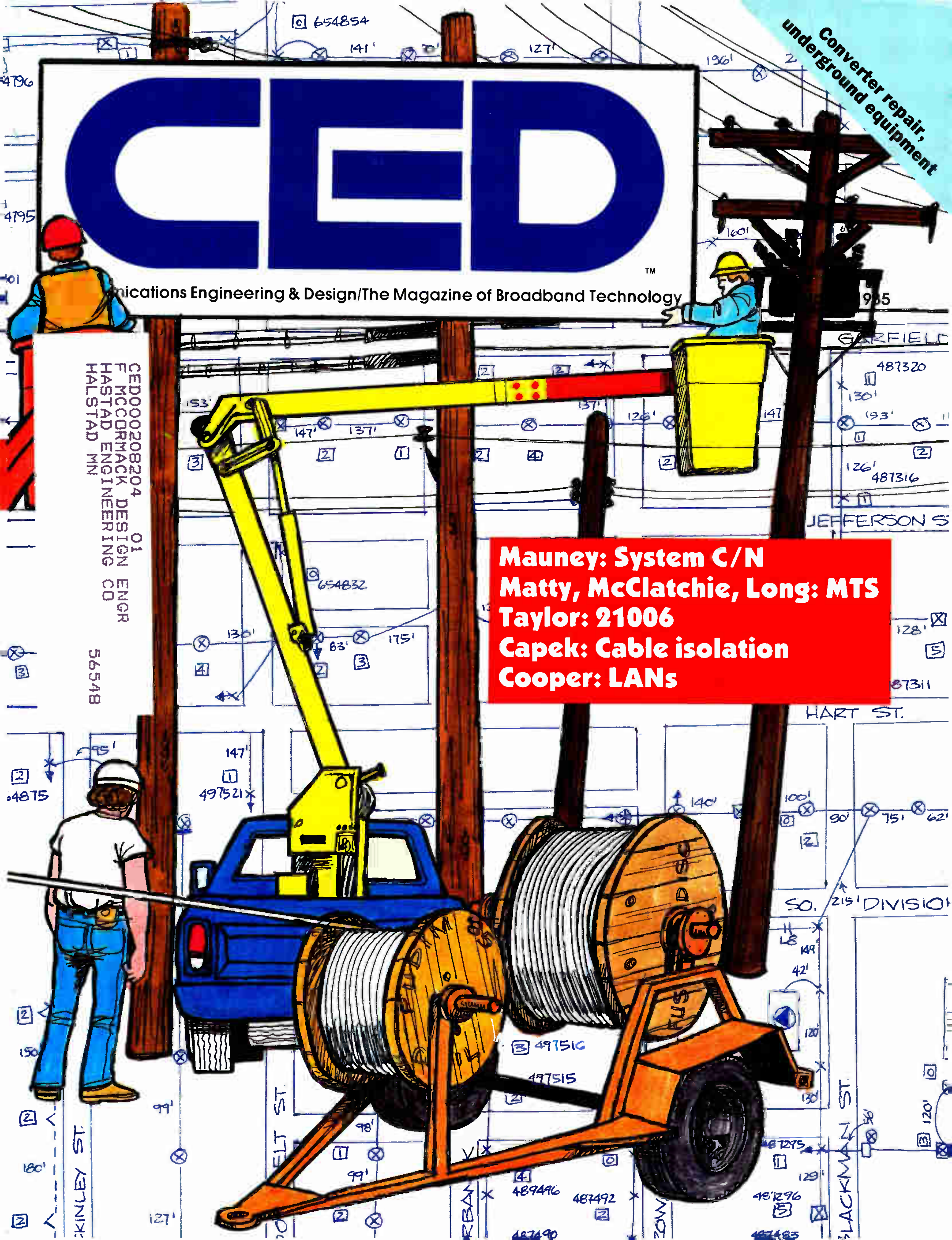
# CED™

...nications Engineering & Design/The Magazine of Broadband Technology

**Converter repair, underground equipment**



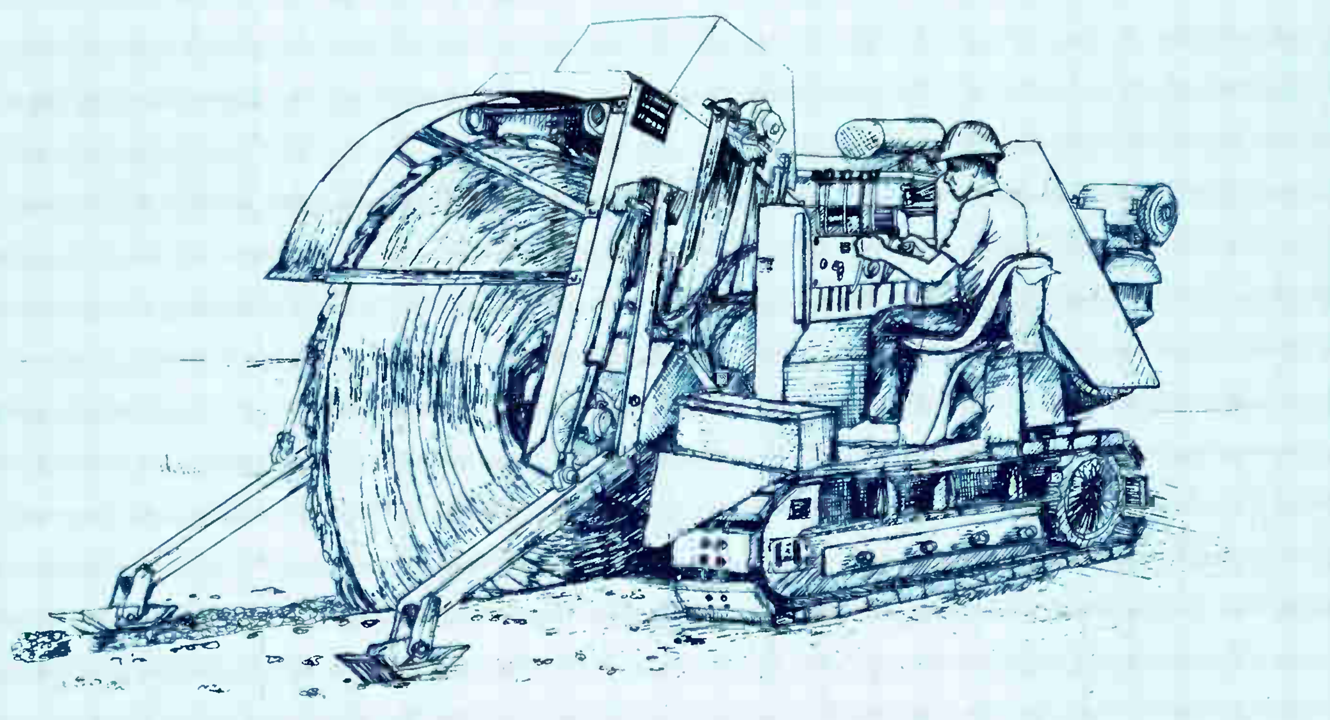

**Mauney: System C/N**
**Matty, McClatchie, Long: MTS**
**Taylor: 21006**
**Capek: Cable isolation**
**Cooper: LANs**

Reader Service Number 2

# CED™

March 1985





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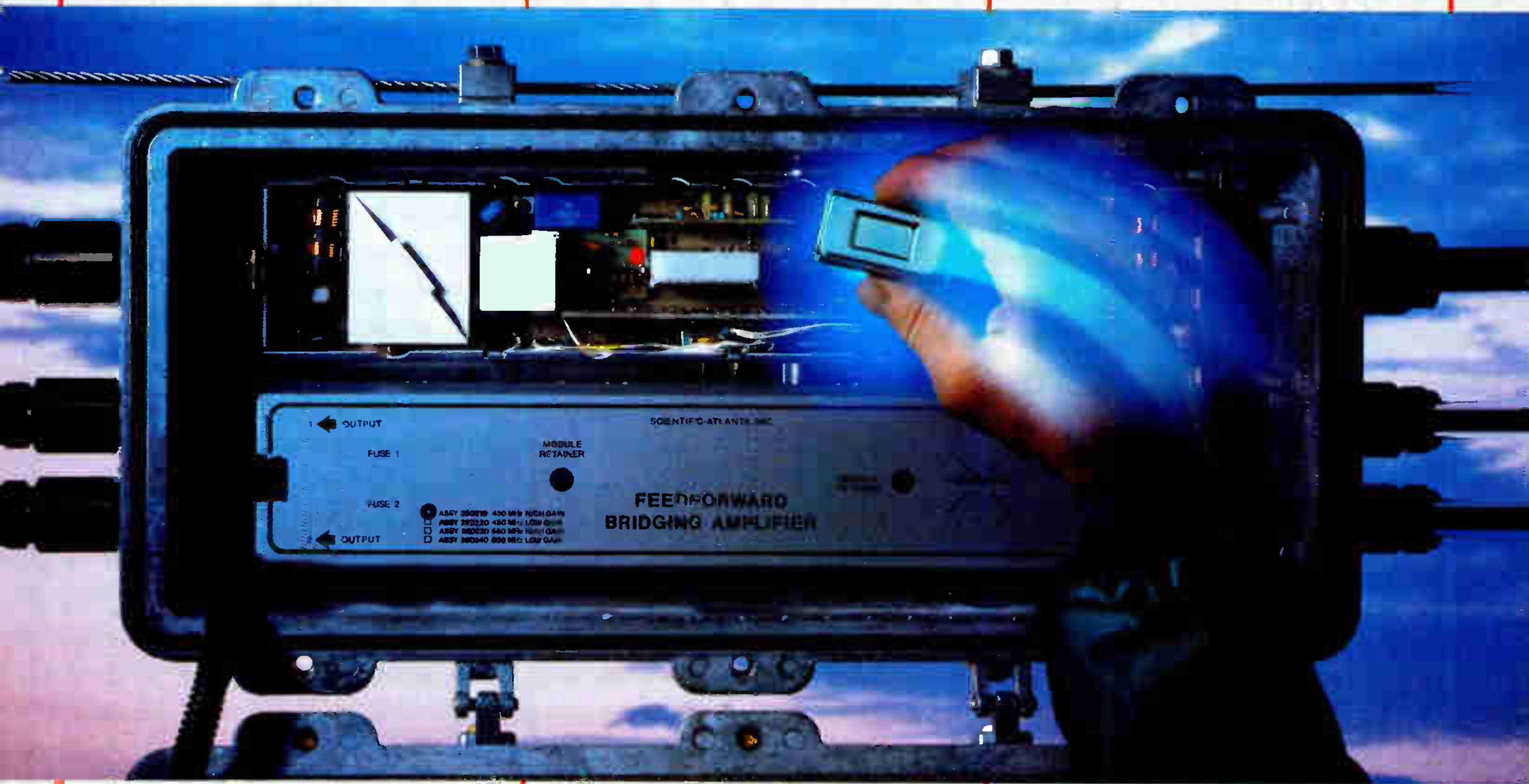


# FEEDFORWARD AMPS BY SCIENTIFIC-ATLANTA. ON-LINE SERVICEABILITY, IN A SNAP.

## FEEDFORWARD GAIN BLOCKS MAKE BACK-TO-THE-FACTORY SERVICE OBSOLETE.

Which feedforward amplifier is easier to service–the one that must be removed from the line, brought back to the bench, tested, and probably sent back to the factory? Or the amplifier that can be tested on-line, and, if necessary, simply opened, serviced with a snap-in replacement module and closed.

