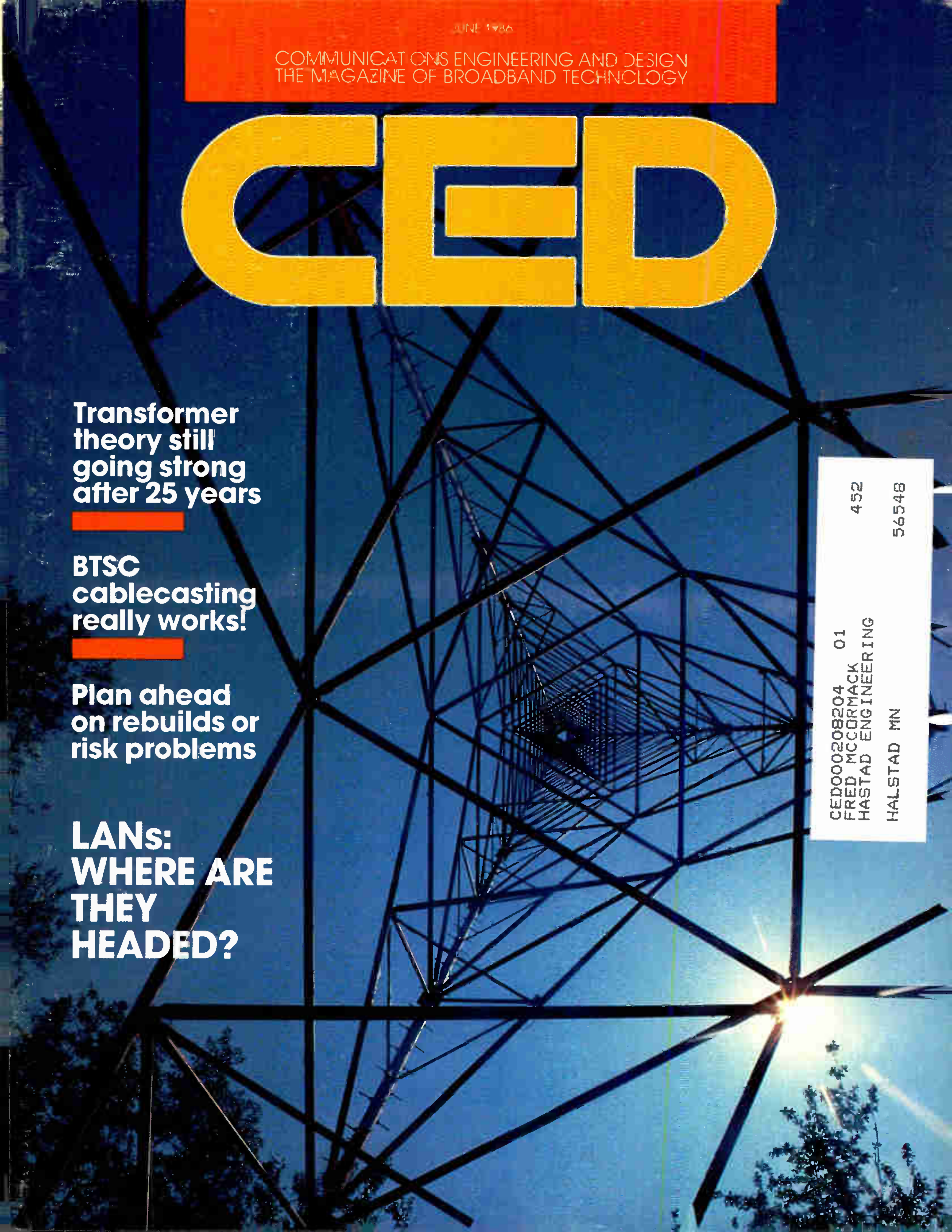
JUNE 1986

COMMUNICATIONS ENGINEERING AND DESIGN
THE MAGAZINE OF BROADBAND TECHNOLOGY

CED



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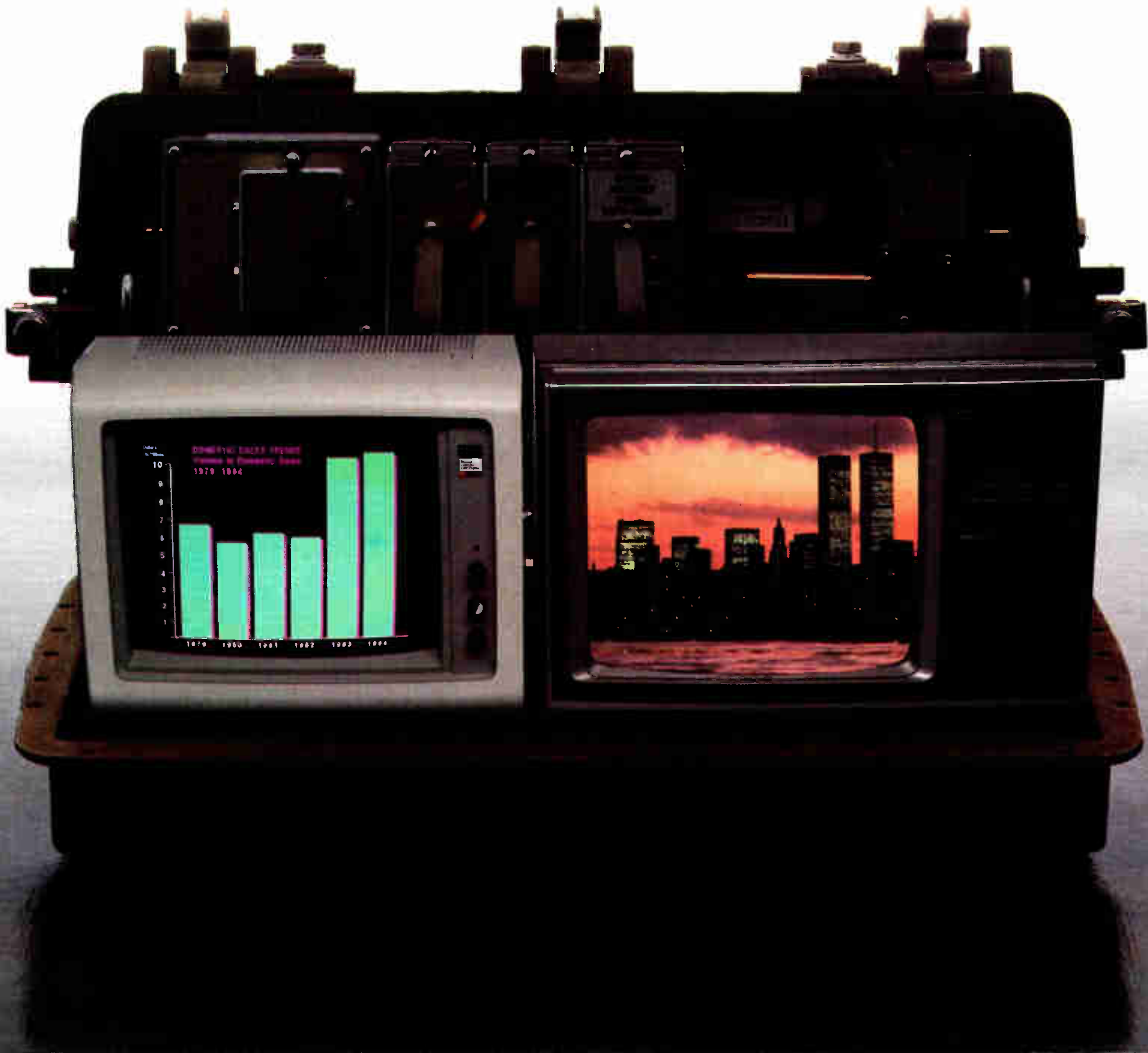

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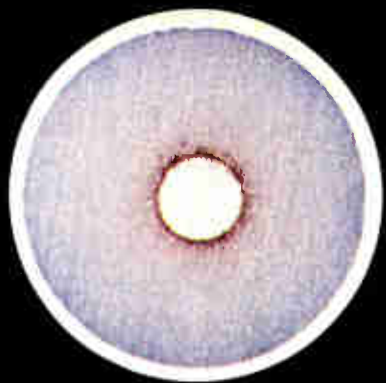

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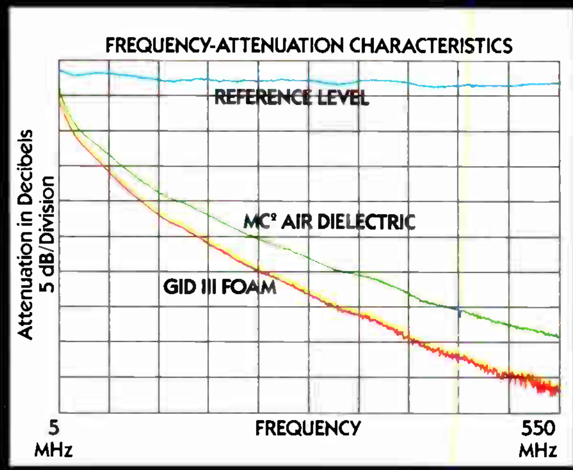

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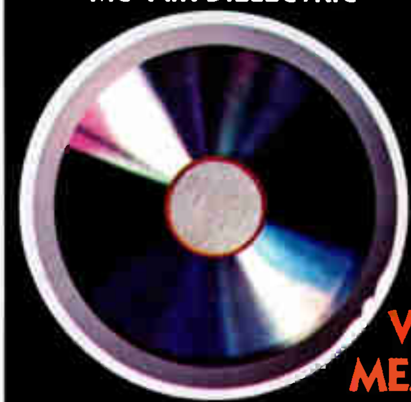

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About the issue
This issue takes a broad look at cable, from its inception (Classics), to current trends (Stereo and Rebuilds), to what the future holds in store for the cable industry (LANs).

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We didn't forget the favorite-channel memory. In fact, the TZ-PC120 can store up to 68 channels. It also features direct-access tuning, two-speed all-channel scan and last-channel recall. All this without an "Enter" button.

When it comes to our optional

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h the result

parental control, the TZ-PC120 lets your subscribers lock out the sensitive channels they don't want their children to see, without affecting the remaining channels. And thanks to our innovative *Stored Charge Non-Volatile Memory,* parental control channels and other memory functions will not be affected by a power outage. There's also an 18-button infrared remote control. It's compact, controls every function and comes complete with Panasonic batteries.

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When it comes to your headend, the new PC-200 addressable converter

can help give you a head start. Downloadable features include channel map, channel authorization, clear parental control, initial activation and emergency alert.

The PC-200 also features 68 channels, a full-function infrared remote control, electronic parental control, favorite-channel recall and two-speed scan.

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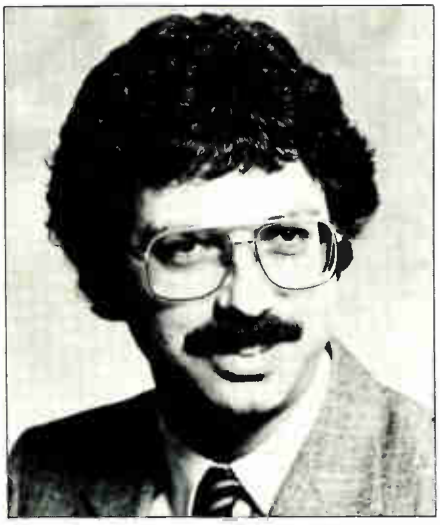


Riker thrives on any new challenge

Bill Riker loves to be challenged. That's an admirable trait, but also a necessary one, given that Riker is faced with new challenges daily in his capacity as executive vice president of the Society of Cable Television Engineers.

A born ladder-climber, Riker has used his tenacity to work his way up through the ranks—from a start in radio to the lofty position he holds today—with just a few short stops in between. Moving up the ladder rungs during cable's growth period, Riker made the most of his opportunities, from researching new technologies to learning how different systems operate.

Starting off at a New York market radio station in the early 1970s, Riker built one of the first quadrophonic broadcast systems in the country. "And you know where quadrophonic went real quick," laughs 35-year-old Riker.

From there he moved into cable television, an option necessitated by the tight broadcast market. "Cable was pretty much my second choice," Riker recalls, "but since I couldn't get anything in 'real' television, I accepted the job in cable."

The job he took was with Amvideo Corp. as chief technician for a New Jersey system located just six miles from the Empire State Building.

In 1979, Riker left the familiar surroundings of New York to become Showtime's West Coast regional engineer based in San Francisco. At that time, the pay service was making the transition from standalone to satellite signal delivery. As a result, Riker spent much of his time traveling to the different affiliates, building earth stations. "It was very enlightening," he recalls, "that was the first time I ever did any traveling that was related to my job. I saw about 100 different systems—some good, some bad."

Riker barely had enough time to get settled in the city by the bay when he was promoted to manager of engineering and moved back to New York. Within the next year he was again promoted, this time to director of engineering for Showtime. As director, Riker created a nationwide network of regional engineers under the company's engineering services department. "At that time we were the only service with regional engineering support people in the field. The affiliates love being able to call an engineer who is in their own state instead of having to call someone in New York," he says.

Riker's increased involvement in research led to his attendance at the National Cable Television Association's engineering committee meetings, where he and Wendell Bailey, NCTA's vice president of science and technology, became fast friends.

In 1983, Bailey created the position of director of engineering and asked Riker to fill the slot. As an NCTA staffer, Riker became involved with the writing and filing of opinions with the Federal Communications Commission. "We were submitting 50- and 100-page comments on issues that were going on at the time," Riker says. Included among them were documents urging defeat of proposals mandating the carriage of videotex and multichannel television sound and comments on signal leakage rules. Riker says his work contributed to the later defeat of the must-carry proposals.

As part of his interaction with engineers related to the cable industry, Riker became involved with the SCTE at the committee level as NCTA's representative. In addition, he was asked to sit in on some of the society's board meetings. At the end of 1984, Riker took over the reins at SCTE.

"This has been the most difficult and challenging job I have ever had, but also the most rewarding," Riker says.

Part of the challenge was to rebuild the reputation of SCTE, which had lost its lustre among industry executives during the early part of the decade. In an effort to do that, Riker is emphasizing a return to basics.

"My personal goal is for the SCTE to elevate the technical competence of each of its members for their own benefit in career growth as well as for the benefit of the company that employs them," Riker says.

In order to bring the education process to the various skill levels, Riker has fostered a local chapter development program where local meeting groups gather and organize a series of one-day technical seminars that installers and technicians can attend for minimal cost.

Maintaining system quality will be the biggest technical challenge of the future, according to Riker. With the advent of technical deregulation, where the FCC is now allowing the marketplace to motivate technical quality, engineers and technicians will find it difficult to keep up with other advancing technologies because of the belt-tightening that is likely to occur at the system level, he says. "That's going to be our biggest challenge because we must remain competitive with those other technologies," he warns.

Riker, who says his belief in the industry and his commitment to grow with it remain his greatest contributions, credits his own meteoric rise to "working too damn hard." But when he makes time for himself, he can be found boating with his wife Anna, practicing the drums or playing the guitar.

This summer he plans to attempt the sport of parasailing, a waterskiing activity that includes the use of a parachute to lift the skier off the water high into the air. It's not something everyone would try, but Bill Riker loves to be challenged.

—Roger Brown

HOW TO TAKE THE RECALL OUT OF THE INSTALL

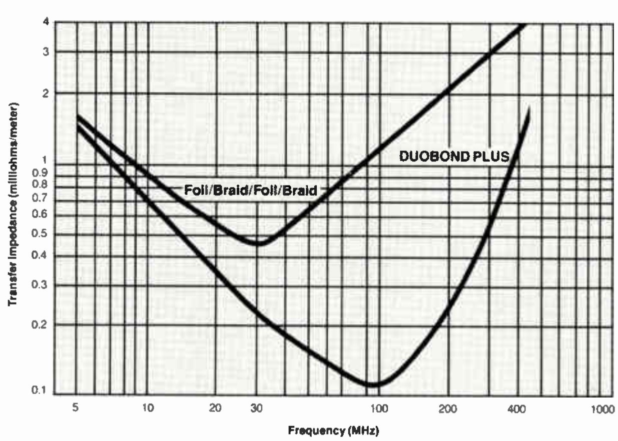
Belden's drop cable with DUOBOND PLUS™ shield helps you prevent costly call-backs. It's also the most shield-effective drop cable in the CATV industry.

Easier termination for maximum shielding integrity.

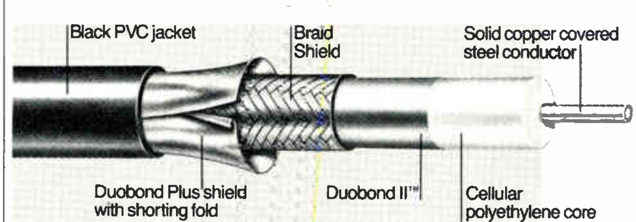
The DUOBOND PLUS shield features a foil/braid/foil construction with a shorting fold in the outermost foil which provides superior shielding effectiveness to typical 4-layer shield constructions. The transfer impedance graph demonstrates this effectiveness.

The added benefit is easier termination. This means less chance for error, resulting in greater shielding integrity and reliability. It also means fewer call-backs, lower operating expenses and more satisfied subscribers.

