Moderator: Ted Hartson, Post-Newsweek Cable. Speakers: Robert Dickinson, Dovetail Systems, "Aerial Signal Leakage Measurement Techniques and Experience;" R. Martin Eggerts, Blonder-Tongue, "Radiation Measurements—Complying with the FCC;" Victor Gates, MetroVision of Livonia, "CLI—A Total Proven Approach;" William Park, Cablesystems Engineering, "A Practical Approach to Airborne Signal Leakage Testing (CLI)"; and Richard Shimp, ComSonics, "Correlating Measurement Results with a Horizontally Polarized Dipole and a Vertically Polarized Monopole in a Cable Television Environment."

9 to 10:30 a.m. Room 217B

"HDTV Transmission Systems Proponents Forum." Moderator, Wendell Bailey, NCTA. Speakers, Rich Iredale, Del Rey Group; Arpad Toth, North American Philips; Yves Faroudja, Faroudja Laboratories; and others to be named later. ■

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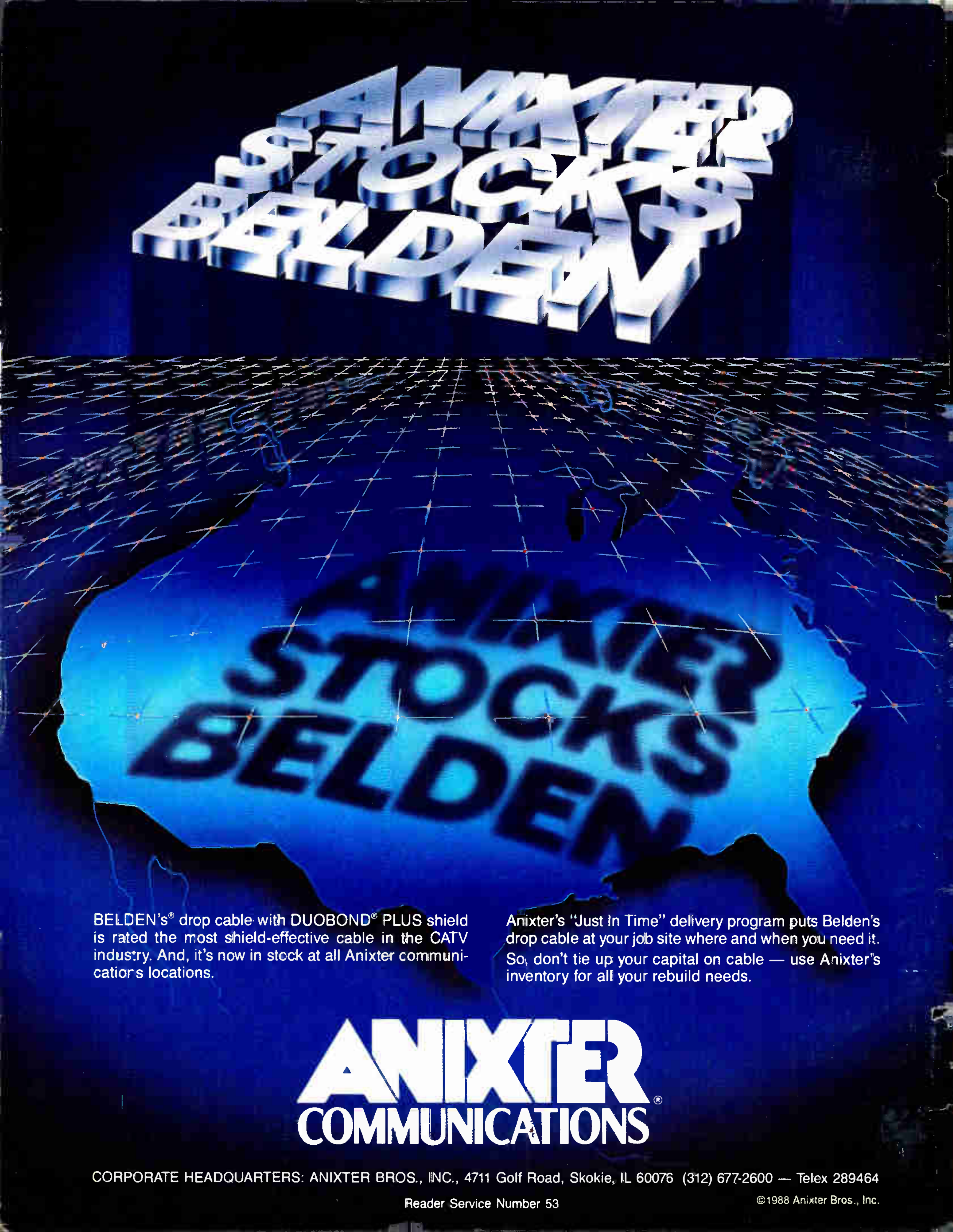
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