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Feedforward Gain Block isn't the whole story, either. Our feedforward amps are more than just unmatched modularity and serviceability. You'll find superior heat dissipation and resulting longer operating life, plus highly effective lightning and surge protection, ultra-stable AGC and dependable stepped pads and equalizers.

With Scientific-Atlanta, you will get the most out of your distribution electronics.

For more information about Scientific-Atlanta's feedforward distribution amplifiers, clip the coupon or call Pat Miller at (404) 925-5462.

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**CED 3/85**

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**Reader Service Number 3**

# Alex Best

Multichannel sound. Just the mention of it can throw system owners and operators all over the country into a panic. Heart rates go up, brows begin to perspire, stomachs start to stew and visions of red ink become the stuff that nightmares are made of. Then along comes the calming, soft-spoken Alex Best, manager of research and business development at Scientific-Atlanta, speaking out in his low-key, Southern way at an NCTA Engineering Committee meeting about some of the actual problems that headends are likely to have with stereo transmission.

Because of his steadying insight into such a volatile issue, Best was asked to chair the NCTA Ad Hoc Subcommittee on Multichannel Sound in August of 1982. He accepted the position, and the results of his committee's report undoubtedly influenced the FCC's January decision not to force CATV systems to carry multichannel sound at present.

"When all was said and done, the FCC could not ignore the fact that our data was solid, reliable, accurate and presented in a professional way," stated Wendell Bailey, NCTA science and technology vice president. "They just couldn't find fault with our data—thanks to Alex's management of the project and his excellent understanding of the issues inherent to MTS."

Best's subcommittee documented, through extensive laboratory tests, the nature and extent of problems the industry would have in transmitting stereo sound over cable. "Alex is one of the best people we have ever attracted to the NCTA Engineering Committee," Bailey added. He has an understanding not only of the technologies, but also of the nuances of business decisions that surround them. He really is a jewel and a terrific find."

Scientific-Atlanta seems to agree with Bailey's assessment of Alex Best. He was hired by the company in 1966 as their first "cable-only" design engineer. Since that time, Best has worked extensively on the development and design of headend equipment for cable systems. His efforts earned him the NCTA's Outstanding Engineering Achievement Award for Development in the Cable Industry in 1977. After completing Harvard University's Program for Management Development in 1980, Best assumed the role of manager of research and new business development for the Communications Products Group at S-A.

What about the future of cable? "I have never seen the industry faced with as challenging a task as we now have in front of us—to continue to coexist from a regulatory standpoint and also in terms of the peripheral consumer devices that are coming into being. The original goal of cable TV was simply to be an entertainment pipeline to the consumer. But as the interface devices change and the regulatory and technical issues on the input end change, it is becoming tougher and tougher to remain just a window," Best declared. "Staying on top o; all the new technologies, while trying to remain compatible with the available consumer devices, and keeping an eye on the new regulatory processes, yet *still* serving as just a pipeline for entertainment is incredibly difficult."

No one can question that cable engineers have some long nights ahead of them. The past year has brought a myriad of complex and serious issues to the forefront of the cable industry. Can cable handle the pace? "Naturally, I believe we can and must," Best asserted, "But it is going to be very interesting and exciting to see exactly what happens. Only one thing is for certain—there has never been a more exciting time to be involved with cable television."

Amidst the confusion, one other fact also becomes clear—never before has cable so desperately needed engineers with the acumen and determination of Alex Best.

—*Lesley Dyson Camino*

# HOW TO TAKE THE RECALL OUT OF THE INSTALL

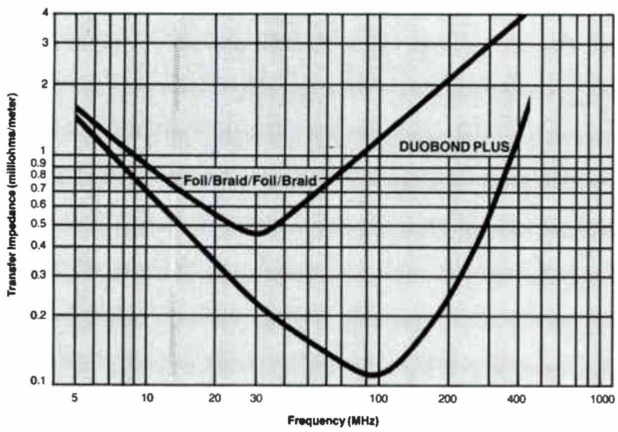
Belden's drop cable with DUOBOND PLUS™ shield helps you prevent costly call-backs. It's also the most shield-effective drop cable in the CATV industry.

**Easier termination for maximum shielding integrity.**

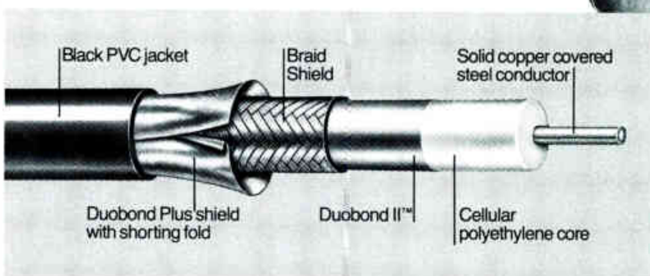
The DUOBOND PLUS shield features a foil/braid/foil construction with a shorting fold in the outermost foil which provides superior shielding effectiveness to typical 4-layer shield constructions. The transfer impedance graph demonstrates this effectiveness.

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.

When it comes to shielding effectiveness and ease of termination, there is <u>no</u> equal to Belden in the CATV industry. Take the recall out of your install. Call Belden today for more information and a free CATV catalog. Belden Electronic Wire and Cable, P.O. Box 1980, Richmond, IN 47375. Phone: 317-983-5200.

**There is no equal.**

Reader Service Number 4

COOPER INDUSTRIES **BELDEN**

# Thoughts on 21006

*By Archer S. Taylor, Malarkey-Taylor Associates*

My first thought on reading the FCC Second Report and Order in Docket 21006 was to yearn for the days when the FCC could boast of such outstanding engineers as Ken Norton, Harry Fine, and Wally Johnson and technical staff who understood cable TV as well as Cliff Paul and Sid Lines.

My second thought was to remember that Dr. Robert Powers is now the Chief Scientist at FCC. Some of you may recall that about 1970, as chairman of the IEEE Coordination Committee on Cable Communications Systems, I appointed Bob Powers chairman of a subcommittee to investigate the matter of aeronautical interference from cable TV systems. Sid Lines, staff engineer in the FCC Office of Chief Engineer and a member of the subcommittee, reported that FAA had requested that FCC prohibit the use on cable TV systems of any carrier frequencies in the bands 108-136 MHz and 225-400 MHz. FCC staff did not agree, and the FCC Cable Television Report and Order of February 1972 did not place any restrictions on the use of the aviation service frequencies.

The objective of the IEEE subcommittee, headed by Dr. Powers, was to ascertain under what conditions, if any, it would be possible to assure, with reasonable certainty, that harmful interference to aviation radio would not occur. This was an issue shrouded in sensitive emotions that tended to obscure reason. Garth Kanan, FAA, told the committee that he had "seen" our advertisements claiming as much as 250 watts (103 dBmV!). In one of the later sessions, in the White House Office of Telecommunication Policy (OTP), representatives of one of the pilot groups insisted that they wanted nothing less than "zero probability" of interference. Not only does "zero probability" not exist in mathematics, but pilots have not been nearly so concerned about interference from a great many other sources.

By this time, Bob Powers had moved from the Department of Commerce Office of Telecommunications (now known as NTIA) to the FCC Cable Bureau, and his authority in negotiations therefore extended beyond that of chairman of an IEEE subcommittee.

Delmer C. Ports, NCTA Director of Engineering, also was a member of the IEEE Committee. Delmer's efforts on behalf of the industry were so demanding and his involvement so intensive, that shortly after the convention at Anaheim in 1976 he suffered a near-fatal heart attack. Two years later, we lost him.

The FCC rules originally codified in Section 76.610 in 1977 were the result of almost continuous negotiation on behalf of the cable TV industry by Bob Powers, Delmer Ports and others. If the 60 nautical mile protected radius, $10^{-5}$ watts power limit, and 100 + T kHz offsets seem excessive, you only have to compare them with the alternatives: "zero probability of interference," and absolute prohibition of the use on cable of any carrier frequency in the 108-136 MHz and 225-400 MHz bands.

But Bob Powers did not stop here. He had earlier arranged for the Department of Commerce to have its Boulder Laboratory investigate the vulnerability of VOR and ILS systems to the kind of interference that could be caused by a defective cable system. That work was done in 1973-1975, and three interesting reports were released. Then, in 1979 a special FCC Advisory Committee was formed, with participation by highly qualified engineering personnel from FAA, FCC, the Department of Commerce and the cable industry. Bob Powers and Ralph Haller, of the FCC Field Operations Bureau, served as co-chairmen.

The Final Report of the Advisory Committee, necessarily statistical in nature, included several significant findings and important recommendations:

- The phenomenon of "phase addition," as compared with power addition, had been cited by some aeronautical people as a potential horrible. It was not observed by the Advisory Committee, and the possibility was discounted in its Report.
- Aural carriers on cable were found to be unlikely sources of interference.
- The leakage threshold should be increased to 100 uv/m at 10 feet from the present 20 uv/m.
- Power levels of $10^{-4}$ watts (39 dBmV) are at the limit of detectability in the airspace.

As a matter of practice, not yet codified in the Regulations, FAA has been consenting to waivers based on the limit service volume of some aeronautical facilities as well as frequency offsets much less than 100 kHz.

In 1981, through the good efforts of Cliff Paul, FCC proposed to amend Section 76.610 closely, but not quite, following the recommendations of the Advisory Committee. Triggered by a

*Continued on page 22*

# Return Path

## Tap trap

I would like to take this opportunity to commend you on the fine job that you and your staff have done in turning *CED* around. Our faith in your publication is evidenced by our resumption of advertising.