Cables with the DUOBOND PLUS shield require only half the steps for termination than 4-shield cables. Because it's less bulky, more flexible and its outer foil is bonded to the jacket, stripping and connectorizing are much simpler tasks. You can minimize your connector inventory to one size connector and one crimp tool.

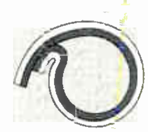


Belden's unique shield protection.



The inner foil of the DUOBOND PLUS shield is bonded *directly* to the core. Foil pushback and signal leakage problems are eliminated. Protection from shielding degradation is eliminated during installation–where most shielding problems occur.

The unique shorting fold in the outer foil of the DUOBOND PLUS shield provides metal-to-metal contact for improved isolation. Traditional overlapping foils fail to reduce slot radiation as effectively.



Belden's exclusive shorting fold

Drop cables with the DUOBOND PLUS shield are available in RG59, RG6 and RG11 constructions—messengered, non-messengered, dual and flooded versions. All cables are 100% sweep tested from 5 to 450 MHz with a minimum return loss of 23db for RG59 and 26db for RG6.

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Reader Service Number 5

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my turn

Signal leakage vs. radiation

A man with a heart pacer, who lives about 500 feet from a CARS microwave receiving antenna, complained that: "You guys are going to kill me!"

The fact is that electromagnetic radiation, even from high powered radio broadcasting transmitters, such as AM, FM, or TV, does not present a hazard to the public except in the most unusual circumstances. A recent report by the FCC Office of Science and Technology[1] indicates that radiation from an FM radio transmitting antenna at least 80 feet off the ground will not exceed safe levels anywhere on the ground, nor more than 100 feet directly in the main lobe, even with 200 KW ERP.

By Archer S. Taylor, Senior Vice President, Engineering, Malarkey-Taylor Associates Inc.

At the present time, there is no mandatory federal standard for human exposure to radiofrequency electromagnetic fields. Existing federal standards refer to the products of radioactivity, such as alpha, beta, and gamma rays, x-rays, and various particle streams resulting from atomic and nuclear reactions.

In the absence of a mandatory federal standard, the FCC has relied on the voluntary standard, generated by the American National Standards Institute[2], for exposure of the general public to radiofrequency radiation, as shown in Figure 1.

The Soviet standard for public exposure, is 2 to 3 orders of magnitude (20-30 dB) more restrictive. (After Chernobyl), one wonders about the Soviet enforcement of its more restrictive standard.) A new report, not yet released, by the National Council on Radiation Protection sets the safe limit approximately five times (7 dB) more restrictive[3] than ANSI.

Power density in watts/m² can be calculated from either of the following formulas:

$PD = EIRP/4\pi^2 \ d^2$ Equation 1

$PD = E^2/120\pi$ Equation 2

Where:

EIRP is the effective radiated power in watts re istropic;

d is the distance in meters from the transmitting antenna;

E is field strength in volts per meter;

$120\pi = 377$ is known as the resistance of free space.

Divide watts/m² by 10 to get miliwatts/cm².

A high power, AML microwave transmitter (2 watts) with a 10-foot diameter, parabolic antenna, could radiate as much as 125 kW EIRP (51 dBW; 81 dBm), assuming 2 dB waveguide and other losses. For a path length of 10 km (6.2 miles), the power density at the receiving site would be, from Equation 1:

$$PD = 125{,}000/4\pi(10{,}000)^2 = 10^{-4} \text{ watts/m}^2 = 10^{-5} \text{ mW/cm}^2$$

This is only 2 one-millionths of the ANSI safety guideline for 13 GHz, 57 dB below the safe level, and at least 20 dB below even the Soviet specification. Obviously, RF energy absorption at this level is not going to harm the man with the heart pacer. Moreover, besides the shielding provided by heart pacer manufacturers, the skin effect limits penetration of the man's body, providing additional protection against circuit resonance under the skin.

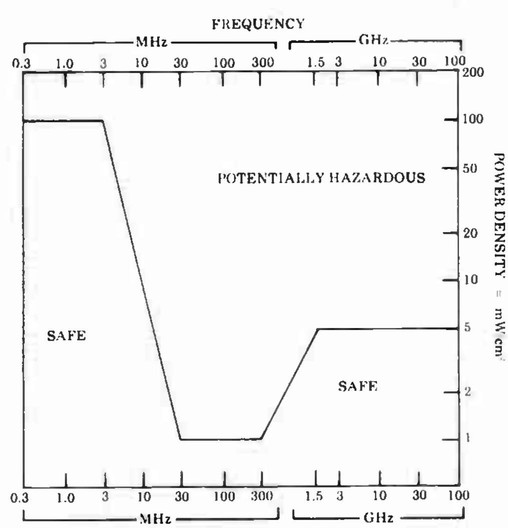
The present FCC rule for cable TV signal leakage is 20 microvolts per meter at 10 feet (3 meters). Using Equation 2:

$$PD = \frac{(20 \times 10^{-6})^2}{377} = 10^{-12} \text{ watts/meter}^2 = 10^{-13} \text{ mW/cm}^2.$$

The FCC rules in Part 76 deal with low level *signal leakage*, and have nothing to do with the health hazards of certain types of electromagnetic radiation. In cable TV, we are concerned with *signal leakage*, not radiation. I recommend using the proper terminology to avoid confusing our public.

For references used in My Turn, call *CED*'s office in Denver.

FIGURE 1



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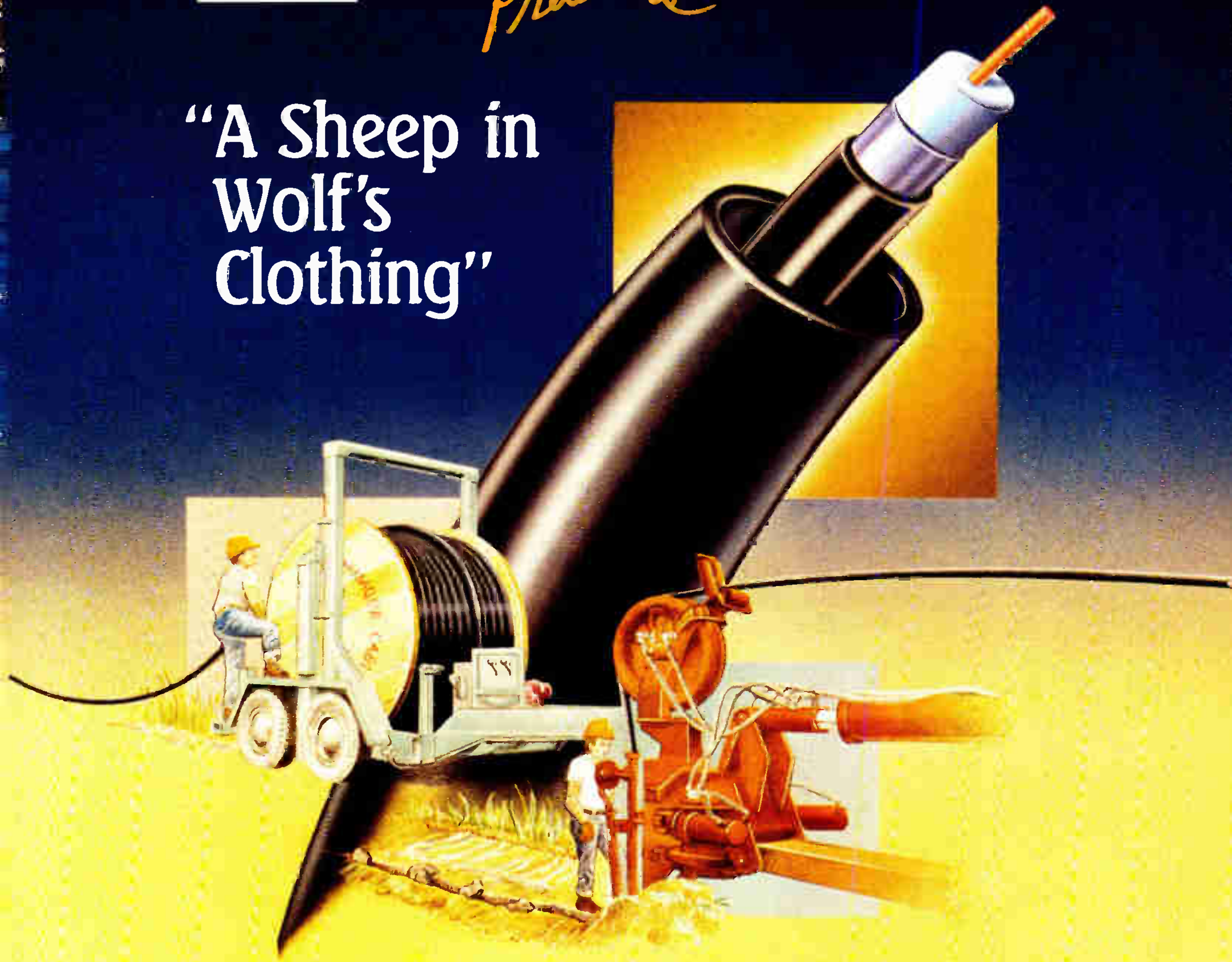

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Reader Service Number 6

Results of editorial survey prove revealing, full of surprises

People can always find something to worry about, no matter how good the circumstances. And we're no exception. We worry a lot about what you want to see in *CED*. We wonder whether you're getting all you need. We want to know who our readers are and why you read the magazine. Luckily, there are some time-tested ways to find out. Editorial studies, for example. We recently commissioned the Harvey Research organization to do just such a study. In it, Harvey asked a random sample of our readers who they were, and what they read and remembered in an issue of *CED*.

The results are revealing.

- ☐ Less than four percent of you are technicians.
- ☐ The rest of you are vice presidents or directors of engineering, system managers or supervisors, plant operations managers or engineers, chief or lead technicians or technical supervisors.
- ☐ 94 percent of you have buying influence in at least one equipment category specific to CATV.
- ☐ 97 percent of you have bought, recommended, discussed or referred products seen in *CED* in the past year.
- ☐ Your issue gets passed along 1.8 times.

What you like best in the magazine are feature-type articles, especially our "Cable Classics" series and Archer Taylor's column, and the classifieds. And although we are surprised by the responses, you're less interested in our sections dealing with new products, calendars and announcements about people in the industry. You tend to spend 39 minutes reading each issue before you pass it on.

We will be commissioning another independent study soon, to give us more insight on what you want and how we can best give it to you. In the meantime. we've done the following: We'll be adding a new monthly column, authored on a rotating basis by members of the NCTA Engineering Committee. It'll let leading lights of the industry give their views on the hottest current topics or most enduring issues in CATV.

We also ask that you send us your suggestions for a "Cable Classics" piece. Is there an older article that you keep for reference and use in training? If so, call Graham Stubbs at Oak Communications and let him know. He's our editor for this much-read series, and is always looking for good material of lasting value.

We've also added a postage-paid card in each issue that you can use to give us your thoughts: what you like, what you hate, what you'd like to see in *CED*. Let us know what you think. We'll do a better job for you.

Editorial additions

We've got some new editorial punch as well. Joining us as a technical writer is Roger Brown. He's been working with *CableVision* as production editor, and has been the guy who's responsible for getting the magazine out the door on time. But we need more help getting solid, analytical features out to you and Roger fits the bill. Be watching for a feature a month from him. He'll also be writing our popular "Spotlight" profiles of industry leaders.

Lesley Dyson-Camino, who has so ably designed and gotten *CED* out the door for over a year, has taken our corporate marketing position, and while we'll miss her exquisite attention to detail, we wish her luck in managing all marketing activities for ITCI. She'll still produce our product profile charts, though, so we won't miss her talents entirely.

Filling in for Lesley is Linda Johnson, a veteran journalist who has already begun to make her mark on *CED*. She's an intelligent, professional editor who is responsible for designing and producing each issue of the magazine for you. She's talented, no question.

Kathy Berlin will still be with us, assuming more responsibilities for the business end of *CED*. Those of you who've worked with her know what an asset she is. There's a lot to this business you can't see upfront, and Kathy really anchors that end for us. She also manages to keep us running on course while preparing for the birth of her second child, so we'll keep you posted.

On that subject, Cathy Wilson, our sales manager, is now the proud mother of a new daughter, Ashley Brooke. Mother and daughter are doing just fine, and Cathy is back on the job.

You'll be seeing more of these people, and they'd like to see and hear more from you. We invite you to use our new reader feedback cards, which you'll find right next to the *CED* subscription cards in each issue. Let us know how we can produce a finer product for you. There's always something to worry about.

Let Di-Tech's Pace 2000 Simplify Your Local Origination, Remote And Multiple Headend Requirements

With Real Time Automatic Control

Di-Tech's Pace 2000 is everything you want in an affordable weekly controller. Anyone on your staff can save you time and money and ensure you that every event (1500 on a weekly basis) will be executed on time everytime.

With the Pace 2000 in use throughout the country, Di-Tech invites you to ask our clients about it's reliability and simple operation. Call, write or telex DI-TECH for more information, or a list of satisfied PACE 2000 users, today!

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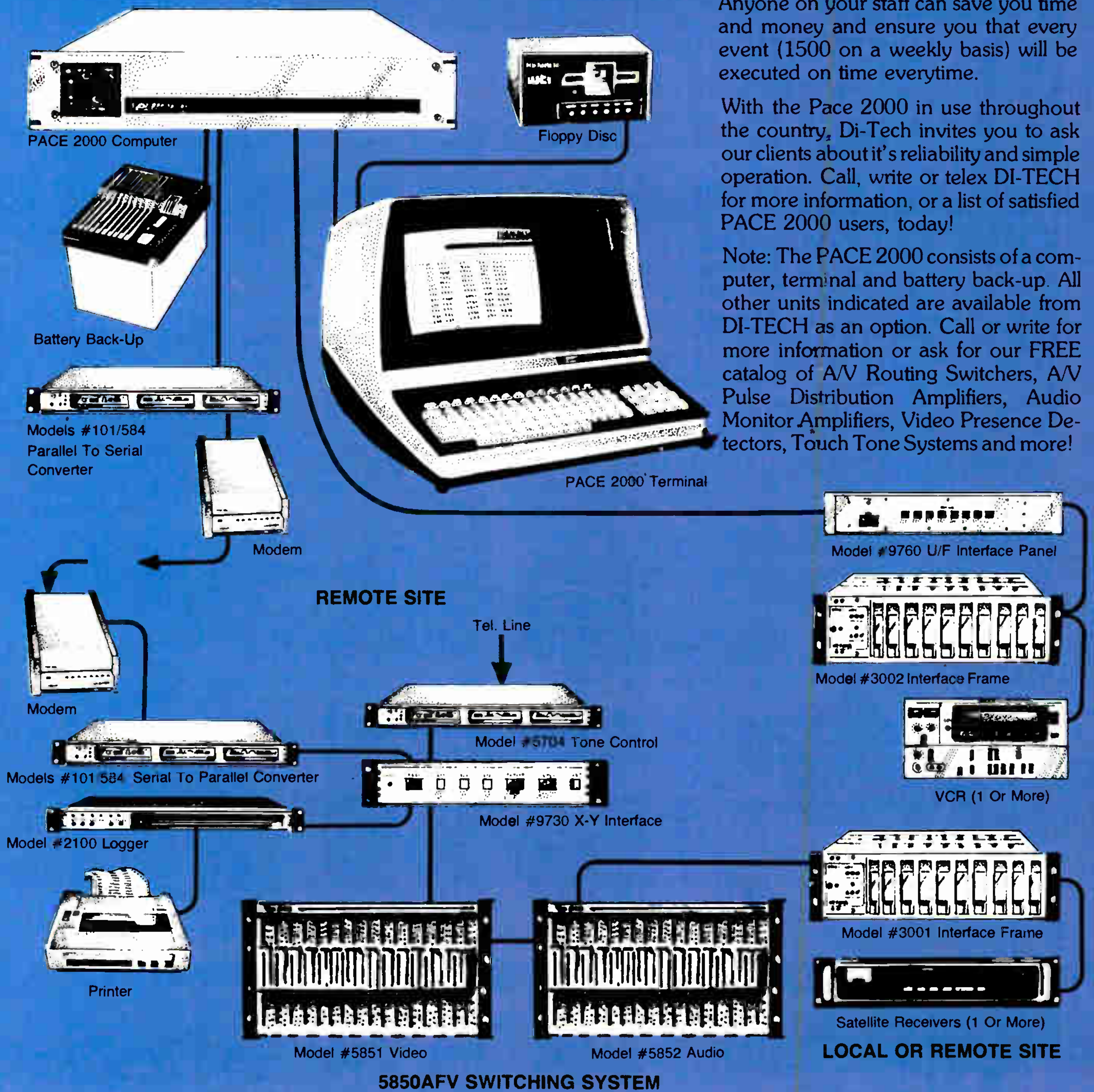

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Reader Service Number 7

New application of old transformer theory

Several transmission line transformers having bandwidths of several hundred megacycles are described here. The transformers are shown in Figures 1-9. When drawn in the transmission line form, the transforming properties are sometimes difficult to see. For this reason, a more conventional form is shown with the transmission line form. Some winding arrangements are also shown. Certain of these configurations have been discussed elsewhere and are included here for the sake of completeness [1-4].

In conventional transformers the interwinding capacity resonates with the leakage inductance producing a loss peak. This mechanism limits the high frequency response. In transmission line transformers, the coils are so arranged that the interwinding capacity is a component of the characteristic impedance of the line, and as such forms no resonances which seriously limit the bandwidth. Also, for this reason, the windings can be spaced closely together maintaining good coupling. The net result is that transformers can be built this way which have good high frequency response. In all of the transformers for which experimental data are presented, the transmission lines take the form of twisted pairs. In some configurations the high frequency response is determined by the length of the windings and while any type of transmission line can be used in principle, it is quite convenient to make very small windings with twisted pairs.

The sketches showing the conventional form of transformer demonstrate clearly that the low frequency response is determined in the usual way, *i.e.*, by the primary inductance. The larger the core permeability, the fewer the turns required for a given low frequency response and the larger the over-all bandwidth. Thus a good core material is desirable. Ferrite toroids have been found very satisfactory. The permeability of some ferrites is very high at low frequencies and falls off at higher frequencies. Thus, at low frequencies, larger reactance can be obtained with few turns. When the permeability falls off the reactance is maintained by the increase in frequency and good response is obtained over a larger frequency range. It is important that the coupling be high at all frequencies or the transformer action fails. Fortunately, the bifilar winding tends to give good coupling. All of the cores used in the experimental transformers described here were supplied by F. J. Schnettler of the Bell Tele-

By C.L. Ruthroff

The ferrite transformer may be one of the most widely used of the RF components, yet the twisted pair transmission lines are the least understood.

Cable Classics

Practically every piece of electronic equipment used in a cable system uses ferrite transformers in one form or another. Converters employ them in balanced mixers. Amplifiers use them for push-pull circuits. In taps they are used for RF power splitting. In headends, signal combiners make use of ferrite transformers. And probably the greatest use of all is in the common matching transformer—used to provide the connection from coaxial cable to the antenna terminals of television receivers.

Did you know that these devices are, for the most part, really miniature twisted pair transmission lines wound on ferrite cores? Do you know why it is possible to make sure devices work as transformers with bandwidth ratios as high as 30,000 to1? Does the term "bifilar" mean anything to you?

The ferrite transformer is one of the most widely used of all RF components —but relatively little understood.

This paper by C.L. Ruthroff was the original account of the theory of operation of ferrite transformers, and it suggested many of the applications for which they are now used by the millions.

Graham Stubbs, Vice President, Science & Technology, Oak Communications Inc.

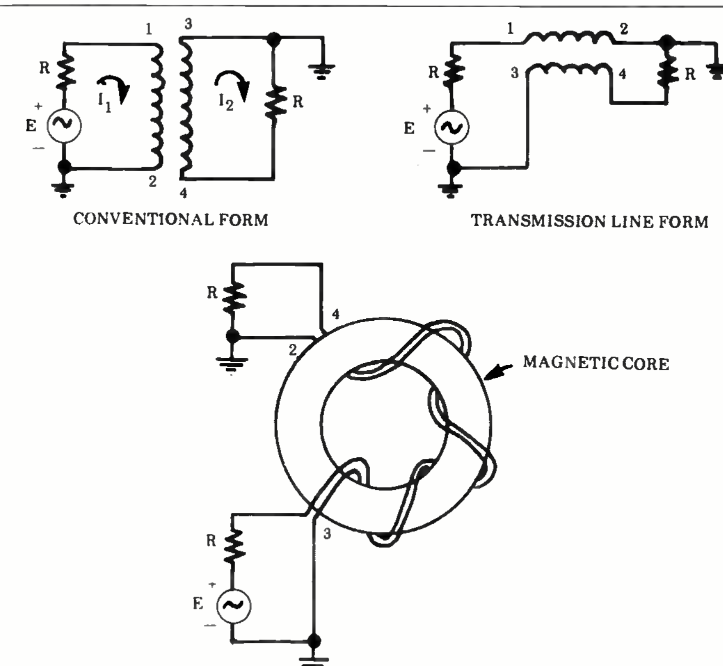
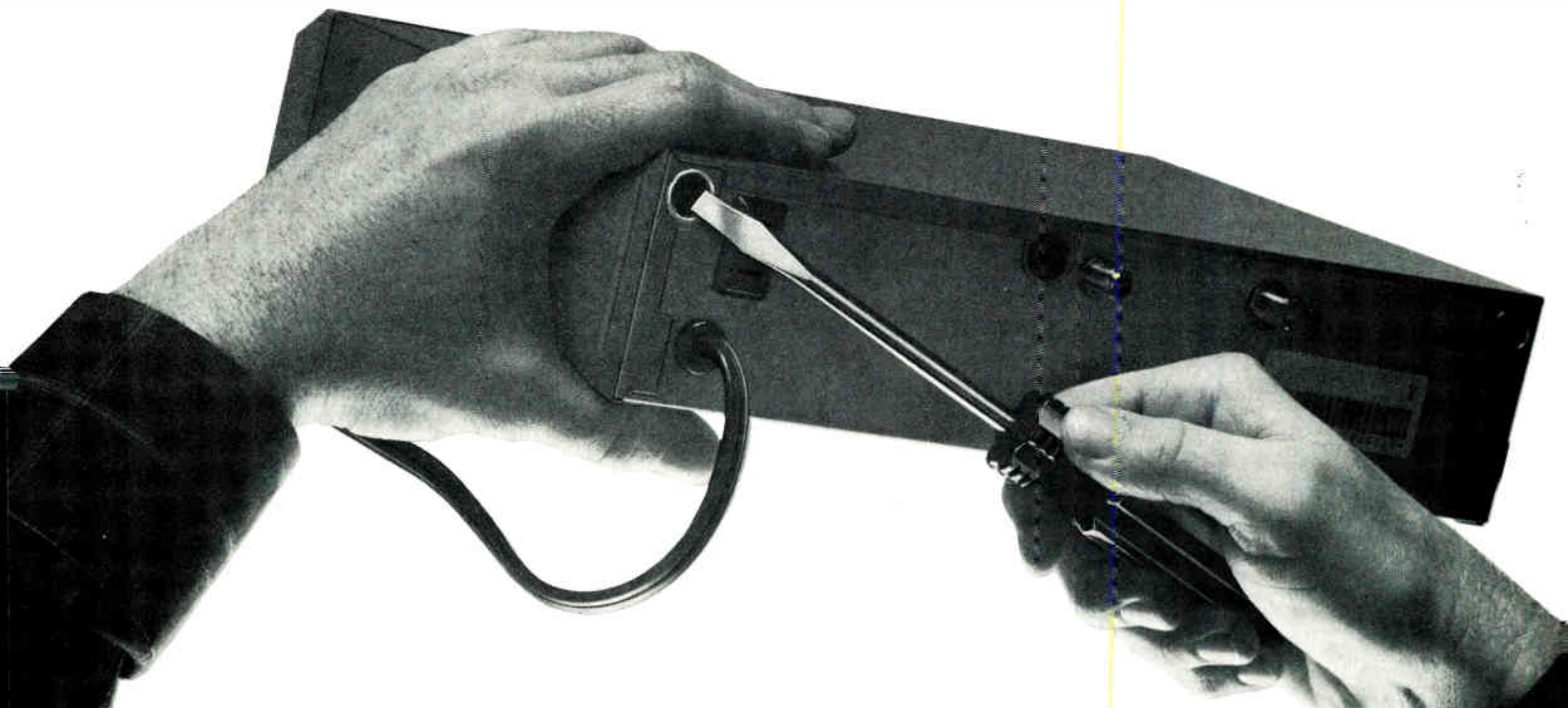


FIGURE 1
Reversing transformer

Don't Let Your Customers Unscrew You.



People are born tinkerers.

Give them a locked box or a sealed package and they've just got to get inside.

A lot of them simply want to see what's in there. They want to learn what makes the gizmo tick.

But a few of them want to rip you off. In fact, some cable operators have begun to believe that theft of service is the great American pastime.

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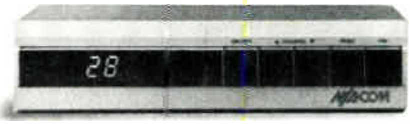

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The Polarity Reversing Transformer shown in Figure 1, consists of a single bifilar winding and is the basic building block for all of the transformers. That a reversal is obtained is seen from the conventional form which indicates current polarities. Both ends of the load resistor are isolated from ground by coil reactance. Either end of the load resistor can then be grounded, depending upon the output polarity desired. If the center of the resistor is grounded, the output is balanced. A suitable winding consists of a twisted pair of Foremex insulated wire. In such a winding, the primary and secondary are very close together, ensuring good coupling. The interwinding capacity is absorbed in the characteristic impedance of the line.

At high frequencies this transformer can be regarded as an ideal reversing transformer plus a length of transmission line. If the characteristic impedance of the line is equal to the terminating impedances, the transmission is inherently broadband. If not, there will be a dip in the response at the frequency at which the transmission line is a quarter-wavelength long. The depth of the dip is a function of the ratio of terminating impedance to line impedance and is easily calculated.

Experimental data on a reversing transformer are shown in Figures 10 and 11. Figure 10 is the response of a transformer with no extra impedance matching. The return loss of this transformer to a 3 mμ sec pulse is 20 dB. The transformer of Figure 11 has been adjusted to provide more than 40 dB return loss to a 3 mμ sec pulse. The transformer loss (about 0.5 dB before matching) is matched to 75 ohms with

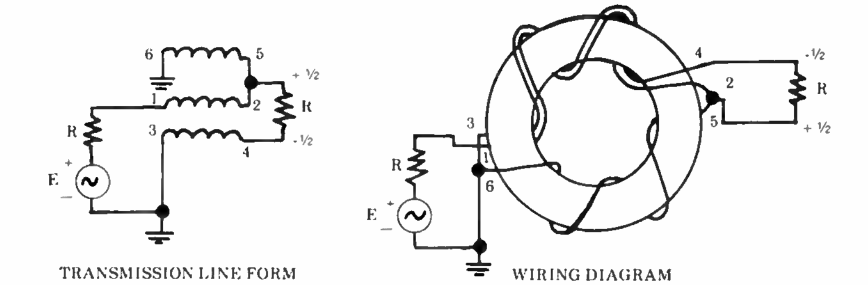

FIGURE 2
Unbalanced to balanced transformer

Not so easily seen is the high frequency cutoff characteristic.

the two 3.8-ohm resistors. The inductance is tuned out with the capacity of the resistors to the ground plane. The match was adjusted while watching the reflection of a 3 mμ sec. pulse.

The Balanced-to-Unbalanced 1 to 1 Impedance Transformer shown in Figure 2 is similar to Figure 1 except that an extra length of winding is added. This is necessary to complete the path for the magnetizing current.

The Unbalanced-Unsymmetrical 4 to 1 Impedance Transformer shown in Figure 3 is interesting because with it a 4:1 impedance transformation is obtained with a single bifilar winding such as used in the reversing transformer. The transforming properties are evident from Figure 3. Not so easily seen is the high frequency cutoff characteristic.

The response of this device at high frequencies is derived in the Appendix and only the result for matched impedances is given here.

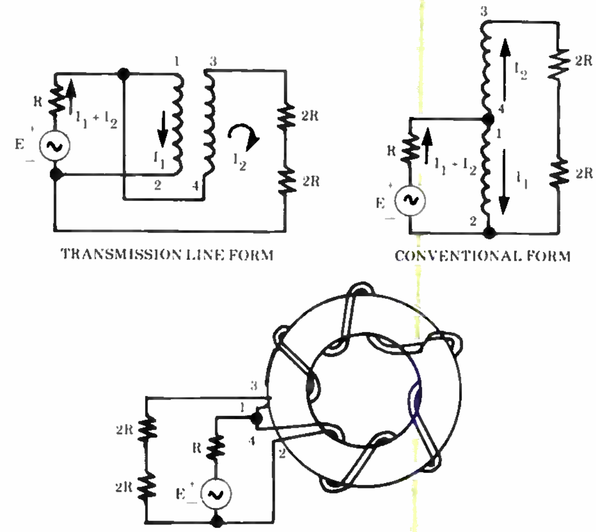

FIGURE 3

4:1 Impedance transformer

The Unbalanced-Symmetrical 4:1 configuration requires three bifilar windings which can be placed on one core.

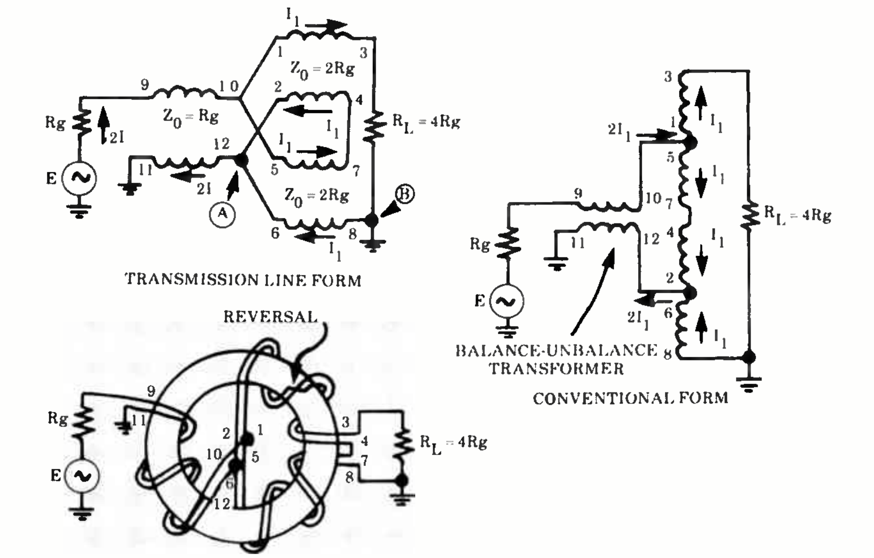

FIGURE 4

4:1 Impedance transformer— Unbalanced-symmetrical

$$\frac{\text{Power Available}}{\text{Power Output}} = \frac{(1 + 3\cos\beta l)^2 + 4\sin^2\beta l}{4(1+\cos\beta l)^2}, \quad (1)$$

where β is the phase constant of the line, and l is the length of the line. Thus, the response is down 1 dB when the line length is $\lambda/4$ wavelengths and the response is zero at $\lambda/2$. For wideband response this transformer must be made small. For a plot of (1) see Figure 16.

Experimental data are given for a transformer of this type in Figure 12.

The Unbalanced-Symmetrical 4 to 1 Impedance Transformer configuration shown in Figure 4 requires three bifilar windings. All three windings can be placed on one core, a procedure which improves the low frequency response.[1] When winding multiwinding transformers the following well-known rule

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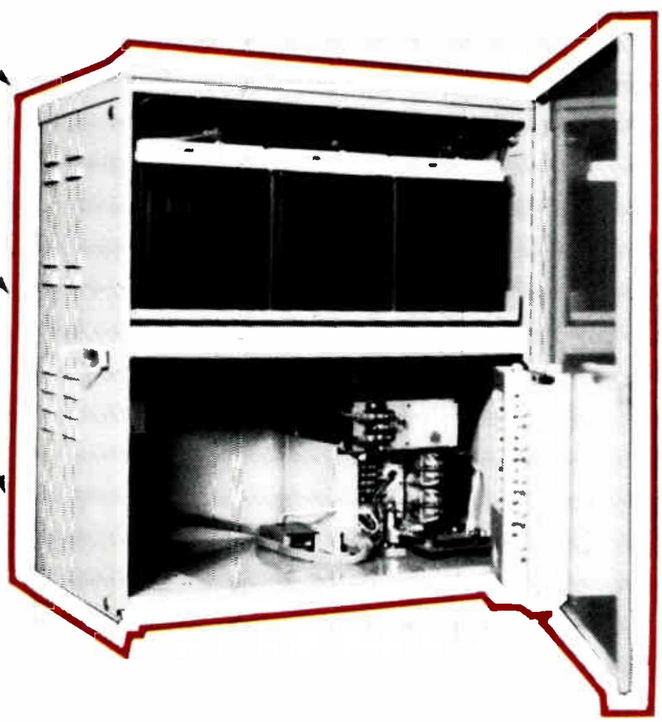

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The fields set up by the currents should be arranged so as to aid each other.