However, I must also address a problem with the Product Profile on Directional Taps in the January 1985 issue. In reviewing the participants, I came across a listing for Macom "Tru-Spec" Taps. The problem with this is that they are 5-900 MHz and Non-Power Passing! Therefore, they have no place in this listing.

***Lee Heller***
***Marketing Coordinator***
***RMS Electronics Inc.***

*Lee's right. We goofed.*

## Counting kHz

Congratulations on your January 1985 *CED*. In that issue, the discussion on multichannel sound is very informative. The cable operators should include the ability to offer such signals so that the subscribers will not think of dropping cable service for off-air signals. After all, how else can they make use of the new top-of-the-line television receiver they just bought?

In Brian James' article, he overstated the aural carrier bandwidth slightly. Using Carson's rule of twice the deviation plus twice the highest modulation frequency for 98% of the signal power is true for *wideband* FM. The "professional channel" contributes only 3 kHz deviation, while its subcarrier frequency is centered at 102 kHz. Therefore, the second sideband will be less than 1% of the signal power.

The "second audio channel" whose subcarrier frequency is centered at 78.75 kHz, with the highest frequency component at 98.75 kHz, deviates the main carrier by 15 kHz. Even the second sideband of this FM audio program channel is approximately 50 dB down since its deviation ratio is only 0.15.

Counting all the signals in multichannel sound, a better occupied bandwidth figure is about 210 kHz, instead of 386 kHz as stated by Brian James.

***Joseph Garodnick, Ph.D.***
***Chief Scientist***
***Phasecom Corp.***

*Continued on page 90*


Reader Service Number 5


Reader Service Number 6


Panasonic
58
CHANNEL
ON/OFF

Volume 11, No. 3

CED

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# Torpedoes? What torpedoes?

A fine line separates reckless abandon from calculated gamble. The difference often depends on whether or not the gamble pays off. In August 1864, David Glasgow Farragut took the risk. At the battle of Mobile Bay, he ordered his sailors to press an attack with the command: "Damn the torpedoes—full speed ahead!"

We at *CED* recently got a glimpse of how Farragut's sailors might have felt at Mobile Bay. The occasion was our annual editorial board meeting. Aside from their other deliberations, our consulting engineers raised an issue certain to give every publisher and national sales manager in the industry pause.

The issue was advertising integrity and standards. The problem is accuracy. From time to time, it seems, ads have run in the cable trades that are either false or misleading. (This is where Sales Manager Cathy Wilson's face begins to turn pink.) Our engineers were uniformly opposed to the practice and vocal in their belief that such ads have no place in *CED*. (Now Cathy's ears are heating up and the color in her cheeks is more akin to scarlet. She has visions of ads blowing away like tumbleweeds. Meanwhile, the publisher begins to squirm. He has visions of red ink dripping from his bottom line.)

Still, Wendell and the others press on. Engineers aren't stupid and, furthermore, they talk to each other. Most embarrassed of all, it turns out, are engineers associated with firms running such advertising. It's hard to face one's colleagues under such conditions.

The discussion continues. There has to be more advertising integrity in the industry and somebody has to lead on this. We can hear the shots and see the geysers splashing now. (Cathy's eyes are the size of silver dollars.)

It's a matter of leadership and responsibility, the board says. It's something the industry needs and will benefit from. Well, they're right, of course. So we're going to play sailor to our board's Farragut.

We're going to ignore the torpedoes and press ahead with a new advertising policy. It's simple. We won't run any messages that we know are misleading or false. It doesn't happen very often, fortunately, and we suspect the rare problems will be easy to rectify. We hope so, and so does our board.

But enough of potential torpedoes. We think you'll agree with us that this is the best, in fact, the only policy worth putting our names to.

And on the subject of names, we are proud to add a few here at *CED*. You'll recognize them.

Joining our board of consulting engineers is Bob Luff, senior vice president of engineering at United Artists Cablesystems. Among his long list of accomplishments and honors is chairmanship of the NCTA Engineering Committee. We're pleased to have the benefit of his insight and counsel. I'm particularly happy because Bob has provided me with critical intellectual sparks before—and sparks can start prairie fires.

Also joining us is another well-respected engineering talent whose thoughts and opinions have heavily influenced the way our industry goes about its work. Beginning with this issue, Archer Taylor will be speaking his mind monthly in a new column called "My Turn." That it is, and we hope you'll be looking forward to his commentaries as much as we are.

Gary Y. Kim

# CATV system C/N analysis

*By Bob Mauney,*
*Application Engineering Manager,*
*Video Communications Division,*
*Scientific-Atlanta*

In a cable television system, the two most predominant factors affecting overall end-of-line picture quality are noise and third order distortion (composite triple beat noise or cross modulation).[1] Third order distortion is generated primarily in the distribution system, while noise is a factor of every component in the entire system. Although both noise and third order distortion are equally important, the following discussion focuses on noise, particularly the method of calculating system C/N performance.

A cable television system generally consists of the system components shown in Figure 1. Methods for carrier-to-noise performance calculations for the earth station system through the satellite receiver and the distribution system are well documented, with computer program C/N analysis generally available from many equipment manufacturers. The problem most often encountered by the system operator is how to combine these C/N ratios to determine overall system C/N performance. The first step in this process requires that all C/N ratios be expressed as numerical rather than dB values. The second step requires that the numerical power ratios be added, and the final step involves conversion back to a C/N dB ratio. An example of this process is shown below:

Assume: C/N Headend System = 52 dB
C/N Distribution System = 48 dB

Step 1. Convert to numerical power ratio:

$$C/N \text{ Headend System} = 10^{\frac{-52}{10}}$$

$$C/N \text{ Distribution System} = 10^{\frac{-48}{10}}$$

Step 2. Add numerical power ratios:

$$C/N_{\Sigma} = (10^{\frac{-52}{10}} + 10^{\frac{-48}{10}})$$

Step 3. Convert to C/N dB:

$$C/N \text{ dB} = -10 \text{ LOG } (C/N_{\Sigma})$$

Combining all three steps:

$$C/N \text{ Total System (dB)} = -10 \text{ LOG } (10^{\frac{-52}{10}} + 10^{\frac{-48}{10}})$$

$$= 46.5 \text{ dB}$$

Note that in the above example the resultant C/N ratio is less than the smaller of the two combined C/N ratios. Since this always holds true, a comparison of the resultant to the original numbers can add a degree of confidence that the result is valid. Moreover, the content of the above three steps can be expanded to include as many individual C/N ratios as required.

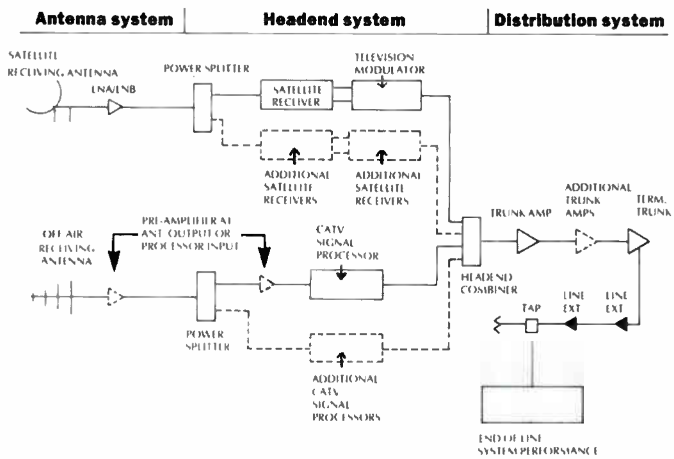
The above procedure seems simple enough and, indeed, it is if all noise performance numbers are given as equivalent NCTA carrier-to-noise ratios. This is not always the case but poses no significant problem if the numbers given are defined and, where necessary, referenced to a known standard. An example of this situation is the typical performance analysis data supplied by many of the earth station equipment suppliers. Figure 2 shows an IF C/N, a Video S/N and a VHF C/N. The problem many system operators encounter when given this data is knowing which number to use to determine overall system C/N. To remedy this, a brief explanation of each of these factors is in order.

The IF C/N is given so system noise margins above receiver threshold can be determined. As such, the IF C/N is not directly the number to be used in the overall CATV system C/N calculation. IF C/N, Video S/N, and VHF C/N are, however, all related. So selection of a specific IF C/N to establish threshold margin without analyzing its impact on Video S/N and VHF C/N can lead to overall system C/N deficiencies. This is especially true today where many system operators are using small diameter antennas to add satellite channels to the system. These small diameter antennas may provide adequate threshold margin but not provide a high enough Video S/N/VHF C/N to meet overall system C/N requirements.

The Video S/N is a baseband video performance parameter measured at the earth station receiver output. As with IF C/N, Video S/N is not directly the number to be used in the overall system C/N calculation. Because of the effects of noise on different picture elements of the baseband video signal, a Video S/N weighting standard typically is recommended. Presently, there are several weighting standards used in the satellite industry, but the one recommended for CATV use is CCIR Rec. 421-3. When Video S/N is stated, it should be stipulated whether it is weighted or unweighted; and if weighted, the weighting standard used should be specified.

VHF C/N is the earth station C/N number to be used in the overall CATV C/N calculation. The VHF C/N is derived directly from Video S/N and depends on whether the Video S/N number is weighted or unweighted and, if weighted, the standard used. If the Video S/N number is weighted using CCIR Rec. 421-3, the equivalent NCTA VHF C/N number will be 0.2 dB

**Figure 1**
**CATV system block diagram**



better. Variations for unweighted numbers and other standards can be as much as 6 dB.

Once proper C/N data for the earth station and the distribution system are acquired, the last requirement is C/N data for the headend modulator and combining network. Generally, modulator manufacturers' data sheets indicate that weighted CCIR Rec. 421-3 Video S/N is typically 60 dB. Translating this to the equivalent NCTA VHF C/N would yield an effective C/N number of 60.2 dB as indicated above.

Moreover, as long as the modulator output level is +55 dBmV or greater, the combining loss will have negligible affect on the modulator C/N. Therefore, the C/N number for the modulator channel at the output of the combiner is 60.2 dB, given that the modulator output is set for +55 dBmV or greater.

Finally, collecting and combining all the individual NCTA equivalent C/N numbers (per steps 1, 2 and 3) will yield the overall system C/N ratio as illustrated below:

Earth Station Channel's C/N = 46.6 dB
Modulator's C/N = 60.2 dB
Distribution System's C/N = 47.4 dB

$$\text{C/N for the Total system} = -10 \text{ Log } \left(10^{\frac{-46.6}{10}} + 10^{\frac{-62}{10}} + 10^{\frac{-47.4}{10}}\right)$$

$$= 43.9 \text{ dB}$$

The above total system C/N number would be the expected C/N on this particular channel at a location in the system that is 20 trunks, 1 bridger and 2 line extenders deep. Moreover, note that the total system C/N number is smaller than any one of the three individual C/N numbers. Therefore, the result is reasonable.