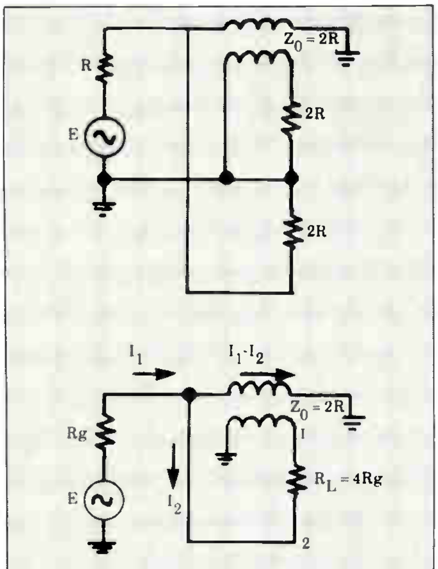


FIGURE 5
Balanced—unbalanced

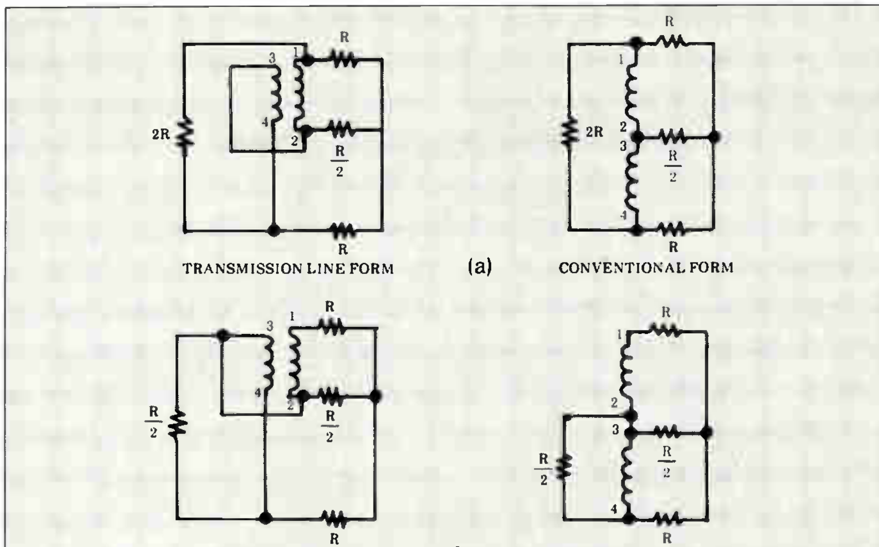


FIGURE 6
(a) Basic hybrid (b) Unsymmetrical hybrid

Various hybrid circuits are developed from the basic form using transformers.

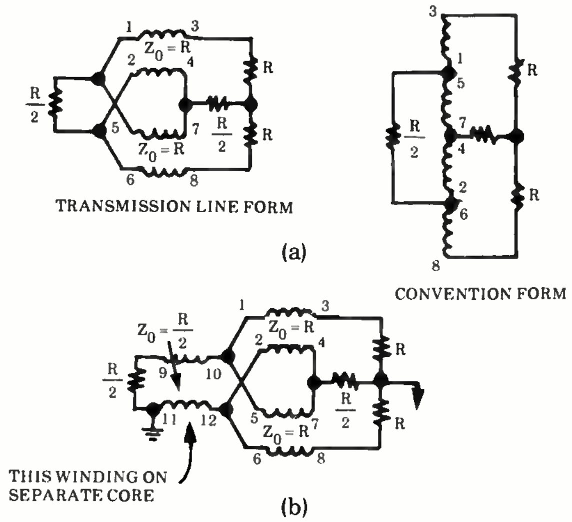


FIGURE 7

(a) Symmetrical hybrid
(b) Unbalanced symmetrical hybrid

should be followed: with the generator connected and the load open, a completed circuit should be formed by the windings so that the core will be magnetized. The fields set up by the currents should be arranged so as to aid each other.

The circuit of the Balanced to Unbalanced 4 to 1 Impedance Transformers of Figure 5 is quite simple. The single bifilar winding is used as a reversing transformer as in Figure 1. The high frequency cutoff is the same as that for the transformer of Figure 3.

In some applications it is desirable to omit the physical ground on the balanced end. In such cases, Figure 5(b) can be used. The high frequency cutoff is the same as for the transformer of Figure 3. The low frequency analysis is presented in Appendix B.

Various hybrid circuits (shown in Figures 6 through 9) are developed from the basic form using the transformers discussed previously. The

In all hybrids in which all four arms are single-ended, it is necessary to use two cores to get proper magnetizing current.

drawings are very nearly self-explanatory. In all hybrids in which all four arms are single-ended, it has been found necessary to use two cores in order to get proper magnetizing currents.

Two hybrids have been measured and data included here. The response of a hybrid of the type shown in Figure 8 is given in Figure 13. For this mea-

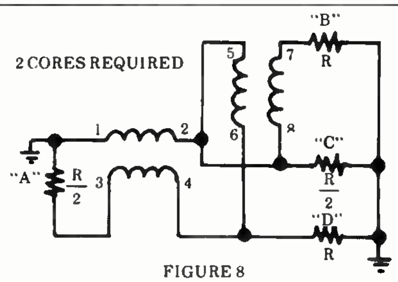


FIGURE 8

Hybrid with equal conjugate impedances

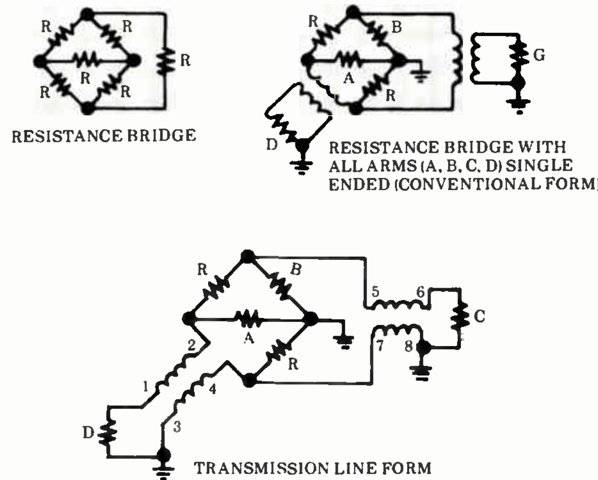
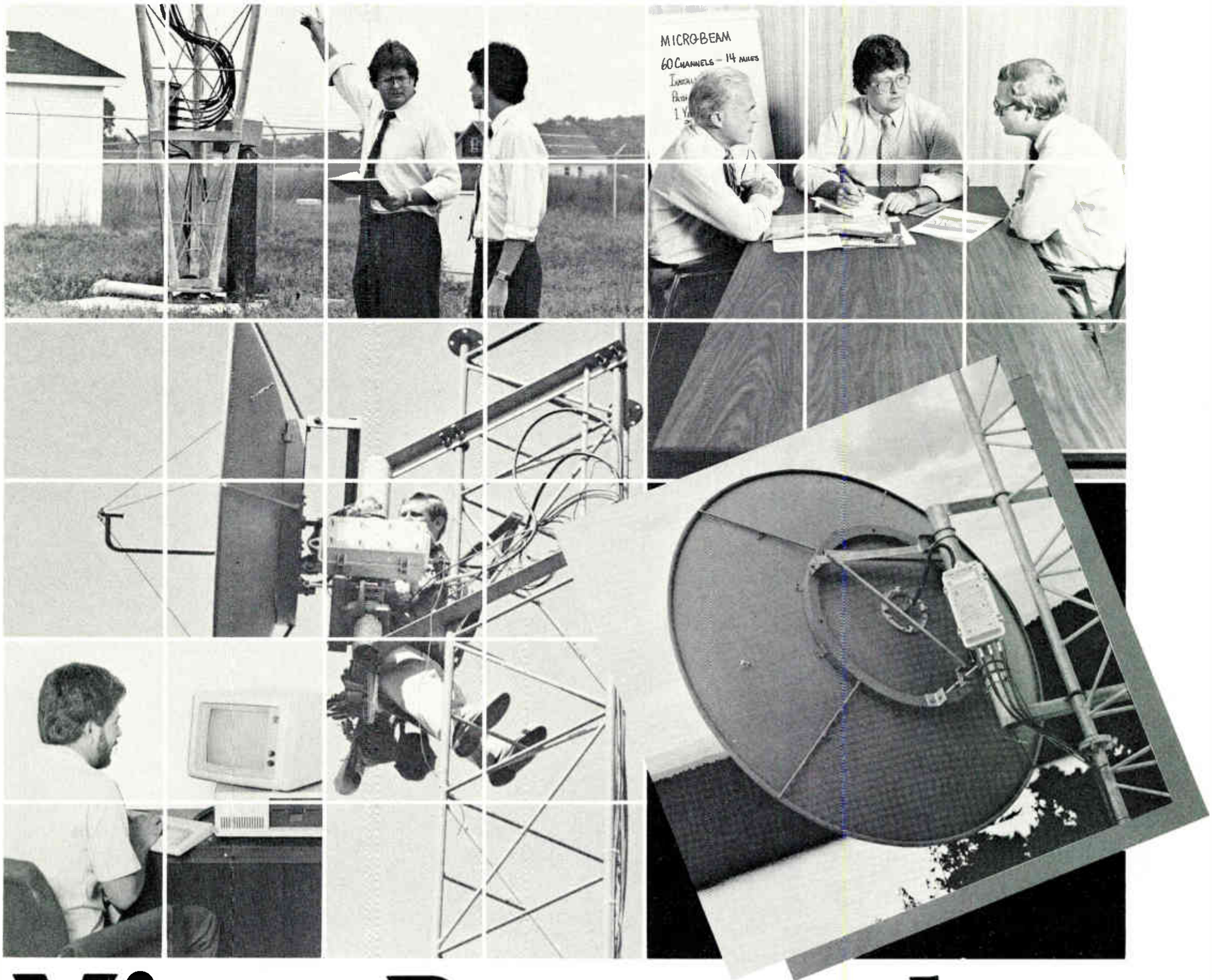


FIGURE 9

Resistance hybrid with equal impedance loads



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Applications of the transformer include reversing the polarity of short pulses, driving balanced antennas and many more.

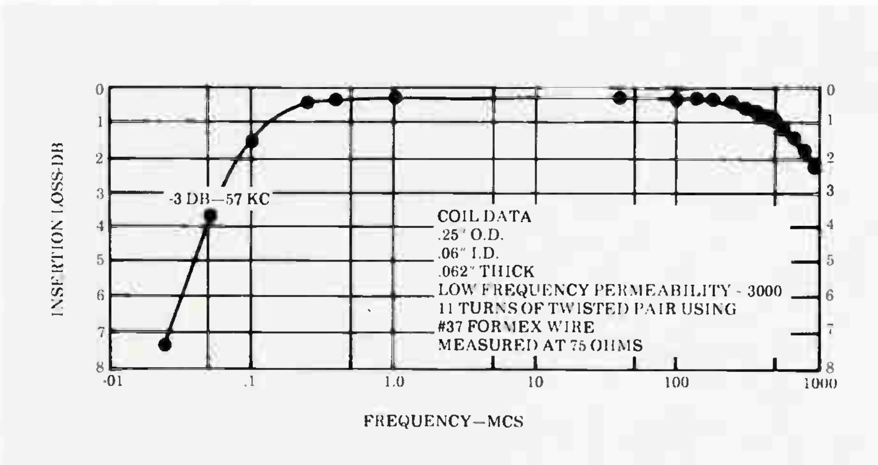


FIGURE 10

1:1 Reversing transformer. Insertion loss vs. frequency

surement $R = 150$ ohms. In order to measure the hybrid in a 75-ohm circuit, arms B and D were measured with 75-ohm series resistance in series with the 75-ohm measuring gear. This accounts for 3 dB of the loss. Under these conditions, arms B and D have a 6 dB return loss.

The transmission of the resistance hybrid of Figure 9 is given in Figure 14. This hybrid has been matched using the technique described previously for the reversing transformer. The results of this matching are included in the figure. This hybrid was designed for use in a pulse reflectometer, the main part of which is a stroboscopic oscilloscope with a resolution of better than 3 mμ sec.

Applications

Many applications for these transformers will occur to the reader. For purposes of illustration, a few of them are listed here.

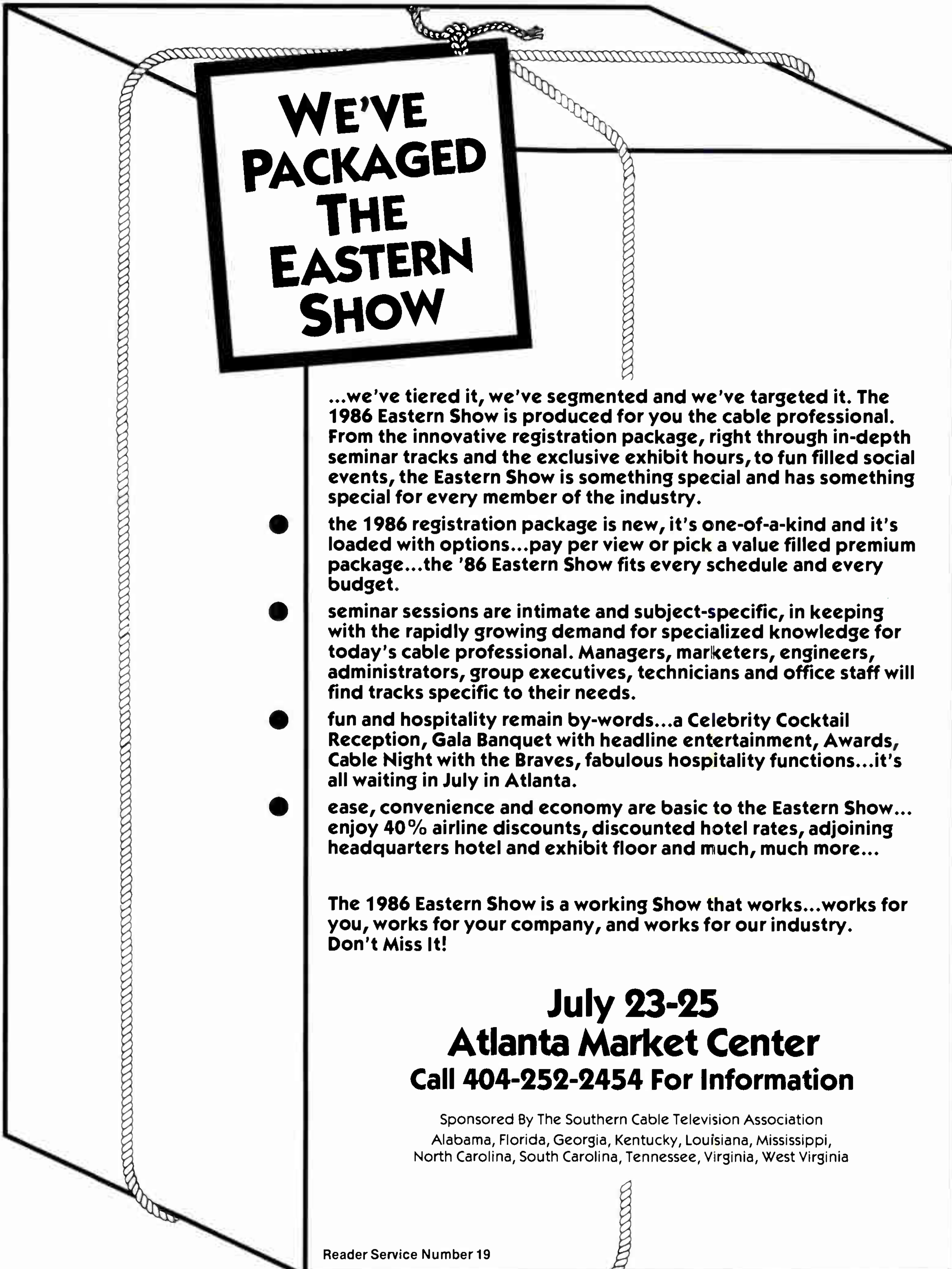
1) The reversing transformer of Figure 1 can be used to reverse the polarity of short pulses, an operation which is frequently necessary. It has also been used in balanced detectors and to drive push-pull amplifiers from single-ended generators.

2) The transformers of Figures 2 and 5(b) are useful for driving balanced antennas. The circuit of Figure 5(b) may find application in connecting twin lead transmission line to commercial television receivers.

3) The transformer of Figure 3 has found wide use in broadband amplifier interstages. It will also be useful in transforming the high output impedances of distributed amplifiers to coaxial cable impedances. They can also be cascaded to get higher turns ratios.

4) The circuit of Figure 5(a) has been used to drive broadband oscilloscopes, with balanced inputs, from single-ended generators.

5) Hybrids have many uses such as in power dividers, balanced amplitude and phase detectors; as directional couplers for pulse reflectometers, IF and broadband sweepers. They might also be used as necessary components in a short pulse repeater for passing pulses in both directions on a single transmission line.



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Hybrids have many uses such as in power dividers, balanced amplitude and phase detectors.

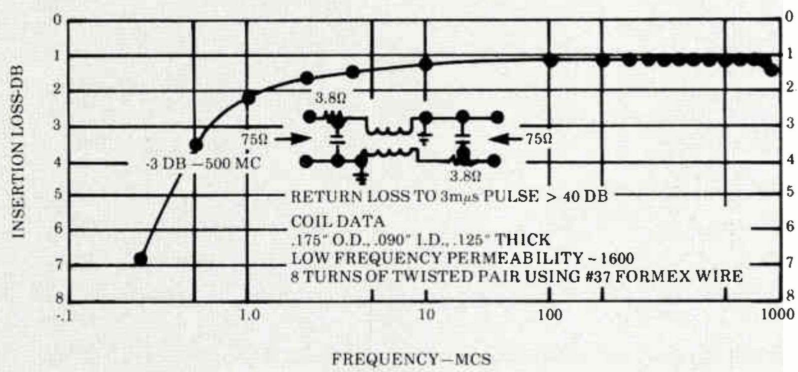

FIGURE 11

Matched reversing transformer

Appendix A

The high frequency response of the circuit of Figure 3 is derived from Figure 15. The loop equations are as follows:

$$e = (I_1 + I_2)Rg + V_1$$

$$e = (I_1 + I_2)Rg - V_2 + I_2 R_L$$

$$V_1 = V_2 \cos \beta l + jI_2 Z_0 \sin \beta l$$

$$I_1 = I_2 \cos \beta l + j \frac{V_2}{Z_0} \sin \beta l. \qquad (2)$$

This set of equations is solved for the output power P_0. $P_0 = |I_2|^2 R_L$

$$P_0 = |I_2|^2 R_L = \frac{e^2(1 + \cos \beta l)^2 R_L}{[+2R_g(1 + \cos \beta l) + R_L \cos \beta l]^2 + \left[\frac{R_g R_L + Z_0^2}{Z_0}\right]^2 \sin^2 \beta l} \qquad (3)$$

Hybrids can also be used as necessary components in a short pulse repeater for passing pulses.