Also, the smallest individual C/N number is that of the earth station system, so the most dramatic improvement in the overall system C/N would be obtained by increasing the earth station C/N number to at least that of the distribution system. After reaching equal numbers for earth station and distribution, further improvement in either or both numbers would have the same magnitude effect. The existing earth station VHF C/N number could be increased by either using a lower noise temperature (LNC) or by using a larger antenna, as seen in the earth station performance report of Figure 2.

## Figure 2

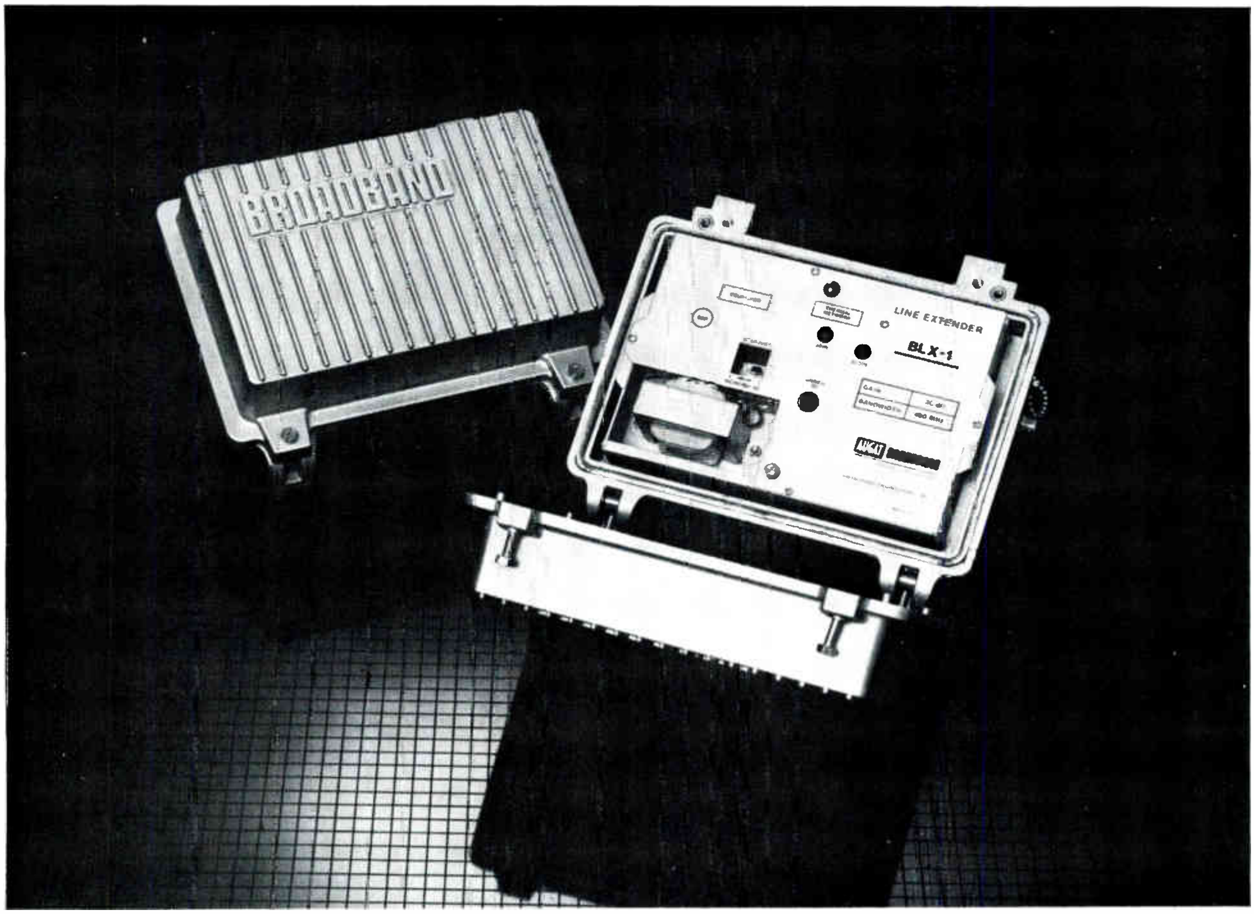
EARTH-STATION SITE: ATLANTA, GEORGI
Lat: 33,45, 0.0 N
Lon: 84,23, 0.0 W

SATELLITE: SATCOM 3R
Azimuth: 242.3
Elevation: 27.1
EIRP at site: 33.7 dBW

------EARTH-STATION COMPONENTS-----
RECEIVER Model: 6650
LEAD-IN Loss* : 15.0 dB

_SYSTEM PERFORMANCE SPECIFICATIONS_**

| ANTENNA: Model | Dia (m) | Gain (dBi) | + LNC: + model | T (K) | Noise T (K) | G/T (dB/K) | IF C/N | Video S/N | VHF C/N |
|---|---|---|---|---|---|---|---|---|---|
| 9028 | 2.8 | 39.5 | 360-1 | 120 | 148.9 | 17.8 | 9.0 | 46.4 | 46.6 |
| | | | 360-2 | 100 | 128.9 | 18.4 | 9.6 | 47.0 | 47.2 |
| | | | 360-3 | 90 | 118.9 | 18.7 | 10.0 | 47.3 | 47.5 |
| | | | 360-4 | 80 | 108.9 | 19.1 | 10.4 | 47.7 | 47.9 |
| 9032 | 3.2 | 41.0 | 360-1 | 120 | 147.9 | 19.3 | 10.5 | 47.9 | 48.1 |
| | | | 360-2 | 100 | 127.9 | 19.9 | 11.2 | 48.5 | 48.7 |
| | | | 360-3 | 90 | 117.9 | 20.3 | 11.5 | 48.9 | 49.1 |
| | | | 360-4 | 80 | 107.9 | 20.7 | 11.9 | 49.3 | 49.5 |
| 8346DF | 4.6 | 42.4 | 360-1 | 120 | 141.5 | 20.9 | 12.1 | 49.5 | 49.7 |
| | | | 360-2 | 100 | 121.5 | 21.6 | 12.8 | 50.1 | 50.3 |
| | | | 360-3 | 90 | 111.5 | 21.9 | 13.2 | 50.5 | 50.7 |
| | | | 360-4 | 80 | 101.5 | 22.3 | 13.6 | 50.9 | 51.1 |
| 8346FF | 4.6 | 43.0 | 360-1 | 120 | 141.5 | 21.5 | 12.7 | 50.1 | 50.3 |
| | | | 360-2 | 100 | 121.5 | 22.2 | 13.4 | 50.7 | 50.9 |
| | | | 360-3 | 90 | 111.5 | 22.5 | 13.8 | 51.1 | 51.3 |
| | | | 360-4 | 80 | 101.5 | 22.9 | 14.2 | 51.5 | 51.7 |
| 8346CS | 4.6 | 43.5 | 360-1 | 120 | 139.9 | 22.0 | 13.3 | 50.6 | 50.8 |
| | | | 360-2 | 100 | 119.9 | 22.7 | 14.0 | 51.3 | 51.5 |
| | | | 360-3 | 90 | 109.9 | 23.1 | 14.3 | 51.7 | 51.9 |
| | | | 360-4 | 80 | 99.9 | 23.5 | 14.7 | 52.1 | 52.3 |
| 8008DF | 5.0 | 43.5 | 360-1 | 120 | 141.9 | 22.0 | 13.2 | 50.6 | 50.8 |
| | | | 360-2 | 100 | 121.9 | 22.6 | 13.9 | 51.2 | 51.4 |
| | | | 360-3 | 90 | 111.9 | 23.0 | 14.3 | 51.6 | 51.8 |
| | | | 360-4 | 80 | 101.9 | 23.4 | 14.7 | 52.0 | 52.2 |


BROADBAND
LINE EXTENDER
BLX-1

## System C/N: off-air channel

The method for calculating system C/N for the off-air channel of Figure 1 is essentially the same as that for the earth station channel. However, because there typically is no computer C/N data available for the off-air headend system, the off-air C/N analysis through the signal processor requires more manual number manipulation by the system operator. This process is either a two- (no pre-amp required) or three- (pre-amp required) step process, but in either case begins by determining the C/N at the output of the off-air antenna.

When the off-air antenna output signal level and C/N are determined, a decision about pre-amp requirements can be made, after which the noise figure of the system through the signal processor can be calculated. This number then is combined with the off-air antenna C/N to provide the C/N of the

### Figure 3
### Standard 400 MHz system

| | |
|---|---|
| ANALYSIS TEMP: | -40 TO 140 |
| SYSTEM FREQUENCY: | 400 |
| CHANNEL CAPACITY: | 54 |
| TRUNK TILT: | 3 |
| DISTRIBUTION TILT: | 7 |

PARAMETERS USED IN SYSTEM ANALYSIS:

| | |
|---|---|
| LONGEST TRUNK CASCADE | 20 |
| LINE - X CASCADE | 2 |
| TRUNK OPERATIONAL OUTPUT | 33 |
| BRIDGER OPERATIONAL OUTPUT | 46 |
| LINE-X OPERATIONAL OUTPUT | 43 |
| TRUNK OPERATIONAL GAIN | 22 |
| LINE-X OPERATIONAL GAIN | 28 |

NOTE
THE FOLLOWING NUMBERS ARE CALCULATED FROM INDIVIDUAL MODULE SPECIFICATIONS AND DO NOT REPRESENT SYSTEM SPECIFICATIONS WHICH MUST INCLUDE NECESSARY ALLOWANCES FOR SYSTEM BALANCE AND TEMPERATURE.

COMPOSITE TRIPLE BEAT IS BASED ON THE AVERAGE VALUE OF ALL BEATS WITH RESPECT TO THE CARRIER.

INDIVIDUAL STATION SPECIFICATIONS

| | TK | TK/BR | LE |
|---|---|---|---|
| C/N | 61.2 | 59.8 | 58.7 |
| X/M | 86.0 | 62.3 | 69.0 |
| 2ND | 84.0 | 71.5 | 75.0 |
| CTB | 84.0 | 65.9 | 72.5 |

### Forward distribution system

| TK | TRUNK CASCADE ONLY | | | | TRUNK CASCADE PLUS BRIDGER STATION | | | | TRUNK CASC PLUS BRIDGER PLUS 6554 CASCADE | | | | SYSTEM NOTES: | MAX LE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CSC | C/N | X/M | 2ND | CT/B | C/N | X/M | 2ND | CT/B | C/N | X/M | 2ND | CT/B | | CSC |
| 1 | 61.2 | 86.0 | 84.0 | 84.0 | 59.8 | 62.3 | 71.5 | 65.9 | 54.3 | 56.6 | 68.8 | 60.1 | | 2 |
| 20 | 48.2 | 60.0 | 71.0 | 58.0 | 48.1 | 55.3 | 68.4 | 55.3 | 47.4 | 52.3 | 66.8 | 53.2 | | 2 |

DISTORTION NUMBERS ARE LISTED AS CARRIER TO DISTORTION RATIOS PER NCTA STANDARDS

ANALYSIS GENERATED BY: RIVERA ( ALL SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE )

### Figure 4
### Signal summary

33 45 0.0 NORTH LATITUDE
84 23 0.0 WEST LONGITUDE

RECEIVE ANTENNA AT 200 FEET

| CH. | CALL | STATION CITY | NET | BNG (D) | DIST (MI) | SIGNAL (DBMV) | ANTENNA |
|---|---|---|---|---|---|---|---|
| 2 | WSB | ATLANTA GA | ABC | 52 | 1.6 | 80.6 | QCA-2 |
| 3 | WRBL | COLUMBUS GA | CBS | 193 | 101.2 | -5.2 | QCS-2 |
| !----> CONTINUOUS CO-CHANNEL FROM: WRCB CHATTANOOGA TN [ 3+; 332 DEG; -32.2 DB] | | | | | | | |
| 5- | WAGA | ATLANTA GA | CBS | 42 | 4.3 | 65.8 | QCA-4 |
| 7- | WCIQ | MOUNT CHEAHA AL | ETV | 258 | 84.1 | 2.7 | QCS-7 |
| !----> FREQUENT CO-CHANNEL FROM: WSPA GREENVILLE SC [ 7+; 50 DEG; -49.7 DB] | | | | | | | |
| 8 | WPBS | ATHENS GA | ETV | 74 | 14.2 | 49.8 | QCA-7 |
| 11+ | WXIA | ATLANTA GA | NBC | 81 | 3.0 | 69.2 | QCA-7 |
| 17 | WTBS | ATLANTA GA | IND | 352 | 2.3 | 72.2 | QCAUHF |
| 18 | WCLP | CHATSWORTH GA | ETV | 345 | 71.8 | 3.1 | UCA-8 |
| 28 | WJSP | COLUMBUS GA | ETV | 197 | 64.7 | 7.5 | UCA-8 |
| 30 | WPBA | ATLANTA GA | ETV | 32 | 4.7 | 58.8 | QCAUHF |
| 36 | WATL | ATLANTA GA | IND | 32 | 4.7 | 62.4 | QCAUHF |
| 46 | WGNX | ATLANTA GA | IND | 32 | 4.7 | 59.5 | QCAUHF |
| 69 | WVEU | ATLANTA GA | IND | 335 | 0.7 | 78.6 | QCAUHF |

13 STATIONS FOUND WITHIN 200 MILES OF HEADEND LOCATION WITH RECEIVE ANTENNA AT 200 FEET

PLEASE NOTE: These median signal strengths are based upon FCC data. Signals of this level or stronger can be expected 50% of the time at 50% of locations with "average" terrain. Signals at your location may vary unpredictably due to atmospheric conditions, terrain and obstructions.

off-air headend system through the signal processor. The combining network following the processor has a negligible effect on the processor C/N number as long as the processor output is run at +55 dBmV or greater. Consequently, the C/N at the output of the signal processor is effectively the C/N of the off-air headend channel through the combining network and is, therefore, the C/N to be used in the overall system C/N calculation.

For initial C/N analysis, the off-air antenna noise level is considered to be the minimum noise level in a 75-ohm system at 68° over a 4 MHz bandwidth. Under these conditions, the minimum noise floor is −59 dBmV.[2] If an off-air computer analysis (Figure 4) is performed for the receive site, a theoretical receive signal level can be found.[3] The difference between the −59 dBmV noise floor and the computer predicted signal level results is the C/N at the antenna output. For example, from Figure 4 the received signal level from CH 28, WJSP, off a UCA-8 antenna is +7.5 dBmV. Therefore, the theoretical C/N at the output of the UCA-8 antenna is [+7.5 dBmV −(−59 dBmV)] or 66.5 dB.

To achieve maximum noise and AGC performance, most signal processor manufacturers recommend an ideal signal processor input level between 0 and +10 dBmV. If the total loss from the antenna output to the processor input is such that the processor input is not within this range, a pre-amp should be considered. Also, if the analysis shows the channel C/N to be low, a pre-amp can be used to increase the C/N performance.

The pre-amp can be mounted at the headend in front of the signal processor or on the tower at the antenna output. If a boost in signal level and a small improvement in C/N are required, the headend-mounted pre-amp probably is the best from a maintenance and signal level handling standpoint. If maximum improvement in C/N is required, the pre-amp should be mounted on the tower at the antenna output. A C/N analysis of each configuration is given below.

Each of the following three examples involves the same basic three-step procedure. The first step is to calculate the noise figure for the headend channel being analyzed. Second, combine the off-air antenna C/N (CH 28 example above) with the headend chanel noise figure. The third step is to combine this resultant headend channel C/N with the distribution system C/N to find overall system C/N for that off-air channel. Each example begins with the 66.5 dB antenna C/N of the CH 28 example above.

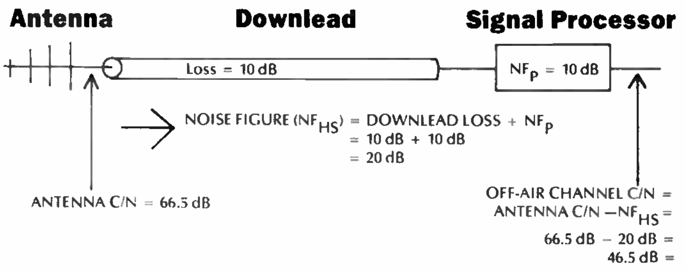
The system shown in Figure 5 is a basic off-air headend system consisting of an antenna, a down lead and its associated loss, which also includes any losses due to splitters or couplers, and a signal processor. Since there are no active devices before the processor, the system noise figure looking into the input of the downlead through the processor is the sum of all losses in front of the processor plus the processor noise figure. The off-air headend system C/N for Figure 5 is determined by subtracting the system noise figure from the antenna C/N. Finally, the headend system C/N is combined with the distribution system C/N (per steps 1, 2 and 3) to find the total system C/N.

$$\text{C/N Total System} = -10\,\text{Log}\left(10^{\frac{-48}{10}} + 10^{\frac{-46.5}{10}}\right)$$

$$= 44.2\text{ dB}$$

The system shown in Figure 6 is the same as Figure 5 except that a pre-amp has been added at the processor input to raise the signal level. The basic procedure to calculate system C/N is the same as above, but the method of calculating noise figure is slightly more complicated because of the addition of the pre-amp.

**Figure 5**




In general, the noise figure of a system or device with several stages of amplification is determined by applying the following expression:

$$\text{NF (dB)} = 10\,\text{Log}\left(f_1 + \frac{f_2 - 1}{g_1} + \frac{f_3 - 1}{g_1 g_2} + \frac{f_x - 1}{g_1 g_2 g_x}\right)$$

This relationship states that the overall noise figure of a device or system is directly equal to the noise factor of the first stage plus the noise factor of the second stage divided by the numerical power gain of the first stage, plus the noise factor of the third stage divided by the product of the numerical power gains of the first two stages, plus the noise factor of the xth stage divided by the product of the numerical power gains of the x stages, etc.

From this expression, it is important to note that the first stage has the greatest impact on the overall system noise figure, since it is a direct magnitude addition while the noise factor contribution of each succeeding stage is decreased by the amount of gain preceding that stage. In effect, this means that the noise figure of a system always can be improved if a device having a lower noise figure and a reasonable amount of gain is added to the system up front.

Since this is what was done in Figure 6, the result should be an improvement in overall system C/N ratio. By comparing the noise figure of Figure 6 (14.9 dB) to that of Figure 5 (20 dB), the improvement is obvious. Moreover, in addition to improving system C/N, the signal level at the processor input has been increased. Both of these benefits were obtained by adding the pre-amp in front of the processor in the headend where active device maintenance is much easier. Finally, the C/N from the headend system of Figure 6 is combined with the distribution system C/N (per steps 1, 2 and 3) to find the final system C/N.

C/N Total System

$$= -10\,\text{Log}\left(10^{\frac{-48}{10}} + 10^{\frac{-51.6}{10}}\right)$$

$$= 46.4\text{ dB}$$

The last example (Figure 7) is again the basic system of Figure 5, except the pre-amp is placed on the tower at the antenna output to achieve maximum C/N improvement. Applying the same analysis as detailed above, the new noise figure becomes 10 dB and the resulting headend system C/N is 56.5 dB. Combining the headend system C/N with that of the distribution (per steps 1, 2 and 3) results in the total system C/N.

C/N Total System

$$= -10\,\text{Log}\left(10^{\frac{-48}{10}} + 10^{\frac{-56.5}{10}}\right)$$

$$= 47.4\text{ dB}$$

**Figure 6**

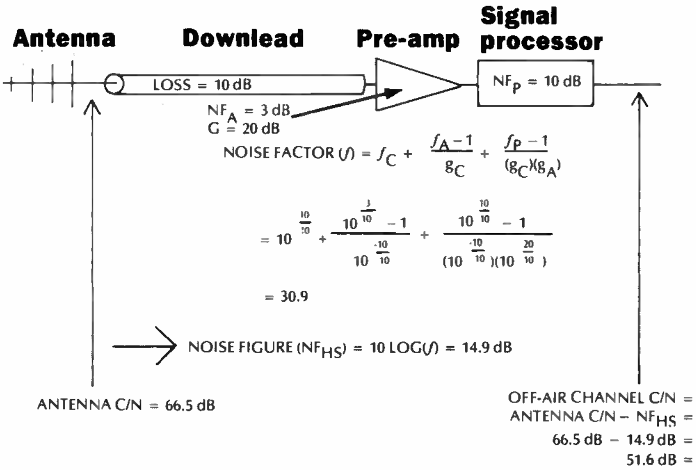
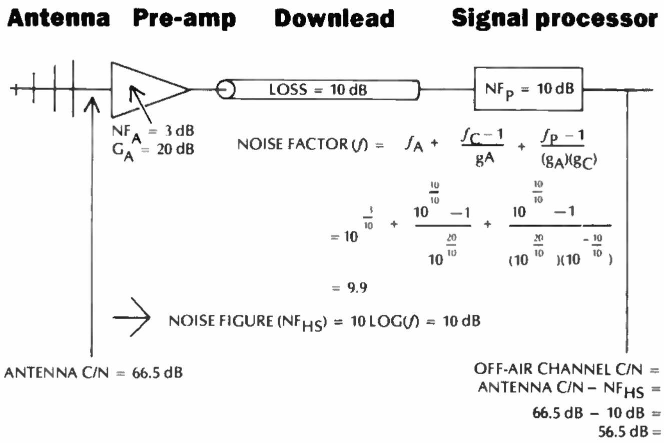