From this expression, the conditions for maximum power transmission are obtained by setting $l=0$ and setting $dP_0/dR_L|_{l=0}=0$. The transformer is matched when $R_L=4R_g$. The optimim value of Z_0 is obtained by minimizing the coefficient of $\sin^2 \beta l$ in (3). In this manner the proper value for Z_0 is found to be $Z_0=2R_g$.

Now, setting $R_L=4R_g$ and $Z_0=2R_g$, (3) reduces to

$$P_0 = \frac{e^2(1+\cos\beta l)^2}{R_g[(1+3\cos\beta l)^2+4\sin^2\beta l]} \tag{4}$$

Also,

$$P_{\text{available}} = \frac{e^2}{4R_g}, \tag{5}$$

and dividing (4) by (3):

$$\frac{\text{Power Available}}{\text{Power Output}} = \frac{(1+3\cos\beta l)^2+4\sin^2\beta l}{4(1+\cos\beta l)^2}. \tag{6}$$

This function is plotted in Figure 16.

The impedances seen at either end of the transformer with the other end terminated in Z_L have been derived. They are:

Z_{in}(low impedance end)

$$= Z_0\left(\frac{Z_L\cos\beta l + jZ_0\sin\beta l}{2Z_0(1+\cos\beta l) + jZ_L\sin\beta l}\right) \tag{7}$$

and

Z_{in}(high impedance end)

$$= Z_0\left(\frac{2Z_L(1+\cos\beta l) + jZ_0\sin\beta l}{Z_0\cos\beta l + jZ_L\sin\beta l}\right) \tag{8}$$

Appendix B

In the low frequency analysis of the transformer of Figure 5 the series impedance of each half of the bifilar winding is denoted by Z. The loop equations are:

$$E = (R_g+Z)I_1 - (Z+kZ)I_2$$
$$E = (R_g-kZ)I_1 + (R_L+Z+kZ)I_2, \tag{9}$$

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It's clear that the center point of RL is at ground potential; this point can therefore be grounded physically.

$$\frac{I_1}{I_2} = \frac{R_L + 2Z(1+k)}{Z(1+k)} \approx$$

$$2 \text{ if } Z >> R_L. \quad (10)$$

We now proceed to calculate the voltages from points 1 and 2 to ground

$$V_{2G} = E = I_1 Rg. \quad (11)$$

When the transformer is matched, $E = 2I_1Rg$ and

$$V_{2G} = I_1 Rg.$$

Similarly,

$$V_{1G} = I_2 Z - kZ(I_1 - I_2).$$

With the aid of (10) this can be rearranged to

$$V_{1G} = ZI_1 \left[\frac{Z(1+k)^2 - kR_L - 2kZ(1+k)}{R_L + 2Z(1+k)} \right] \quad (12)$$

Now let the coupling coefficient $k = 1$, then

$$V_{1G} = I_1 Z \left[\frac{-kR_L}{R_L + 2Z(1+k)} \right] \approx - \frac{I_1 R_L}{4}$$

for $Z >> R_L$.

When the transformer is matched, $R_L = 4Rg$ so that

$$V_{1G} = I_1 Rg = - V_{2G.} \quad (13)$$

and the load is balanced with respect to ground.

From (13) it is clear that the center point of R_L is at ground potential. This point can therefore be grounded physically, resulting in Figure 5(a). ■

Acknowledgement

In addition to those mentioned in the text, the author is indebted to D. H. Ring for many stimulating discussions on every aspect of these transformers.

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[1] Willmor K. Roberts, "A new wideband balun," Proc. IRE, Vol. 45, pp. 1628-1631; December, 1957.
[2] H. Gunther Rudenberg, "The distributed transformer," Raytheon Mfg. Co., Waltham, Mass.

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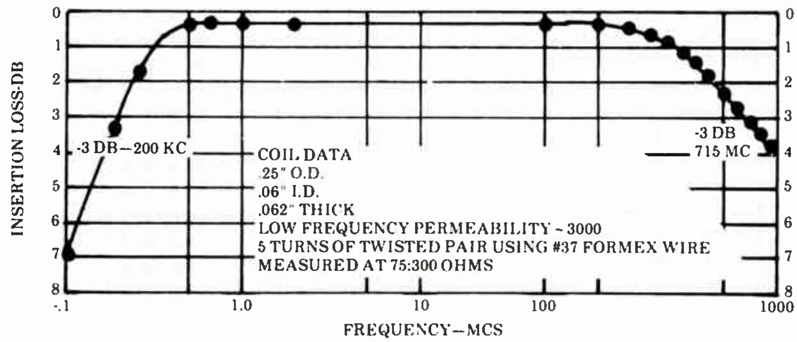

FIGURE 12

Winding 4:1 impedance transformer unbalanced—unsymmetrical

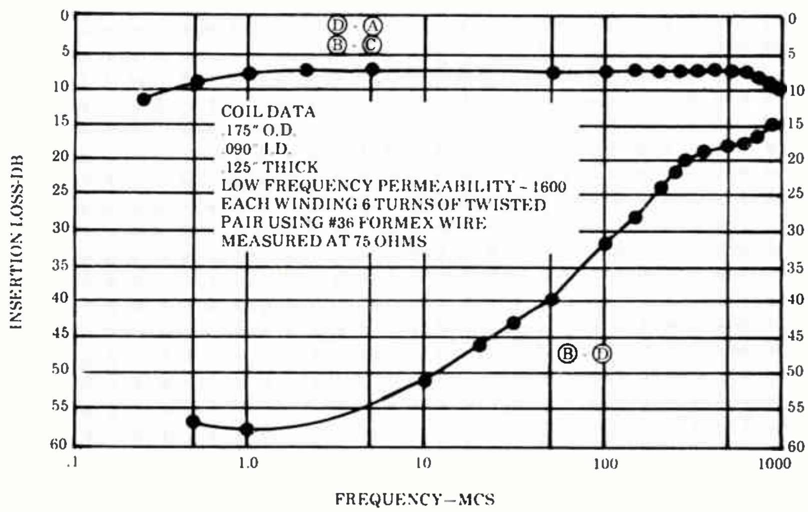

FIGURE 13

Hybrid of Figure 8

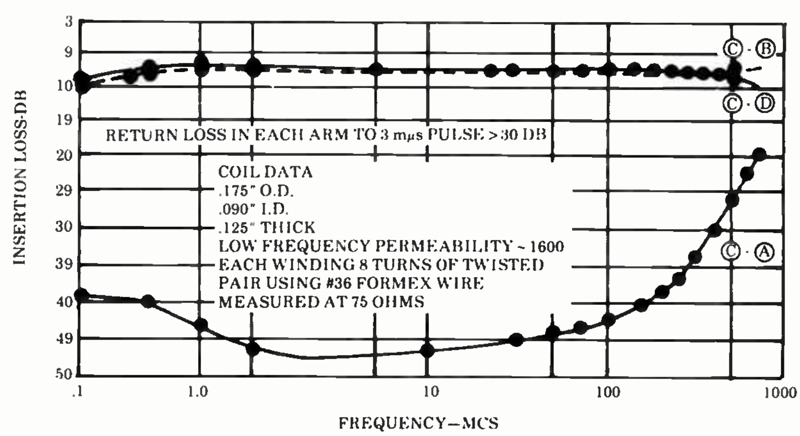

FIGURE 14

Matched resistance hybrid. Insertion loss vs. frequency

Continued on page 65

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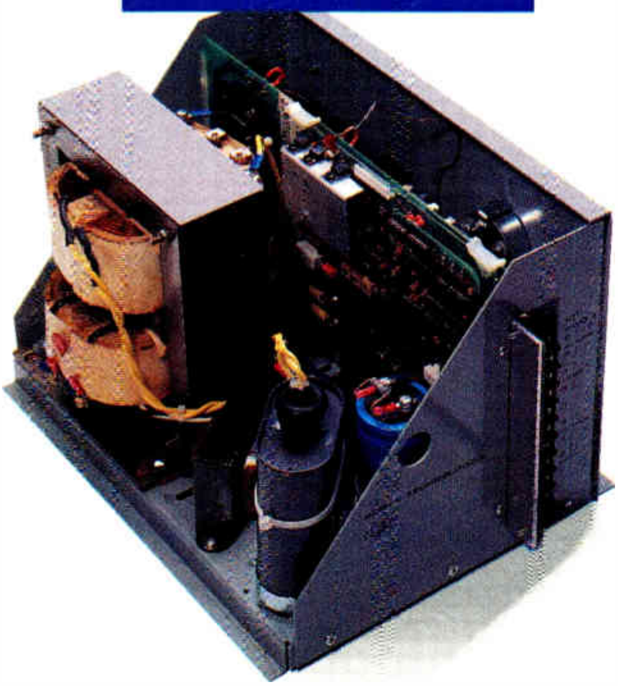

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Rapid rise in use of LANs result of local needs

The term local area networks (LAN) encompasses a wide variety of communication systems that are loosely grouped together by virtue of such common characteristics as:

- ☐ Wholly owned by one organization
- ☐ Limited geographically (under several kilometers)
- ☐ High bandwidth (over one megahertz)
- ☐ Packet data transmission
- ☐ Uniform interfaces
- ☐ Uniform protocols
- ☐ Distributed network intelligence
- ☐ Ability to connect dissimilar equipment
- ☐ No single point of failure

Rapidly being installed by businesses, universities, factories and the military, LANs often are used to allow users with related needs to share mutually useful information. In some instances, such as factory applications, however, the types of users and information are quite varied. Yet LAN techniques can be readily applied to meet the requirements of these applications.

The need for LANs comes from the desire for more and better communication at the local level. In particular, widespread digital computer capability and microprocessor technology have provided vast amounts of information. To be useful, this information must be accessible when and where it is needed. LANs promote effective communication arrangements that can move information. Some types of communication needs that LANs are being designed to handle are shown in Table 1.

> LANs are frequently being installed by businesses, universities, factories and the military.

Many LANs consist of a number of computers or computer-associated devices, an electronic hardware interface of some sort of each, specialized software to allow proper communication and a cabling medium for interconnection. Often the computers and their network interfaces all connect to a common cable such as with Ethernet. They then can communicate with each other or with peripherals, using the LAN. This software usually is at least partially contained in a nonvolatile memory in the network interface, which includes a microprocessor and specialized hardware to handle network functions. This interface provides the distributed network intelligence.

Still, gray areas exist as to what is a LAN and what is not. In the past, private branch exchanges (PBXs) and computer branch exchanges (CBXs) have been used to provide the bulk of local communication, both voice and data, usually through the same system. Having some of the features of a LAN, they generally are not considered in this category since they lack the uniform interfaces and protocols of a LAN and have a single point of failure. Computer packet-switching networks, also commonly used for data communication, are not considered LANs since they usually handle long-distance traffic and rely on hardware (switches, leased lined, satellite links, etc.) owned by more than one company.

Many communication chores are handled today by connecting a desktop computer to an electronic switch or PBX, and then to a large computer. Such arrangements allow electronic mail, file sharing and many features that are common to LANs, but such a system is still not itself a LAN. In this case, network intelligence is concentrated in the PBX or large computer; it is not dispersed throughout the network as in a LAN.

In addition, not only does a PBX system not provide for uniform protocols and interfaces that will allow dissimilar equipment to communicate easily, it also usually has a very limited bandwidth. When dissimilar equipment is to be connected through a PBX, additional devices such as protocol converters must often be added and shared when needed by users in the system. Traditionally, PBXs also were limited in data speeds to 19.2 kb/s, although new machines can support higher rates.

Confusion can arise in the case of certain types of LANs, for example AT&T's Datakit. Here, all of the net-

Table 1. Typical data speeds

DATA SOURCE	DATA RATE (kb/s)
Sensors, Security	0.1
Common Terminals	1.2-4.8
Graphics-Character	4.8-9.6
Word Processor	9.6
Facsimile	9.6
Line Printer	19.2
Data Enquiry Terminal	56
Digitized Voice-Real Time	64
File Server-Light Duty	100
Graphics-Noncompressed Pixel	256
Gateway to Outside Network	1500
File Server-Block Transfer	10,000
Video-Noncompressed	25,000
Video-Broadcast Quality	80,000
Host Channel	10,000-100,000

Scientific Atlanta

TECHNICAL KNOCKOUTS.

WE'RE FIGHTING FOR BETTER TECHNOLOGY AT LOWER COST.

Scientific-Atlanta began pioneering new technology for cable TV back in the early 60's with an off-air antenna and headend equipment for receiving distant TV signals. Then in 1975, Scientific-Atlanta headend and earth station equipment made possible one of the first satellite-delivered commercial broadcasts for cable distribution: The Ali-Frazier "Thrilla in Manila" world boxing event. And today, we're still fighting to bring you new technology while keeping costs down at the same time.

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Our two latest contenders in state-of-the-art design and engineering are the 6680 and 9630 receivers. Both are technical knockouts and the result of extensive research and development. Of course, innovation is nothing new to Scientific-Atlanta. We were the first to introduce a low-cost 4 GHz receiver as well as a receiver which worked in conjunction with an LNB.

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To fully appreciate the new 6680 and 9630, you need to take a closer look. The 6680's modular configuration, for example, provides a variety of applications and greater serviceability. It was designed for increased performance in a multiple subcarrier environment, and provides accurate demodulation of high-speed data. The 6680 also has a tunable audio subcarrier demodulator.

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As a single-source supplier of cable products, Scientific-Atlanta can put together a complete package for you at an attractive price. And back it all up with a single warranty. For more information, call 1-800-722-2009 or write to Scientific-Atlanta, Department AR, P.O. Box 105027, Atlanta, GA 30348.

Reader Service Number 29

Four considerations, interconnection media, modulation, access method and topology differentiate LANs.

work interface units and the interconnecting media of the LAN are contained within one electronic cabinet. Stations then are connected to this box by individual cables, typically existing phone lines. For all intents and purposes, this system looks like a PBX. The actual electronic architecture is that of a LAN, however.

Thus, a LAN is basically characterized by a conceptual architecture for a communication system that has the elements mentioned above. There are many physical ways to implement a LAN, some of which may appear like other types of communication systems. In fact, some LANs may be wired and installed much like today's systems, simply for the ease of doing so or to allow graceful changeover from current technology to a LAN.

Four primary considerations differentiate one LAN from another, impact the performance to be expected from a particular LAN and drive the hardware needed for the application. The considerations are interconnection media, modulation, access method and topology.

Media

The network medium is the major cable and is used to interconnect stations. While twisted pair cable is inexpensive and extra wiring is already installed in many buildings, it does limit performance to the very low end of the data rates possible for LANs. Coaxial cable is used in over 90 percent of LANs today. It is a mature technology with acceptable bandwidth in keeping with the capability of the other components in the system.

It is, however, relatively expensive and has distance limitations. Triaxial and other forms of shielded controlled-impedance cable may find similar use in LAN applications. Optical fiber represents an area of high growth and decreasing costs, with high performance driving the technology. Because of the short distances in LANs, multimode fiber at 850 nm wavelength is finding immediate application. The 1300 nm wavelength will increase in popularity as compatible electro-optic components become more readily available.

Additional types of media may be used in the interface cables that connect the user's station to a network interface unit (NIU), or from the interface unit to the network media. These interface cables, frequently twisted pair because of the very short cable lengths involved, are usually of a type different from the network medium.

Information is transmitted digitally in a LAN. Each bit of information is represented by some change in a signal on the network medium. If the bit is

Access method, a unique area for LANs, stems from their distributed network intelligence.

represented as a particular signal level on the cable, this is called baseband modulation or signalling. If the bit is represented by some state (amplitude, frequency, phase) of an RF carrier, this is called broadband modulation or signalling. Although baseband allows for simpler electronics using line drivers and receivers, it is limited to typical digital electronic speeds in its information carrying capacity. This capacity may well meet users' needs, however. Broadband modulation requires RF circuitry (an RF modem) similar to CATV devices, but can deliver signals on various frequency bands, or channels. Each channel can carry a sizeable amount of information approaching the capacity of a baseband LAN. Note that optical systems rely on the amplitude modulation of a light beam, which is a form of carrier as in RF systems, but that these systems generally are considered to use baseband signalling, with the optical intensity variation similar to the voltage variation seen in electrical baseband systems.

A feature related to modulation is digital encoding. The digital data must be represented by some form of code on the network. A simple code is NRZ, in which each bit is represented by one of two states of the modulated signal. Other codes often are used to impart special characteristics to the signal in order to provide enhanced capabilities to the network hardware. For example, Manchester code, a type of biphase code, employs two states to encode each bit of data, which doubles the signalling rate, or baud rate, on the network. This code is used in Ethernet applications and many fiberoptic links since they provide an average 50 percent duty cycle to the network signals.