**Figure 7**




Below is a summary of the calculated C/N performance from all the previous examples. Generally, for CATV system operation, headend C/N numbers greater than 50 dB are desired. From the C/N summary, it can be seen that the earth station headend channel C/N and the off-air headend channel C/N performance fall below this rule-of-thumb number and, ideally, should be improved. Moreover, it is desired to have less than 3 dB C/N difference between individual headend channels so that no discernable C/N picture quality differences can be seen at the subscriber's location in the system. In addition, the total system C/N for a CATV system typically should be greater than 44 dB.

| | |
|---|---|
| C/N Earth station headend channel | = 46.4 dB |
| C/N Off-air headend channel | |
| No pre-amp | = 46.5 dB |
| Pre-amp in headend | = 51.6 dB |
| Pre-amp on tower | = 56.5 dB |
| C/N Distribution system | = 47.4 dB |
| C/N Total system (earth station channel) | = 43.9 dB |
| C/N Total system (off-air channel) | |
| No pre-amp | = 44.2 dB |
| Pre-amp in headend | = 46.4 dB |
| Pre-amp on tower | = 47.4 dB |

Notes

[1]In general, CTB is the third order limiting factor for systems carrying more than 12 channels, and cross modulation, the third order limiting factor for systems carrying 12 or fewer channels.

[2]The noise level at the output of the antenna also is affected by manmade and galactic noise sources. The additional noise from these sources is frequency-dependent and can increase the −59 dBmV noise floor considerably. Since no rule-of-thumb number typically is recommended, an on-site noise measurement should be conducted to obtain actual noise level. Additional information about manmade and galactic noise can be found in the *ITT Reference Data for Radio Engineers Handbook*, published by the Howard W. Sams Co.

[3]Before a receive site is selected, it is essential that an actual on-site signal survey be performed. The computer-generated data of Figure 4 can aid in the survey but should not be relied on for site selection without the on-site analysis. CED

## Appendix:

$NF_A$ = noise figure (dB) of pre-amp
$NF_P$ = noise figure (dB) of signal processor
$NF_{HS}$ = noise figure (dB) of off-air headend system
$G_A$ = gain (dB) of pre-amp

$f$ = noise factor = $10^{\frac{NF}{10}}$
$f_C$ = noise factor of coaxial cable
$f_A$ = noise factor of pre-amp
$f_P$ = noise factor of signal processor

$g$ = power gain = $10^{\frac{G}{10}}$
$g_C$ = power gain of coaxial cable
$g_A$ = power gain of pre-amp

*Continued from page 8*
suggestion from Sruki Switzer, a compromise was accepted by FAA by which HRC systems could offset their reference oscillators by a precise 300 Hz, in order to provide acceptable offsets throughout.

This proposal never really saw the light of day, primarily because NCTA insisted that if we offset from aeronautical assignment, we should not also be required to prove leakage compliance. I do not agree. We have been obliged, ever since the 1950s, to comply with a leakage limitation on any frequency, not just the aeronautical frequencies. This obligation continues to exist, regardless of offsets.

Now, we have a Second Report and Order, the intent of which is to interlace our frequency assignments with present and future aeronautical assignments so that frequency coordination will no longer be needed, and all channels, properly offset, can be used without prior approval.

There were some drafting goofs, or perhaps oversights, that I hope and believe will be corrected. For example, the Report indicated that HRC and IRC would be accommodated, but the language of the rules does not say so. Grandfathering is effectively provided, but the notification rule seems to take it away, at least for systems planning to add frequencies not previously approved.

I sense that NCTA is still reluctant. This time, it seems worried that if we accept offsets to solve the aeronautical conflict, the land-mobile and amateurs will be next. They seem concerned that if we accept a channelling plan, we will be locked in forever.

Again, I disagree. The Second Report and Order (except for what I believe are correctable drafting errors) is a carefully designed engineering solution to a highly emotional problem. I, for one, feel rewarded by the outcome of the IEEE subcommittee I appointed 15 years ago.

***"The Second Report and Order (except what I believe are correctable drafting errors) is a carefully designed engineering solution to a highly emotional problem. I, for one, feel rewarded by the outcome of the IEEE subcommittee I appointed 15 years ago."***

***Archer S. Taylor***

The Second Report and Order, is *not* a channelling plan. You can use 6 MHz, 8 MHz, 18 MHz, 30 MHz, or any width TV or data channels you wish. You are obliged only to choose carrier frequencies (if operated at more than $10^{-4}$ watts) that are odd-numbered integers of 12.5 kHz. While the freedom to assign frequencies is not quite unlimited, you still can choose among 40 acceptable frequencies in every MHz of system bandwidth to which you can assign carriers; 240 in each 6 MHz channel.

As to land-mobile and amateurs, the engineering situation is quite different. Just as the Second Report and Order has required both give and take, so will the solution of land-mobile and amateur interference. I refuse to believe these matters do not have sound engineering solutions, and I do not accept the premise that the principle features of the Second Report and Order foreclose sound engineering solutions to other problems.

Finally, some responsible cable engineers have pointed to situations that do not conform to the normal pattern of use of TV channels. High-level sweeps and FSK data transmissions are cited as examples. It may be that power averaging will be found to be a sound engineering way of dealing with this matter. If so, the rules can be amended if necessary.

I will have more to say in another essay about the Cumulative Leakage Index (CLI) which seems to have terrified some operators. Just remember that Section 76.611 (a) (1) requires only that you "demonstrate compliance" with the CLI, not that you determine its actual value. CED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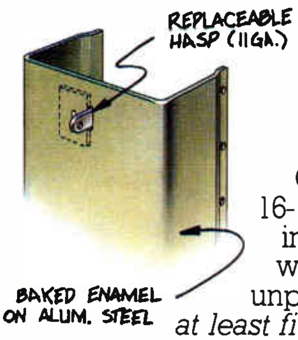


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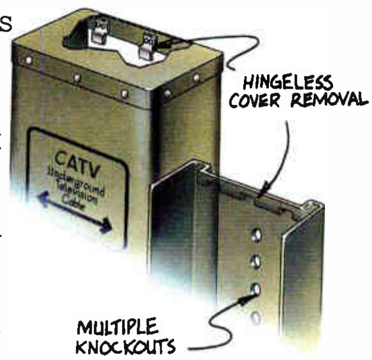


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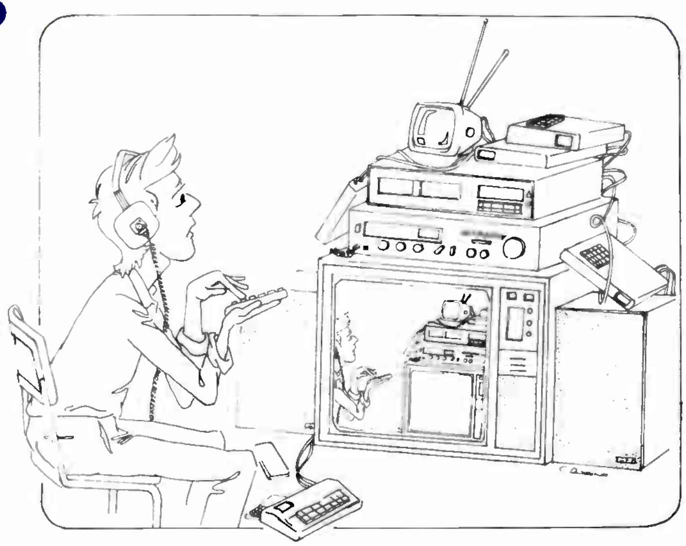
# MTS: No marching orders, many options



Walt Ciciora probably said it best. Speaking at the Society of Cable Television Engineers' Jan. 22-23 seminar on multichannel sound, the ATC R&D VP gave a "good news, bad news" message: "You can all go back and tell your managements that you fully grasp the problems posed by cable stereo. The bad news is there may be no solutions."

Having gotten a reprieve from the FCC on MTS must-carry, the 120 technical managers immersed themselves in the options available: in-band/out-of-band, digital/analog or FM/BTSC. Field reports and lab tests gave listeners a state-of-the-art update on how MTS signals affect and are affected by modulators, AML and FM CARS systems, RF and baseband terminals.

The conclusion? "We still don't have all the answers yet," said Scientific-Atlanta's Alex Best.

But a surprise visit by NCTA Chairman Ed Allen left no doubt that trends in consumer audio, rather than FCC regulations, would drive the market for the time being. Although the industry had been expecting a vote on must-carry MTS, Allen brought good news: No votes are expected any time soon. "You may proceed as if there will be no must-carry requirement," Allen told listeners.

The driving trends in consumer audio? Compact disc sound quality of 90 dB and hi-fi VCR fidelity of 80 dB. "In the normal listening environment, these will set the standards by which your systems will be judged," argued Gill Cable's Dave Large.

The competition? Turntables delivering 70 dB S/N, off-air FM city-grade signals at about 67 dB, audio cassette S/N of 65 dB and simulcast FM cable stereo of 55 dB. "The market is rejecting the old VHS VCRs offering sound at 47 dB, and is slowly migrating to about 70 dB as acceptable sound quality," Large said. "About the best cable can do now is 57 dB at the end of a transmission line with a blank screen and no other degradation sources, using BTSC standards."

It isn't good enough, he argued. The choices? Digital audio (16- or 8-bit) or advanced analog. Digital takes bandwidth and is expensive. Advanced analog with separate L and R carriers can go out-of-band with about 80 dB S/N. In-band 8-bit digital is important because broadcasters might go this way.

The trade-off for out-of-band systems is the simultaneous tuning of the FM tuner separate from the video channel, "and I don't think that will fly," Large insisted.

### Field, lab tests

Few cable systems have had actual experience with off-airs broadcasting in stereo. But Viacom's Seattle, Wash., system is ahead of most on the learning curve. It is carrying two stations, KIRO and KRMO, in synthesized stereo. "It's been difficult to assess the parameters of stereo separation loss because we haven't been dealing with true stereo," reported Joe Van Loan, Viacom engineering VP.

The company has found that its microwave equipment tends to overload when carrying lots of FM. "We also get backfeed through splitters when FM tuners are connected. Cut-off filters reduce the backfeeding but are expensive," Van Loan said.

Stereo signals also have interfered with an anti-tampering program Viacom had been running. "We'd been impressing a jamming signal on the aural carrier, but it triggered the stereo sound mode and resulted in an audible buzzing," he said.

Reporting on the NCTA's lab tests, Alex Best concluded that heterodyne processors degrade MTS signals very little, but demod-remod systems might reduce signals 15-20 dB when processed at 4.5 MHz. Demod-remod systems that process to baseband audio are mono-compatible but won't pass stereo or the second audio program. Also, the percentage of AM on the FM sound carrier may increase from 1-2% to 7-9% when stereo is passed through processors with narrow filters.

Speakers at the seminar were divided on the merits of BTSC. Tom Matty of W & S Systems wasn't enthusiastic about it. "BTSC is very sensitive. The main channel L+R is linear, but the L—R is nonlinear. Broadcasters are having trouble maintaining separation, and there are significant levels of horizontal frequency in the audio output."

But Pete Morse, Jerrold marketing VP, came down on the other side of the fence. "BTSC is the *de facto* standard for broadcast and will be difficult to work around."

Pioneer's Larry Brown, VP, new business development, reported on the company's work with headend tagging of signals to solve the channel tracking problem at low cost. "Our preference is to keep BTSC completely off the system and reprocess the sound at headend for FM simulcast."

The picture is mixed for stereo carried on microwave links. "There's no real answer yet on which transport system is best for FM CARS systems," reported M/A-Com's Carl Guastafero. "You can go with separate narrowband subcarriers—1 video and 4 sub-carriers using K Plan frequencies—or put everything on a wideband subcarrier. With wideband, everything has to be very linear."

AML should have little effect on stereo signals except for out-of-band IM, Tom Straus of Hughes reported. "You should reduce levels by a decibel or two to minimize the IM noise."

*See the full text of papers presented at the seminar in this and following issues of CED.*

*—Gary Kim*

Reader Service Number 15

FEATURE

# BTSC compatibility

***By Michael E. Long, Zenith Electronics Corp.***

Transmission of the new multichannel TV sound system already has begun in many U.S. communities. The MTS system adopted by the Broadcast Television Systems Committee of the EIA is the Zenith stereo transmission system combined with a dBX noise reduction system. The new audio transmission standard allows full compatibility with existing monaural reception hardware by providing the L + R matrixed monaural signal as the main channel on the broadcast channel's normal 4.5 MHz aural intercarrier.

The introduction of broadcast TV stereo into the marketplace can be beneficial to the cable industry. The promotion of stereo by TV manufacturers and broadcast networks will bring renewed consumer interest in television programming over any media. Programming suppliers will produce more entertainment software in stereo to meet real or anticipated demand and consumers will become more interested in cable's delivery of an increased selection of stereo programming. With existing technology, a cable subscriber can enjoy new stereo programming without having to replace his existing monaural TV receiver.

In studying the stereo TV market, a cable operator will find two types of potential subscribers. Initially, the market will consist of only a small percentage who own BTSC stereo TV receivers. However, over the long term, the number of subscribers having stereo TV sets will increase and compatibility must be considered.

There has been much discussion about the best technology for delivery of stereo on cable. Among the several approaches being considered are:

- Out-of-band vs. In-band
- Digital
- Advanced analog

**Figure 1 4.5 MHz Interface Converter**

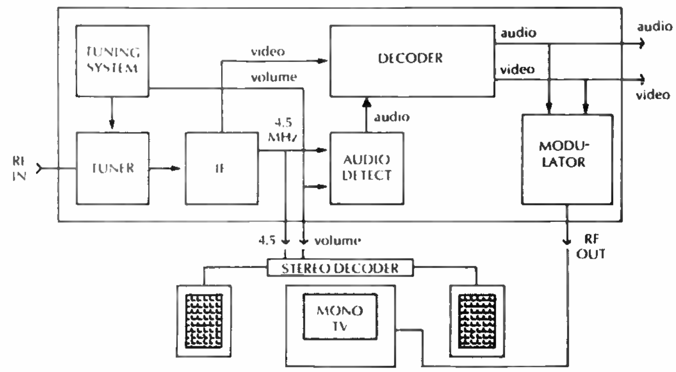


**Figure 2 4.5 MHz Interface Converter Stereo TV Interface**

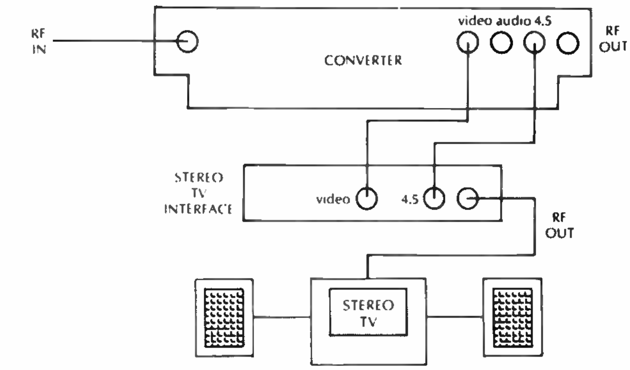
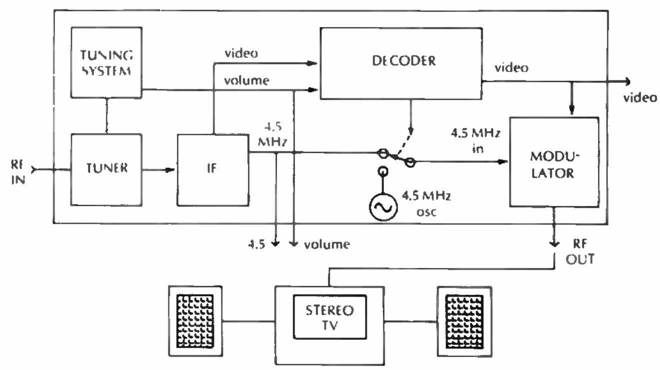



**Figure 3 4.5 MHz Bypass Converter**




- Conventional FM
- BTSC

Many are proposing sophisticated in-band or out-of-band digital stereo or use of advanced or conventional FM-band stereo with converter tracking FM receivers. These proposed ideas can provide excellent audio quality but are complex, costly and have little relationship to the BTSC TV stereo system around which TV receivers will be designed. The use of non-standard stereo would add another source of incompatibility and invite increased consumer confusion.

One of the alternate delivery techniques involves the use of conventional FM-band stereo. Accessory FM stereo receivers that track converter channel tuning promise acceptable delivery of stereo if designed correctly. However, conventional FM stereo over cable will result in reception S/N ratios less than could be accomplished with BTSC TV stereo techniques. Calculations show that on a TV channel having an FCC limit 36 dB visual C/N, an intercarrier detector can yield a BTSC decoded stereo S/N of 59.8 dB (64.7 dB S/N for a split-sound detector). An FM band stereo channel operating at the same level as the TV aural carrier will result in a received stereo S/N of only 51.8 dB.

For FM receiver tracking of converter

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channels, direct detection of the converter's I-R remote control signal might be used. This technique would be adequate for remote control direct channel entry but will not work for favorite channel scanning or with manual channel entry. Digital or conventional FM techniques would cost more than a BTSC approach since additional tuning and signal processing would be necessary.

The most straightforward approach to stereo on cable networks is the broadcast BTSC system. Headend costs would be minimal for retransmission of local BTSC encoded broadcast programming. For other programs, low-cost headend BTSC encoding equipment for the cable industry soon will be introduced. On the home-terminal end, all systems (baseband and RF) will have some problems to overcome, but baseband converter/decoders can be made compatible at a lower cost with the BTSC stereo system.

Baseband converters can be an ideal vehicle for delivery of BTSC stereo to the cable subscriber because baseband scrambling techniques do not affect the channel's sound carrier as do many RF scrambling systems. The addition of a 4.5 MHz stereo accessory port and output of DC volume and muting for an external stereo decoder can easily be accomplished in new and existing baseband products. Stereo decoder products could represent increased revenue through subscriber rental of accessory equipment.

In the design of BTSC-compatible baseband converters, several goals should be kept in mind:

- Quality of audio
- Cost
- Simplicity of design and consumer operation
- Upgradability of existing converters
- Addressability and security
- Retention of volume control and muting
- Compatibility with stereo TV receivers

One important measure of audio quality is audio S/N ratio. Recent BTSC testing for the Canadian Cable TV Association included measurements of resultant stereo noise with respect to visual C/N. The test results showed little increase in the stereo noise floor until the visual C/N was reduced below 30 dB.

By calculation, and assuming a cable TV channel with an FCC minimum visual C/N of 36 dB (4 MHz), white video modulation and a BTSC modulated aural carrier (200 kHz bandwidth) 15 dB below the visual carrier, a baseband converter using an intercarrier detector can yield a BTSC decoded stereo S/N of 59.8 dB. The use of a split-sound detector could result in a stereo S/N of 64.7 dB. In either case, because of the BTSC companding, there is little degradation over monaural S/N.

Other measures of audio quality include intercarrier buzz and stereo separation. Each of these must be considered in the hardware design of BTSC compatible converters.

An effective method for providing high quality BTSC stereo compatibility through baseband converters is to output either IF or audio intercarrier (4.5 MHz) from the converter to an accessory stereo decoder. This method avoids modifications to the converter audio demodulator and video/audio remodulator circuits necessary to pass high quality BTSC audio. Although this approach will satisfy today's majority of subscribers having older monaural TV receivers, it is not a solution for the subscriber with a new stereo TV set. For stereo TV receiver compatibility, a cable converter must pass the BTSC encoded aural carrier through to the receiver unaltered.

Bypassing of the 4.5 MHz intercarrier directly to the converter remodulator can provide compatibility but eliminates the baseband converter's volume control feature. For applications where remote converter volume control is not important, this approach may be acceptable.

High quality stereo sound demodulated and remodulated through a baseband converter requires improvements in audio frequency response and intercarrier buzz. These improvements can be accomplished through careful design and alignment of audio demodulator and RF remodulator circuitry.

In a wideband audio pass-through converter, the audio FM detector must provide adequate frequency response and linearity to pass the BTSC carriers with minimal degradation. In addition, good stereo separation requires both amplitude and phase matching in the receiver de-emphasized L + R signal and the expanded L—R signal.

It is, therefore, important to accurately control converter detected composite audio levels to the remodulator. At low frequencies, a L—R channel frequency response mismatch from the L + R channel of 0.5 dB in the converter composite audio would result in 24.8 dB of decoded channel separation. Similarly, a 1.0 dB decrease from optimum volume level in composite audio from the converter audio detector to the remodulator would result in maximum low frequency stereo separation of 24.8 dB.