Access method

Access method is an area somewhat unique to LANs. It stems from their distributed network intelligence. One method to access the LAN medium is through contention. Here, any unit on the LAN begins to send data whenever it wants. Since two devices sending signals concurrently will garble the data, most contention schemes require that a station first listen to the network and then send data only when it is idle. Additional problems can arise if two stations begin transmitting at the same time, which results in a collision of the data on the netork. Features such as collision detection are implemented to reduce the time that collisions exist in a network, and thereby, improve overall network throughput.

Even so, contention systems will function even without these restrictions since there is usually error checking included in the software associated with message transmission.

Another access method is token passing. In this approach, a special message (the token) is sent from one station to another throughout the network. The token is used to grant permission to transmit a message on the network. A unit can transmit only after being granted permission by receiving a particular token indicating that the network is idle. Some problems can arise in passing the token around the network. For example, a station may go off-line and, therefore, not be available to receive this special message and pass it on. Also, the token can be corrupted by noise, so it is never detected as being received and the network activity ceases. The network usually requires one unit to serve as a watchdog or controller to handle these conditions.

A time slot network operates by allowing each unit to send data only during a designated interval of time. No single station can use the full capacity of the network since each unit can transmit only during a small percentage of the total time that is available on the network. Effective use of the communication system suffers with this method since the capacity required is not uniform from station to station in the LAN, nor is it static with time.

One advantage of the time slot is in

Topology refers to the physical and logical arrangement of a local area network.

the handling of voice communications. Real-time voice transfer requires access to the communication system on a regular repeatable basis, since even slight delays in voice transfer are unacceptable to the human ear. A time slot network can supply this capability, while neither the contention nor the token passing access methods can do this for any appreciable number of voice connections.

Other proprietary methods and combinations of methods also are used in LANs, and many offer advantages for specific applications. Even so, those discussed above probably will account for over 90 percent of the networks installed in the future.

Topology

Topology refers to the physical and logical arrangement of a LAN. The four most common topologies, are the bus, tree, ring and star.

A bus involves a linear, usually continuous, medium to which all units attach directly, often by tapping. Each station can both detect signals and place signals on the bus according to the access method of the network. These signals usually travel in both directions down the bus from the point of insertion. The tree topology is similar to the bus, except that connections are not linear, but branch out, allowing two or more paths from a particular point in the network. A ring usually involves a series of point-to-point links, from one unit to the next, that closes back on itself to form a circular and continuous chain. At each station on the ring the signal is received, regenerated and transmitted to the next station on the ring. Transmission usually is in one direction on the media. The ring requires some method to bypass stations that go off-line or otherwise tail.

A star topology has each unit connected to a central point.

There is a distinction between physical and logical topology. Physical topology concerns the way a system is wired; logical topology concerns the way signals flow in the network.

Network layers

The important objective of LANs is to allow dissimilar equipment to communicate easily resulting in the need for uniform protocols and interfaces. In the past, various vendors of communication systems have defined their particular standards independent of each other. For LANs, a standardization effort has been underway with wide industry acceptance. Under the International Standards Organization,

The OSI model doesn't imply all LANs are compatible, even if they follow OSI specifications.

this work is called the Open Systems Interconnect model—The ISO OSI model.

The ISO OSI model embodies the following concepts:

- Defined protocol for messages and their exchange
- Hierarchical structure of tasks
- Functional grouping of tasks
- Defined boundaries between tasks (interfaces)
- Encapsulation of information with headers and trailers
- Defined communication between tasks on equal hierarchical levels, as well as between the next higher and lower task

The OSI tasks are specified in seven layers:

Physical layer—This part of the specification involves transmission of bits on the media. Involving mechanical and electrical issues, it mainly deals with hardware. Specified here are connector and pin assignments, voltage levels, and how initial connections are established. This involves RS-232-like specifications and deals with bits.

Data link layer—This layer involves controlling a single channel. Data are segmented into groups of some specified number of data bits. Additional bits (a header and trailer) are added to this group to form a frame. This function usually involves specialized electronics in the interface, as well as some intelligence in the interface of the station to the network.

Network layer—This layer involves moving messages from place to place within the network. In this layer, frames are put together to form packets, which contain routing and sequencing information for proper passage through the network. This layer usually is implemented in specialized hardware and software in the interface.

Transport layer—This layer involves end-to-end message, flow, routing and message integrity. Packets are put together to form messages. This is the lowest layer that has hardware dependency, and is mainly implemented in software, as are each of the following layers.

Session layer—This layer, managing dialog between users, is responsible for setting up and terminating communications in the network. It provides the equivalent of a "log on" function to the network.

Presentation layer—This layer performs code conversions and format translations. It not only establishes the character set and meaning to be used, but also controls line length, page length, text compression and data encryption/decryption. This is a software function.

Application layer—This is the layer that includes the software drivers that interact with the user's application programs—what he actually wants to accomplish. The OSI architecture provides interfaces to the communication system of the user's hardware at this level and may provide services such as terminal support, file transfer, mail service and so on.

Note that a total communication system requires all of these layers to be functional. A typical interconnection system deals only with the physical layer.

Network interfaces

The OSI model does not imply that all LANs are directly compatible, even if they follow the OSI specifications to the letter. LANs of different types still need some special apparatus to communicate with each other, as may two LANs of the same type. The OSI model does, however, provide for defined and characterizable methods to allow intercommunication between LANs.

Repeater—A repeater operates at the bit level and, hence, at the physical layer of the OSI model. It is used to extend a particular LAN past the normal physical boundaries imposed by its electrical characteristics and the media used. The repeater restores voltage levels, sharpens signals and sends

Some major standardization activity for local area networks is in the IEEE 802 committee.

them on their way over an additional section on the same LAN.

Bridge—A bridge operates at the frame level and, therefore, at the data link layer of the OSI model. It connects together LANs of identical type and allows communication between them. A bridge does not operate like a repeater. The two sections on either side of the repeater form a single LAN and can, therefore, operate on only one message at a time. A bridge allows two LANs to function independently, yet provides a path for a unit in one LAN to communicate easily with a unit in the other LAN. Each commercial LAN will likely offer a bridge product that will provide this function.

Gateway—A gateway operates at the packet or message level and, therefore, at the network layer or transport layer of the OSI model. The gateway will connect together dissimilar LANs; it also allows connection of a LAN to an external nonLAN communication service. Since there are many types of LANs and services available, a wide variety of gateway devices is expected to be produced commercially.

Some major standardization activity for local area networks is in the IEEE 802 committee. Two subcommittees, 802.1 and 802.2, deal with architecture and logical link control. Other subcommittees are dealing with specific LAN types as discussed below.

IEEE 802.3: carrier sense multiple access/collision detect bus

The LAN type known as CSMA/CD is most closely associated with the Ethernet product, although this product and the 802.3 specification have been slightly different in the past. This standard involves contention access on a bus topology. In order to reduce simultaneous transmission on the bus, one feature required in a CSMA/CD design is that any station that desires to transmit can do so only after listening to the bus and confirming that there is no transmission in progress. This is called carrier sense, even though many systems like Ethernet are baseband and do not employ a carrier per se. Active transmissions are sensed by the presence of a dc voltage (due to signals) on the coaxial media.

Collision detection is also required, since it is possible for one or more stations to begin transmission at the same time. In this case, the data streams overlap (collide) and become garbled. Collisions are detected on the bus by a transceiver in the act of transmission sensing improper dc voltage levels caused by two or more signals being present.

Once a collision is detected, the interface must stop transmission and

Through industry support, the 802.3 LAN continues to be the most popular of the standard types.

then begin retransmitting at a later (random) time. A jam signal is also sent on the bus when a collision is sensed, so that all stations on the network will detect the collision and act accordingly. In any event, mechanisms are built into the data protocol structure to allow receiving stations to recognize message fragments or messages that contain errors and to discard them.

The CSMA/CD networks perform well in practice. The 802.3 networks operate at 10-Mb/s data rate, (or 20 Mbaud) because of the Manchester encoding used. The bus works best in lightly loaded applications, which thereby allow near instantaneous bus access. Several studies involving actual hardware and computer simulations have shown that performance does degrade with heavy bus usage, however. Here collisions occur frequently, and substantial time is wastedin garbled data and the associated recovery.

One disadvantage stemming from the random nature of collisions is that bus performance is not deterministic: performance characteristics and message transmission delays are not predictable. One obvious case where this can be a problem is for priority messages, such as from a fire-detection system. It also is not well suited for voice traffic where uniform access to media bandwidth is required.

IEEE 802.3 specifies a large diameter, high-grade coaxial cable allowing invasive tapping to occur on an active network through the use of AMP's coaxial tap. Although network performance is excellent, this media tends to be expensive. Other versions of this LAN now are being installed under the name "Thin-net" or "Cheaper-net" which use a less costly cable, RG-58. Higher cable losses limited network lengths to less than 802.3's 2,500 meters. These systems use simple BNC connectors and T couplers for device attachment.

Optical fiber versions of the 802.3 bus, also available, typically employ star connection of optical fibers to a central location, which houses either an active or passive optical coupling scheme to distribute signals. Collision detection often is implemented at this central location, rather than at each individual station. Fiber is also frequently used to interconnect two segments of an Ethernet system that are physically separated by a kilometer or more. An optical point-to-point link, with repeaters to regenerate the bus signals, is used.

Through industry support, the 802.3 LAN continues to be the most popular of all the standard types thus far. It is used for a variety of applications, often seen in areas employing desktop computers, work stations and host processors. Most systems use coaxial cable, either standard size or thin size, while some systems now are done in optical fiber.

IEEE 802.4: token bus

The token bus, involving token passing access on a bus topology, is receiving strong industry support from GM, IBM and others through the MAP program, aimed at use in factory applications. As planned, the LAN will commonly be a broadband modulation system using coaxial cable to support a number of high data-rate paths, advantageous where very large communication systems are needed. The major advantage of such a configuration is that the token bus network can actually be implemented on a sub-channel of a larger RF communication system that has independent channels for CATV, voice, point-to-point trunks or even other LANs. The user can install a broadband RF communication system and be assured of a variety of services over the common medium.

Baseband implementations also are planned for in the standard and will be used where less complex systems are desired. Both types will operate at a 5- or 10-Mb/s data rate, for each 802.4 network installed. ■

Practical experience with stereo cablecasting

A stereo telecast on a metro-wide local origination channel in Atlanta was undertaken in order to gain experience with BTSC stereo in a cable television environment. The signal path was long, and involved several modulation, transmission and demodulation steps. The fact that the signal arrived at the observation location in good condition shows that BTSC stereo can work in a CATV environment.

Background

On October 25, 1985, the world's first known cablecast in stereo took place in Atlanta, when Metrochannel 13, serving Atlanta, DeKalb County and outlying areas, featured a special stereocast of David Scott's program, *Electronic Avenues*. Scott writes about consumer electronics for the Atlanta Newspapers, as well as hosting this program. The program originates in the Video Edition studio in the Atlanta Newspapers building. In order to achieve this stereocast, it was necessary to temporarily modify numerous transmission paths and interconnects between commonly owned and independent CATV systems.

We feel that the fact that stereo was successfully transmitted is proof that BTSC stereo in a cable environment is viable. It is an economical service desired by our subscribers. We can, in most cases, deliver it without incurring excessive cost or complexity, though we do have to pay attention to what we are doing.

The idea of a stereocast originated when one of the authors was honored by being invited to appear on *Electronic Avenues* specifically to discuss stereo on cable. A number of professionals in Atlanta had indicated confusion over this issue, so Scott put together a program with representatives of Prime Cable, Wometco Cable, Scientific-Atlanta, WXIA-TV (NBC) and Video Warehouse, a retailer and sponsor of the program.

We decided that rather than just talk about stereo, we would do it. This gave us real-life experience with stereo and allowed us to state with authority that it really works.

By James O. Farmer, David Sedacca, Thomas Williams, Harley Jones, Scientific-Atlanta Inc.

"We feel the fact that stereo was successfully transmitted is proof that BTSC stereo in a cable environment is viable."

The program invites live telephone calls from viewers. We were thrilled when the first call was from a man who had bought his stereo TV a week before and confirmed that we were coming through in stereo! A videotape in stereo was made at author Farmer's house, at the end of a cascade of three CATV systems owned by two different companies. We will show the transmission path involved.

While we were not able to make measurements, the stereo separation observed on the video tape was very good. Signal to noise ratio was competitive with that produced by the normal monaural audio path, with stereo noise being dominant.

Studio modifications

In the studio, mixing board techniques are determined by the sources of sound to be transmitted. Scott's show included sources typical in locally originated cable programming. On stage, Scott and three guests each wore lapel microphones. Video tape recorders were used in the control room to play pre-recorded segments and commercials. The VTRs provided monaural soundtrack outputs. The show featured telephone questions from viewers watching the live program. A telephone coupler in the control room made the callers' voices available for mixing and monitoring. This coupler also sent the voices of Scott and his guests back to the caller. Audio cassette decks were available in the control room to provide music for segues or effects.

The goal of the mix was to provide an obvious stereo signal during the show, while maintaining the production style established by Scott for his program. To understand the special efforts required for the stereo mix, an examination of the studio's monaural equipment and normal practices is necessary.

The Video Edition studios mix sound with a Tascam mixing board. This board has eight input channels and four output channels. Each output channel may have a different combination of signals on it. Any source may be routed to several of the output channels, or none, as desired by the operator.

Specific tasks

The four output channels are dedicated to specific tasks in the studio: one of the channels is designated as Program Output. This line sends the actual monaural soundtrack to the cable headend. Another channel is designated as Monitor Output. This drives the studio amplifier and monitor loudspeakers. Next is a Cue output. This auxiliary channel is used to audition alternate sources without interfering with the mix in the Program channel or Monitor channel. (At the time of our broadcast, the Cue channel was suffering from undesired crosstalk with other busses in the board, rendering it useless.) The fourth output channel is used to send audio to the telephone coupler. Live call-in programs require that audio from the control room's telephone lines be sent to the monitor loudspeakers and that the announcer's voice be sent to the telephone circuit. The mixing board can send the announcer or any other input to the telephone coupler.

The input modules on the mixing board receive signals from individual sources, some through input selector switches, as there are more sources than inputs. Sources include six microphones in the studio, three video tape players in the control room, a telephone coupler and an audio cassette deck.

When Video Edition is produced with a monaural soundtrack, all sound is controlled by the director in the control room. The program mix and monitor mix, as well as all volume levels and telephone connections, are controlled through the mixing board.

In planning the stereo cablecast it was agreed that while Scott's show

To assure that Scott's show would not lose audio because of a failure of any type in the stereo set-up, a monaural mix was required.

would be done in stereo, the following live program, *Tracking*, would be produced in the studio's normal monaural system. This allowed about two minutes to remove the stereo equipment and resume monaural techniques in the studio and at the controls. In addition, to assure that Scott's show would not lose audio because of a failure of any type in the stereo set-up, a monaural mix was required as a back-up. At any sign of signal loss, an engineer could return immediately to a conventional monaural mix.

Pan controls

A separate audio board with facilities for producing a stereo mix was brought to the Video Edition studio. This board answered several specific needs. It provided pan controls for individual input sources. An input signal can be placed anywhere between the extreme left and extreme right of the image. It provided several auxiliary output busses for flexible signal routing. These included separate mono mixes. Finally, it allowed the studio to be set up for stereo sound without dismantling any of the existing monaural connections.

The stereo mixing board used is similar in concept to the main board described above. Operational differences arise from the fact that the stereo board has 10 output channels instead of four and has features like the pan control that are useful for stereo mixing. Six of the output channels are configured as stereo pairs, so there really are few extra controls to keep track of.

Figure 1 shows how the stereo mixing board was used. Sound from each microphone was sent to the Left and/or Right channel of one pair of outputs. An audio cassette deck and a line coming from the control room's regular mixing board were available in this same mix. The regular board sent audio from the control room's video tape recorders and the telephone coupler. A stereo limiter was used on the Left and Right audio channels to control peaks in the signal. A mono feed was derived to send back to the main mixing board for the telephone coupler. The Left and Right audio channels were sent to the 6380 encoder.

The stereo mixing board was located in the studio to avoid clutter in the control room. The only connections to the normal mixing equipment were the two audio cables between boards. One operator mixed sound at the stereo board. This included control of the microphones, cassette deck and the level coming from the main board in the control room. The director operated the telephone coupler and VTRs and sent sound from these to the stereo board.

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We were gratified that the tape showed good stereo separation and signal to noise ratio after all the processing.

Encoding and modulation

The output of the stereo mixing board was routed to a prototype Scientific-Atlanta model 6380 stereo encoder. Studio output video normally feeds a Catel VFMM 2000 FM modulator for transmission to the Prime Cable headend on 10th Street. Video was interrupted just before the Catel modulator and supplied to the stereo encoder, allowing it to sync the pilot carrier to the video line rate. The encoder contained the optional 4.5 MHz modulator, allowing it to modulate the composite stereo baseband onto a sound carrier, which was then added to the video for transmission. Following traditional microwave techniques, the sound carrier was added at a level of 0.1 volt peak to peak.

In order to provide monaural backup, the existing Catel sound modulator was fed with output from the mono mixer and remained on line. Had the sound transmission failed, an engineer at the 10th Street headend could have quickly reverted to conventional monaural sound. His services were not required.

The signal is widely distributed in the Atlanta area, but we show one path here because it is interesting for the amount of equipment involved. At the end of this path, we had set a stereo VCR to automatically record the program. We were gratified that the tape showed good stereo separation and signal to noise ratio after the signal underwent all of this processing.

Figure 2 shows a portion of the distribution path the Metrochannel 13 signal follows. The Left and Right audio were applied to a prototype Scientific-Atlanta Model 6380 BTSC encoder, as was the video from the studio switcher. The encoder included the optional 4.5 MHz audio modulator, which allowed us to add the audio to the video as a 4.5 MHz subcarrier. The audio was treated throughout the plant as a subcarrier, in order to reduce deviation errors and distortion (see reference 1). We strongly recommend this technique for handling audio wherever possible.

Video signal

The video signal with audio subcarrier was supplied to the Catel VFMM 2000 modulator normally used for signal transmission and transmitted to Prime's 10th Street headend on a dedicated trunk cable. Also in the Video Edition studio was a monitoring system consisting of an S-A 8550 set-top terminal connected to the normal subscriber drop and feeding a TV set as a monitor. We added a Model 6250 demodulator with an audio module we had modified to output the broadband composite stereo baseband signal. The demodulator fed a Sony consumer-

Finally, 15 amplifiers deep in North DeKalb's system, the signal was received in author Farmer's home.

grade stereo decoder which drove a pair of earphones. The output level from the demodulator was matched to that required by the decoder before installation (again see reference 1).

Tenth Street headend

The signal from the Video Edition studio arrived at Prime's 10th Street headend, where it was demodulated by a Catel VFMD 2000 and routed to the switching center, which could select the Video Edition studio or other sources to feed channel 13. As in the rest of the signal path, the audio accompanied the video as a 4.5 MHz subcarrier. At this point the monaural audio also was routed, but not used, and is not shown on the diagram.

From the switching center the signal was returned to the headend, where it was modulated onto channel 13 using an S-A 6350 modulator with wideband audio module. Use of this module is explained below.

The modulator normally accepts video and baseband audio from the switching center. Had the baseband audio been selected, the telecast would have been in monaural, so an engineer stood by at the headend to change the modulator to accept 4.5 MHz audio subcarrier with the video. Programming the modulator consisted of grounding terminal 13 on a rear panel barrier strip on the modulator. Terminal 13 was grounded as the program began and was ungrounded at the end.

The output from the modulator was routed to the headend combiner for distribution in Atlanta. It was also routed to an AML microwave transmitter for transmission to several hub sites and to the DeKalb headend at Avondale.

At the Avondale headend the signal was received and downconverted to channel 13, and then fed to an S-A 6250 demodulator. This demodulator was not modified for stereo, the normal sound subcarrier output having adequate bandwidth to handle the stereo signal. The demodulator was configured to add the 4.5 MHz sound subcarrier to the video by looping one video output through the audio subcarrier loop-through. At this point it was not necessary to provide for monaural back-up because, had the engineer at 10th Street reverted to the monaural mode, the monaural signal would have appeared on the subcarrier.

From the demodulator, the signal was routed through a test panel (not shown) and to an S-A 6350 modulator for distribution in DeKalb County by direct cable and by another AML hop. The signal looped through the modulator and was routed to a second Catel VFMM 2000 modulator, where it was transmitted to Telescript's North DeKalb CATV system on a subsplit intertie.

The signal from the intertie was received at North DeKalb's Chamblee headend and demodulated by another Catel VFMD 2000 demodulator. The signal was supplied to a third S-A 6350 modulator for transmission on that system.

Finally, about 15 amplifiers deep in North DeKalb's system, in Doraville, the signal was received in author Farmer's home and recorded on a hi-fi VCR with BTSC decoder.

Evaluation

Unfortunately, time didn't permit measurements to be made on the transmission system, so we are restricted to reporting subjective quality based on listening to the tape. Separation was quite good, with the limiting factor being direct pickup in the studio of the Left channel by a Right channel microphone and vice-versa. This could be determined by listening to the characteristics of the cross channel sound.

Signal to noise ratio was adequate for the type of show done and seemed to be similar to that experienced in monaural. Studio noise tended to be rather high, as expected for a show with many people in the studio. Considerable character generator buzz was noted, to the extent that use of the character generator was discontinued

Distortion wasn't noticeable, and a segment of music played at a segue sounded very good.

a few minutes into the program. We feel the source was probably overdeviation of the first FM link, which we did not have time to adjust. This may have also accounted for most of the transmitted noise noted. Distortion was not noticeable, and a segment of music played at a segue sounded very good.

Since we interfaced with the 6350 modulators at 4.5 MHz and were not using a SAP signal, it was not really necessary to substitute the wideband audio module. However, we wanted to try this new module in an actual system test, and we were cascading two modulators, with any distortion adding.

Differences

In this section we explain the differences between the normal audio module and the wideband module. This wideband module is needed when the modulator is used to accept a baseband stereo signal and when using a 4.5 MHz subcarrier with SAP.

Alternate audio allows switching to a second audio source if the option is installed. It may be used with stereo.

A modulation limiter option is available for mono sound, to prevent overdeviation of the audio carrier. This option should not be used with baseband stereo input because it will destroy separation (again see reference 1). The overdeviation detector has been modified in the broadband module, to include a 10 kHz low pass filter. This allows the overdeviation lamp to illuminate based only on the sum portion of a stereo signal, or on a monaural signal, both of which deviate 25 kHz. The modulator in the broadband module is substantially the same as in the older audio module.

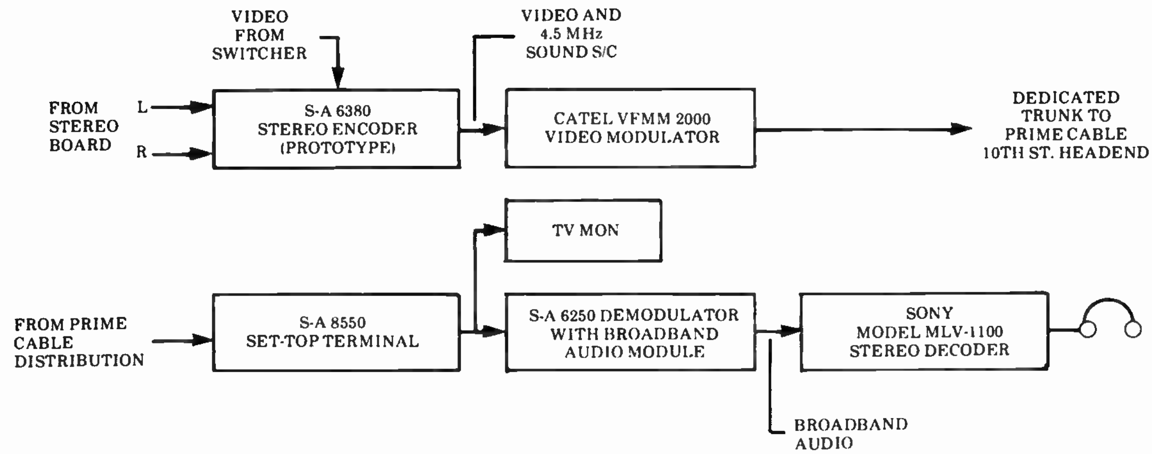
The 4.5 MHz subcarrier is supplied from the video modulator to a bandpass filter in the audio module. In the monaural module, this bandpass filter is not as wide as it is in the stereo module. It is sufficiently wide, however, to handle stereo if the SAP channel is not used. In the stereo cablecast, we did use the wideband modules as an experiment, but experience has shown the wider filter to be unnecessary if SAP is not carried.

The remainder of the module is identical in function regardless of the version. A switch, controlled by grounding terminal 13 on the rear of the modulator, selects either the internal 4.5 MHz modulated oscillator or the external sound subcarrier.

Conclusion

To gain experience with BTSC stereo in a real cable environment, we transmitted a stereo program over a hook-up involving three CATV sys-

Subjective evaluation indicated good stereo separation, adequate signal to noise ratio and no noticeable distortion.



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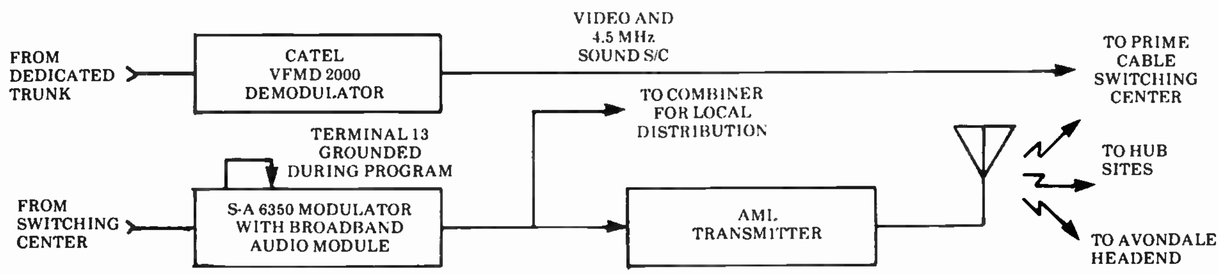
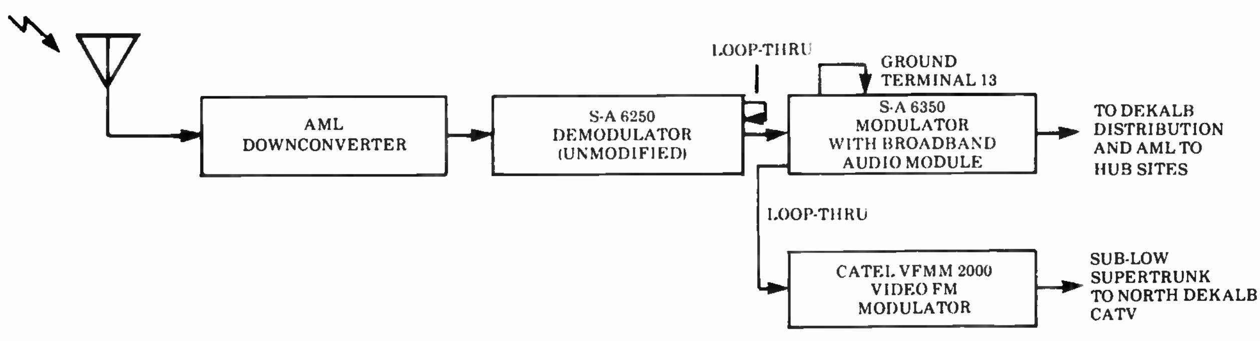
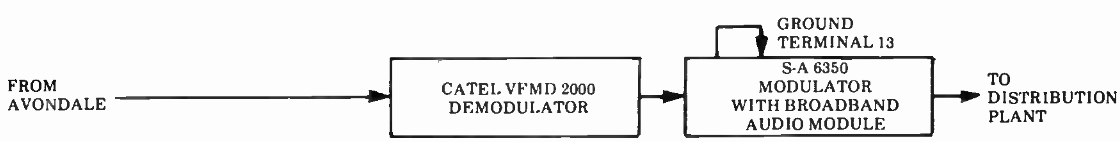


Prime Cable Atlanta Headend (10th Street)



Prime Cable DeKalb Headend (Avondale)



North DeKalb CATV Headend (Chamblee)

The maintenance of audio on a 4.5 MHz subcarrier is an important ingredient in maintaining the integrity of the audio.

tems under two different ownerships. The signal was transmitted more places, but this is the path we followed. The signal was processed as follows:

- Audio subcarrier added to video.
- Transmitted as FM on a supertrunk.
- Demodulated, routed to another building and back, then modulated onto VSB-AM for distribution.
- Transmitted via AML.
- Demodulated.
- Frequency modulated onto trunk.
- Demodulated.
- Remodulated onto VSB-AM for distribution.

Subjective evaluation of the signal demodulated and recorded at the end of this signal chain indicated good stereo separation, adequate signal to noise ratio and no noticeable distortion. An important ingredient in maintaining the integrity of the audio is the maintenance of audio on a 4.5 MHz subcarrier, which preserves the deviation set at the originating point. This is good advice for monaural transmission and even more important for stereo. We feel this experiment allows us to assert that the BTSC signal is suitable for transmission in a CATV plant, given that adequate care is taken to preserve the signal quality.

Acknowledgements

The authors express their sincere appreciation to all of the people who worked to make this telecast a success. Scott was very patient in allowing us to use his show as a test bed. His studio crew, Tony Marshall, Doug Congleton and others were most cooperative. Prime Cable allowed us access to their equipment and provided technical help. Dennis Evans, Tom Mersinger and others were very supportive. Guy Lee at North DeKalb Cable was very helpful in allowing us to work over his headend, too. Besides the authors, Scientific-Atlanta engineers Vic Williams and Lu Rovira were enthusiastic helpers. We borrowed the stereo mixer and limiter from radio station WREK.

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2. Best, A. et al, "Considerations in the Operation of CATV Headends Carrying BTSC Stereo Signals," *NCTA '85 Technical Papers*, page 130.
3. Farmer, J., "RF and Stereo," *CED*, December 1985, page 18. ■

Preparation now saves problems later

Preventing problems is the key to a successful rebuild, say experts.

Get your ducks lined up or risk laying an egg, say managers and engineers who are currently or getting ready to rebuild CATV systems. Among the feather-ruffling dangers: inadequate planning, failure to keep your customers and regulators up-to-date on progress and assuming that your contractors are doing things exactly the way you want. You may find yourself squawking if the company that does your pole attachments needs 90 days to finish your make-ready and you've got crews ready to go right now.

Want to minimize customer outrage as you do the cut-over to the new system? Things will be just ducky if you do all your splicing and trunk work between midnight and 6 a.m.; your feeder work between 7 a.m. and 5 p.m.; and no work at all during prime time, or on Saturdays or Sundays. "Be as transparent as possible," advises John Southard, general manager for Warner Communication's Bakersfield, Calif., system which is now in the initial stages of an 850-mile rebuild/upgrade to 400 MHz.

"No surprises" also is a good motto. "The biggest thing to understand is that the community has to know what's going on," adds Ron Barckhoff, regional manager for Adelphi Communications. "When people see your trucks out there, the phones are going to start ringing."

Things can really get sticky if the rebuild you're facing is your first, especially if it requires dramatically newer technology. That's the situation facing Richard Graham, manager of the Post-Newsweek Cable systems serving Denison and Sherman, Texas. He's got 380 miles to upgrade, primarily overhead except for 20 underground miles. It's 12 channels now and going to 550 MHz. He's also switching from push-pull to feedforward technology and is going with Zenith's Z-TAC system for addressability. A new on-line billing system also is part of the upgrade. The system already had AML and FM microwave links, but will need to activate an extensive I-net using one-inch supertrunk as well. And the systems are getting standby power for the first time. It's a lot to swallow.

"Even people who've been in the industry 18 years have learned something," says Chief Engineer Carl Spradlin. "Two years ago the technology wasn't advanced enough to let us do all this. We'd only have gone to 450 MHz."

Spradlin was lucky as far as make-ready. Tim Hall wasn't. Hall is plant supervisor for the Viacom systems in Red Bluff and Redding, Calif. He's rebuilding to 300 MHz from 220 MHz and needs to overlash one-inch cable at some trunk stations. Unfortunately, Pacific Bell requires that when this happens on more than two consecutive spans, the cable is re-engineered. "It's just like applying for a new pole attachment," he says. "We're trying to minimize the overlash, but it really can take 90 days from the time you apply until the engineering is finished. That can really slow you down." Hall's also doing his own make-ready, because Pac Bell charges $95 an hour.

And nobody knows better what a surprise make-ready costs can be than Ken Vickers, manager of the Jones Intercable system in Sebastian, Fla. He's just about finished with a 150-mile rebuild that went from 100 percent underground to 85 percent aerial, partly for ease and speed of construction, and partly because of the high acidity of the soil and high water table.

Vickers also had a problem because his strand maps and permits were not lined up early; something else for rebuilders to watch out for. "We had crews ready to go and couldn't because we didn't have our permits," Vickers says. "About 30 days lead should work."

Robert Gaboury, manager of Greater New England Cablevision in Ludlow, Mass., also recommends getting together with the utility people in the field. "Don't let it go to the head office—that's trouble. Also, watch out for hidden charges on contractor bids. Sometimes you don't pay close enough attention to labor costs and little things like taps and fittings."

Dex Sedwick, on the other hand, doesn't worry about hidden costs at all. But few operators can afford to be so casual. Sedwick is manager of the Armstrong Utilities system in Ashland, Ohio, and when he upgraded from 12 to 35 channels, he used Armstrong's own crews.

When possible, module change-outs are a good idea. Berny Masonis, chief technician at DuBois Area Cable TV in DuBois, Pa., did so a number times. In fact, he's rebuilt his system several times, switching amplifiers from vacuum tube to solid state; then to push-pull; then to broadband. He saved money by dropping in retrofit modules. But there are limits. He wants to take the system from 23 to 45 channels, and so the entire system is being upgraded, a process that should take four years.

Sometimes you don't know just how much it'll cost to rebuild or upgrade your system. Jerry Rotondo, manager of Cable TV Puget Sound in Tacoma, Wash., sure didn't. He was looking at 700 miles of rebuild, 60 percent aerial. Some of the plant was 20 years old, some brand new. The system had already been electronically upgraded to 270 MHz, but the latest upgrade would take the entire plant to 450 MHz. He knew what his direct bury costs would be, but not resplicing and repulling costs. So here's what he did.

He divided the plant into types: repull and conduit; aerial and underground; old and new. He started slow on actual upgrades of test segments of each type. That way he was able to generate accurate cost estimates for each type of plant. Right now he's got 60 to 70 miles finished, and is using a combination of AML and feedforward to span the longest runs.

Sometimes, though, operators choose to install feedforward throughout a sytem, not so much to handle long cascades but to improve reliability of the system. Brian Wade is the regional engineer at United Artists' Walnut Creek, Calif., system. He's getting ready for a 200 mile rebuild, 50 percent aerial and 50 percent undergound.

Jim Robinson, technical supervisor at UA's Tracy, Calif., system, also is "crazy about feedforward. When we ran push-pull we had lots more maintenance because the condition of the cable makes such a big difference. The levels would always change and we'd

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A rebuild is harder than a newbuild because of existing routes and subscribers.

have to go out and tweak, compensate and reset the amps all the time, because bad cable doesn't stay constant." He likes feedforward because, relatively speaking, it's distortion-free.

If anything, a rebuild is harder than a newbuild. You've got existing routes that have to be considered, and existing subscribers who have to be cut over to the new system. Some disruptions are inevitable, and that's why communication is so important.

William Vail has a different problem. He's regional manager for Centel Cablevision's Aurora, Ill., system, and is looking at cable-ready TVs and VCRs as his biggest headaches. "We're a trapped system now but are going with Z-TAC because we've got a high theft problem. That's going to cause problems with our cable-ready TV customers." He's also got a remote control problem, since a Z-TAC remote will be added to the customer's collection. And then there's the problem of recording one pay while watching another. That'll take two converters. So what's he going to do? "Just be open and honest about our need to secure the system," he says.

—Gary Kim

Tips for rebuilding a system

Before you start, make sure you've got accurate as-built maps, including: cable routes; location of all existing electronics, passives and taps; MDU inside wiring (where and how much); power supply locations; connector types and operating levels; existing and potential home passings; and exact cable mileage. After you're sure that as-built maps are right, make a physical inspection of the plant so you know what you can salvage and what can't be saved.

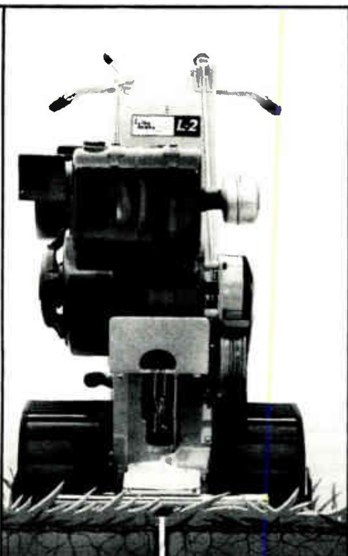
It probably isn't wise to upgrade too far—don't jump a 12-channel system to 80 channels. Going from 12 to 23 or 32 channels can make a lot of sense. Sometimes, you can even squeeze a few more channels out of a 12-channel system without switching out the electronics by adding H, J, and I, depending on the amplifier and equalizer roll-off. Generally, the beats should fall outside of band.

Also, remember that channel expansion may require new converters and better security. Both will cost money. In low-churn situations with few pays, traps might be an answer. But in high-churn and many-pay environments, converter/descramblers will be better. If you're using traps, do you want block conversion or single-channel output? If using scrambling, you must choose between single-mode and dynamic mode. And don't forget addressability if you've got high churn and multiple service levels are planned.

More channels will require more headend equipment, so check on space available in headend buildings and racks. Heating, cooling and powering also are important. And you'll need more land for additional receive antennas. Maybe multi-beam feeds will do. In some cases, new microwave hubs will be added. So don't forget to check the load-bearing strength of your existing tower.

If you're considering an upgrade, look for: ability to redesign without major re-routing or cable switchouts; passives that can handle the higher bandwidths; soundness of existing cable and ability of existing active components to handle the new frequencies.

When evaluating cable, start with the ages, types and manufacturer's specifications. If you've got styrene foam dielectric, corrugated or braided sheath, it should be replaced. Solid polyethylene or chemically foamed polyethylene dielectrics probably can be used up to about 35 channels. Medium-age cable using gas-injected polyethylene or air dielectrics can handle 40 channels. Newer gas-injected and air dielectrics can pass more than 40 channels. If your existing cable seems



When evaluating the trunk, double check your service area boundaries for potential growth of additional subscribers.

capable of handling the new bandwidth, make sure you test it in the field for attenuation and return loss across the entire proposed bandwidth.

When evaluating the trunk, double check your service area boundaries. If you're expecting growth, you've got to leave room for the additional subscribers. Your maximum trunk length must incorporate the end-of-line specs at the proposed bandwidth with the future subscribers loaded on. If not, then additional hub sites are needed.

Assuming the trunk length isn't a problem, you need to examine a trunk map and space your amplifiers at the highest operating or expected frequency. To double check on whether your spacings are correct or not, measure the inputs and outputs of every trunk amplifier in the system. That'll tip you off to defective cable or actives, faulty design or construction. Once you're satisfied that the spacings are right, you can convert the spacings to dB at the highest frequency to be passed. Now you can determine whether existing amp locations are okay.

When evaluating the distribution portion of your plant, three concerns are paramount. Can line extenders and passives stay where they are? Do you need more trunk? Do you need more cable? Pick a cross section of your plant—distribution samples representing various subscriber densities, ages and trunk cascades—for a sample test. Redesign each sample section at the new bandwidth, using the existing passive locations. Change only the levels, gains and tap values. Does it work? If not, see whether new trunks will solve the problem. But don't stop there. You still want to compare the cost of putting in the new trunk versus running more feeder.

When looking at actives, plug-in modules should be considered when it's possible to do so. Maybe the existing modules can be upgraded. If high performance is desired, then you ought to look at feedforward or power doubling technology.

Splitters, couplers and taps need to be checked to make sure they really can pass the higher bandwidths you want. Check through loss and tap loss across the full new band; flatness of the response; port-to-port isolation and ability to pass 60 volt and 30 volt power without excessive hum. And don't forget the connectors. Check shielding and return loss, because if your existing connectors don't measure up, the additional cost of splicing may outweigh the savings you gain by leaving the existing passives and taps in place.

Higher-gain amplifiers also will draw more power, so don't neglect your power system. You might need more supplies, or 60 volt units.

Check the physical integrity of the amplifier housings. You're looking for water leakage, thermal dissipation and RFI leaks. There's no point in putting new modules into defective housings. You might as well get new mainstations.

Feeder cable loss shouldn't normally be a big problem. But check for physical problems and attenuation at the new upper bandwidth. Are line extender locations okay? Do you need to re-space them? Check power supply loading. Are your existing LE cascades greater than two? See if you can reduce them. Otherwise, distortion and AGC problems can result.

And check tap output levels at the new upper bandwidth and channel 2, with new bridger and LE levels and locations. Are output levels sufficient for all subscribers, particularly if you have many multiple outlets. Generally, tap outputs need to be at least 2 dB higher at 300 MHz than at 216 MHz, and 3 dB higher at 400 MHz.

Also, reverse feeder tilt and converter overload in LEs, not needed at 216 MHz, are needed at 300 MHz and above. All new drops, taps, passives and amplifier housings should have new connectors with RF sleeves. And as long as you're putting in new connectors, check taps and passives. You might as well replace them now if they're getting borderline.

—Gary Kim

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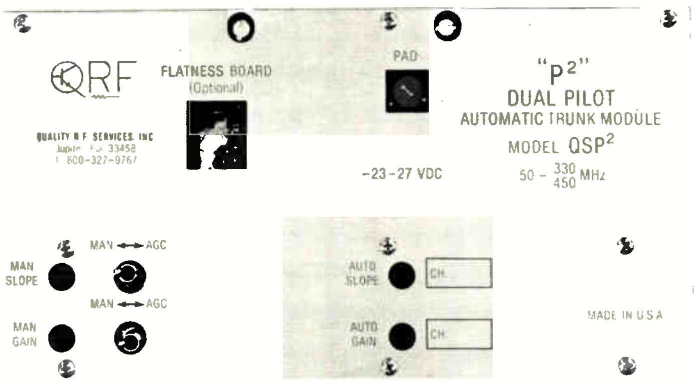

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Flatness	± dB	0.2	0.2	0.2	0.2	0.25	0.25	0.25	0.25
Min. Full Gain	dB	29 or 30	29 or 30	29 or 30	29 or 30	30	30	30	30
Gain Control Range	dB	8	8	8	8	8	8	8	8
Slope Control Range	dB	-1 to -7	-1 to -7	-1 to -7	-1 to -7	-2 to -8	-2 to -8	-2 to -8	-2 to -8
Control Pilots ASC: Turned to Ch.		"Q"	"Q"	"W"	"W"	"W"	"W"	"W"	"W"
Oper. Range	dB	Selectable	Selectable	Selectable	Selectable	Selectable	Selectable	Selectable	Selectable
AGC: Turned to Ch.		4	4	4	4	—	—	—	—
Oper. Range	dB	Selectable	Selectable	Selectable	Selectable	Selectable	Selectable	Selectable	Selectable
Return Loss	dB	16	16	16	16	16	16	16	16
Noise Figure	dB	6	6	6	6	6	6	6.5	6.5
Typical Oper. Level	dBmV	34/30	34/30	34/30	34/30	35/30	35/30	35/30	35/30
Distortion at	C/CTB	-93dB	-88dB	-92dB	-87dB	-91dB	-86dB	-89dB	-84dB
Typical Oper.	XMod	-94dB	-89dB	-93dB	-88dB	-91dB	-86dB	-89dB	-84dB
levels	2nd order	-85dB	-82dB	-85dB	-82dB	-85dB	-82dB	-85dB	-82dB
DC Requirement at -23 VDC	mA Note 1	630-730	420-500	630-730	420-500	650-750	430-500	650-750	430-500

Note 1: DC requirements are stated as typical to maximum.
Note 2: Specifications should be referenced to the modules, not the connector chassis.

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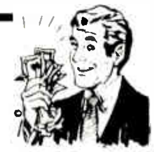

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In the low frequency analysis of the transformer, the series impedence of each half of the bifilar winding is donated by Z.

Continued from page 36

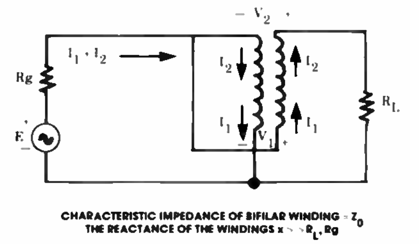

FIGURE 15
Transformer schematic

[3] G. Guanella, "New method of impedance matching in radio frequency circuits," *Brown-Boveri Rev.*, vol. 31, p. 327; 1944.
[4] A. I. Talkin and J. V. Cuneo, "Wide-band balun transformer." *Review of Sci. Inst.*, vol. 28, No. 10, pp. 808-815; October, 1957.
[5] C.A. Burrus, unpublished memorandum.

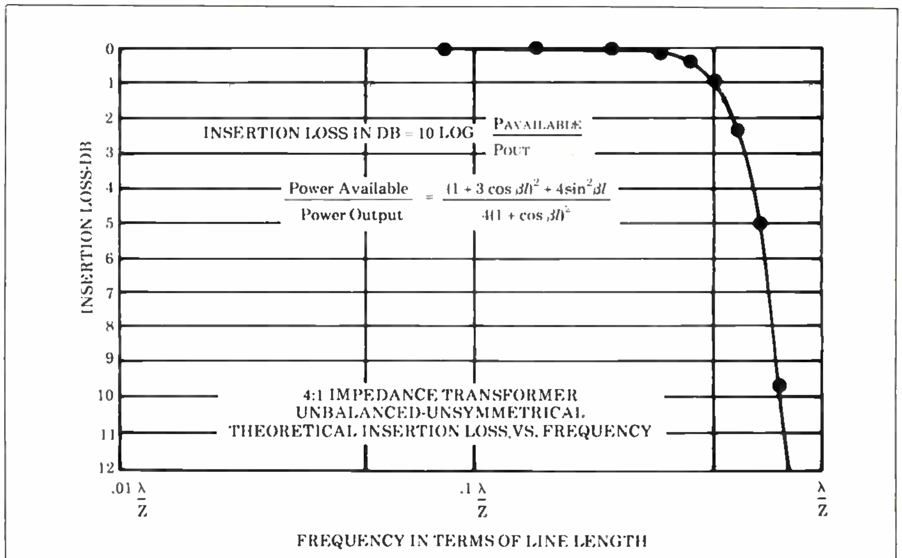

FIGURE 16
Theoretical insertion loss vs. frequency

Advertiser's Index

Viacom uses LAN advantages

"Star Wars" director George Lucas uses plenty of planetary electronics to produce his intergalactic effects. He also uses a broadband local area network to tie his special-effects gear together. Air freight giant Federal Express also uses a broadband LAN at its Memphis, Tenn., national distribution center to link terminals to mainframes. Both networks were installed by Viacom Telecommunications, a new company specializing in private communication systems using CATV-type, microwave and fiber optic technology.

Operating at present with four full-time personnel at its Pleasanton, Calif., headquarters, the firm operates nationally, drawing on technical personnel working at Viacom cable systems. The company also takes advantage of volume purchasing available to it as a large MSO. Within the next year, Viacom Telecommunications expects to open regional offices in southern California, Texas and Colorado.

And in a few years, the company expects to be a major LAN industry player. VT recently was certified to install the IBM cabling system, and expects to work closely with baseband LAN vendors moving into broadband technology. In cases where a client wants a VSAT capability as part of a network, VT works with companies like Equatorial Communications or Vitalink. "We try to work co-marketing agreements with manufacturers," says Dave Archer, general manager.

It appears to be the only CATV MSO with plans this ambitious. Aiming at Fortune 500-type companies and soliciting business primarily through direct mail and in-person sales calls, the company does turnkey installations on an original basis, or it can modify an existing network already in place. There seems to be plenty of room for both types of business.

The company has some significant advantages in a field crowded with competitors, some of whom have overpromised on what they can deliver. Wary customers often are put at ease because "we're part of a $1 billion a year corporation," Archer points out. "That gets our foot in the door." Viacom also has the advantage of familiarity with a variety of technologies, ranging from microwave and fiber optic nets to CATV and telephone-type gear. The company's already been involved with data communications and network construction. Too, many end-users and manufacturers from a baseband environment don't really understand broadband technology, and can use an experienced partner.

George Lucas and Federal Express have one thing in common. They both used Viacom to install their broadband LAN networks.

There are financial advantages as well. Obviously, the company can take advantage of purchasing economies of scale through its affiliation with Viacom Cable. But that's not all. "Our agreement with Federal Express was more than an inch thick," Archer says. Part of the reason is that large corporate buyers want legal protection, insurance and bonding, all of which VT got easily, since it's affiliated with a major corporate parent.

Government jobs also require the bonding and insurance protections, and many small companies simply can't get them.

VT has another advantage in the design area—an advantage that can save a customer money. "We've always had to design and work with our own money; not somebody else's," Archer says. So, often, VT can save a customer money by building a simpler system with fewer amplifiers, for example. Viacom, remember, pioneered the use of bridger switching, "for which there is amazing demand," Paff says. Status monitoring is another hot item. On the other hand, systems are sometimes oversold, Archer adds. "End-users sometimes insist on pilots, although a three-amplifier system doesn't really need it." So VT will always break out the cost of those bells and whistles for a client who really wants them. "Sure, we can build hot standby systems, but is it worth the money in every case?" Paff asks. "It just depends on the application."

The company isn't technology-specific, as much as it is comfortable with the capabilities broadband possesses. If a client wants microwave or fiber optics, TV will build that type of a network. But that isn't to say fiber optics is a better choice today. "I question whether fiber optics really is a good replacement for broadcast in most LAN applications," Archer believes. "It's fine for long-distance applications, but is a baseband approach really the best in a factory? I think we'll see lots of parallel systems, depending on what the need is."

And despite the differences between CATV-type outdoor construction and the demands of the LAN environment, VT hasn't run into too many problems. "There hasn't been a fear that we'd ride up in a bunch of bucket trucks," Archer says with a laugh. "And many of our jobs are in factory-type environments, where amplifiers really need the protection provided by the outdoor-type amp housings," he adds.

And unless a system is really big, "you usually don't need that many actives," Paff adds. Costs per drop for broadband now are roughly comparable with baseband. A typical quote would be $800 a port for broadband and $600 a port for baseband. About half the cost of a system is tied up in terminal equipment. The other half is the medium and associated actives and passives. And although many clients aren't initially interested in installing broadband when perhaps a twisted pair network will do, relocation costs can quickly change the economics.

And while VT distances itself from Viacom Cable, there's no question Viacom's earlier experience with I-nets and video has helped.

"We're a packager of products and services," Archer emphasizes, ready to install the network a user wants. In fact, while he's talking with us, the phone rings. It's a pizza parlour owner, unhappy with the $10,000 costs he's been told he'd have to pay for cable service. Paff gets right on the phone, offering a quote in the vicinity of $3,500 for an operational SMATV system. "Quality and cost effectiveness" is the name of the game, Paff says. "If we can't do something, we say so." You can probably guess that the converse is true as well. If Viacom Telecommunications says it can do something, don't bet against them.

—Gary Kim