A combination of the two effects would result in 18.8 dB of separation. Mid- and high-frequency audio separation would exhibit even more sensitivity to level due to companding and variable pre/de-emphasis. This effect of audio level on decoded stereo separation also must be considered if a converter is to use a composite audio output for an auxiliary stereo decoder.

Proper design and alignment of IF amplifier circuits and video/audio detectors is essential to reduce intercarrier buzz problems.

Remodulators present problems of their own. Incidental carrier phase modulation (ICPM), for example, must be controlled to minimize detected audio buzz in TV receivers. ICPM, angle modulation of the visual carrier by video components, can be caused by non-linearities and/or carrier leakage in visual modulators. ICPM can be minimized by proper remodulator PC board design and through injection of proper phase visual carrier to the modulated visual carrier.

Several product design options could be used to achieve BTSC compatibility. These approaches include: complete BTSC channel bypassing, upconversion of IF to the output channel, or the provision of a stereo decoder accessory IF output or a composite audio output. To satisfy the diverse demands of the market and meet technical goals, several products should be made available:

- 4.5 MHz audio intercarrier output on conventional baseband converters
- 4.5 MHz audio intercarrier bypass to the remodulator on converters not requiring volume control
- Composite audio pass-through (demodulation-remodulation) for volume control
- Full-feature, low-cost, converter-interfaced BTSC stereo decoders

Figure 1 shows a baseband cable TV converter incorporating a 4.5 MHz output interfaced with an accessory stereo TV decoder and a monaural TV receiver. A 4.5 MHz output is used instead of composite audio to avoid audio level change effects with resulting loss in stereo separation. A subscriber who does not own a stereo TV set needs only to add a low cost accessory stereo decoder to the converter output port to enjoy full stereo audio.

The accessory stereo decoder can be inexpensive, using the converter's standard circuitry for tuning and signal processing. In addition to supplying the 4.5 MHz audio carrier interface signal, the converter can provide DC volume control, mute and de-authorization control of audio and/or 4.5 MHz feedthrough. The simplicity of the 4.5 MHz output approach also allows for low-cost upgrading of existing baseband converters.

A baseband converter incorporating a 4.5 MHz output and video output could be interfaced directly to a stereo TV by using an accessory containing a 4.5 MHz bypassed remodulator (Figure 2). This accessory could remodulate the converter's output video and BTSC encoded 4.5 MHz audio intercarrier directly to a stereo TV set. Although, in this case, the converter remote volume control will have no audible effect, the accessory could sense the level of the converter's DC volume control (or absence of audio intercarrier in case of de-authorization) for muting purposes. Muting would be accomplished by substituting an unmodulated 4.5 MHz carrier for the bypassed audio carrier within the accessory.

The purpose of the 4.5 MHz bypass converter design (Figure 3) is to provide stereo TV BTSC compatibility in add-on baseband descrambler applications or for baseband converters where audio volume control is not required. This approach will provide the TV receiver a BTSC-compatible RF channel produced by bypassing the IF audio intercarrier signal directly to the remodulator. Muting for de-authorization, subscriber remote muting and inter-channel muting can be retained by unmodulated audio carrier substitution.

**Figure 4 Wide-band Audio Pass-Through Converter**

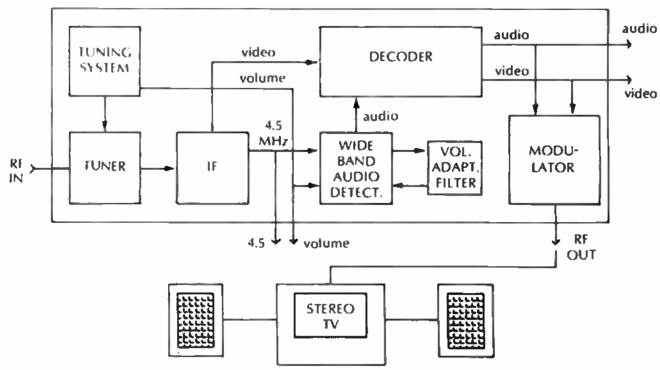


Figure 4 shows the application of a wide-band audio pass-through converter with a stereo TV receiver. This approach provides a cable TV converter which passes through to the consumer TV the demodulated and remodulated composite BTSC encoded audio. A viewer with a new stereo TV receiver will be able to receive stereo by connecting his cable converter directly to his TV set.

For full stereo separation, the baseband converter would need to be operated at maximum volume control. Listening volume should be adjusted through the stereo TV set. However, full use of converter remote muting and headend addressable de-authorized muting would be retained. Use of the converter volume control (without correction) would result in the desired volume reduction but also with some reduction in stereo separation. The use of an adaptive L—R level correcting volume control could provide acceptable stereo separation over a reasonable range of converter volume control. CED

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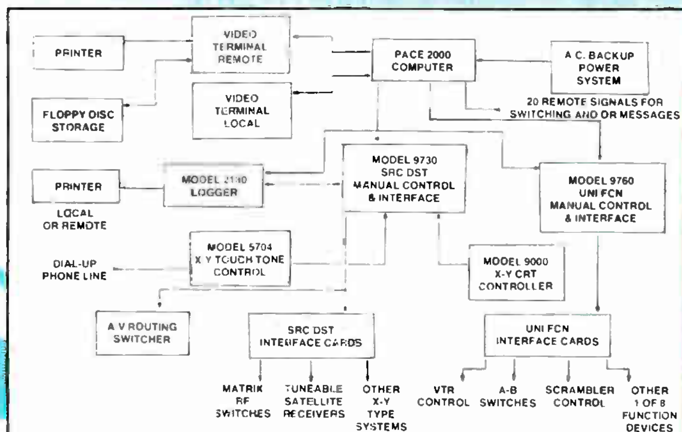


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# Stereo audio on cable

*By Tom Matty,*
*Vice President of Engineering,*
*W & S Systems*

When Group W initiated the stereo audio test program in May, the goal was identification of engineering issues. Later on, other studies were conducted to evaluate some of the commercial aspects. We now believe that there are some exciting commercial opportunities for high-quality stereo audio. First of all, customers want it, our research indicates.

Based on the early results with BTSC at Chicago and Philadelphia/Wildwood and the new awareness of these commercial possibilities, we have added emphasis to the evaluation of alternatives to the BTSC format.

The program is now comprised of four phases:

- Lab checkout and tests
- KYW installation and verification
- Wildwood reception and delivery on the cable
- Alternative evaluation

The first phase of the program was to assemble the equipment at the Telecommunications Lab, located at the Westinghouse Research Labs in Pittsburgh. After proving to ourselves that we understood how to operate the equipment and verifying its characteristics, we moved it to the field.

The objective of the second and third phases is to broadcast real stereo test signals that are useful for engineering evaluation, receive these at Wildwood, evaluate performance and identify issues.

This test is being conducted between KYW in Philadelphia and the Group W cable system in Wildwood, N.J. At KYW, we are using an Eiden Model 465 stereo generator to provide the BTSC signal for transmission. In addition to the built-in audio generators, the input to this generator normally is a Sony compact disc player with the Sony test disk. At Wildwood we have received various stereo TV receivers and a stereo adapter from Sanyo. We also are using a Technics FM receiver that has TV sound capability.

**Figure 1 Test of stereo generator**

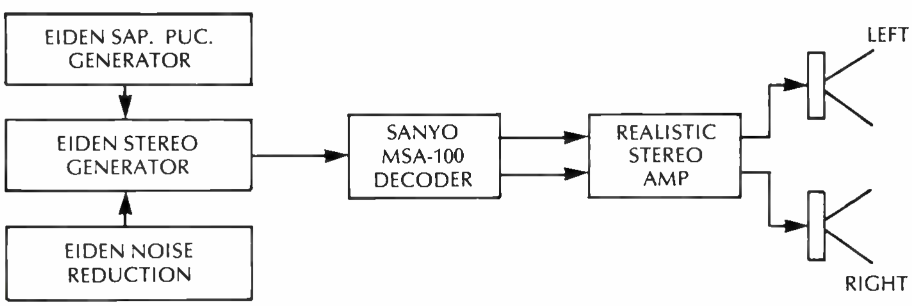
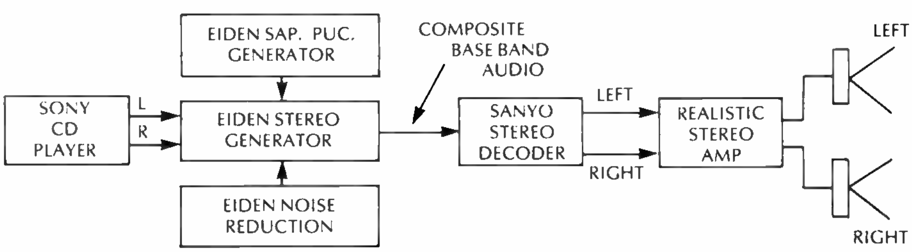



**Figure 2 Test of stereo generator with audio**




## Lab test results

The Eiden 465 BTSC generator was tested with cable equipment at the Westinghouse R&D Center before being sent to KYW for on-air testing.

Figure 1 shows the initial equipment configuration. The Eiden BTSC generator, consisting of three units, was directly connected to a BTSC decoder, which in turn drove a stereo amplifier with a pair of speakers. Internally generated test frequencies in the Eiden were used to modulate the stereo carrier and were audible from the speakers. Push-button switches on the Eiden controlled the L and R signals plus the addition or removal of noise reduction (dBX) and the Separate Audio Program (SAP) signal. The composite-output-level control was used to vary sound volume and to determine the level of pilot carrier at 1H (15734 Hz) necessary to illuminate the stereo indicator on the stereo decoder module and to activate its circuitry.

Figure 2 shows the addition of the Sony compact disk player to the setup. This permitted music to be played through the system so that stereo separation, frequency response and dynamic range could be judged. Good quality sound was achieved.

The block diagram of Figure 3 shows the equipment arrangement for the

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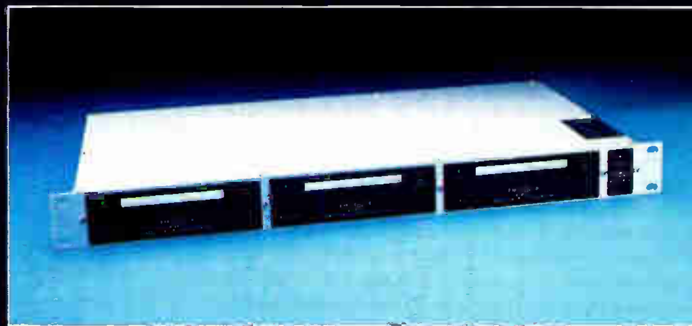

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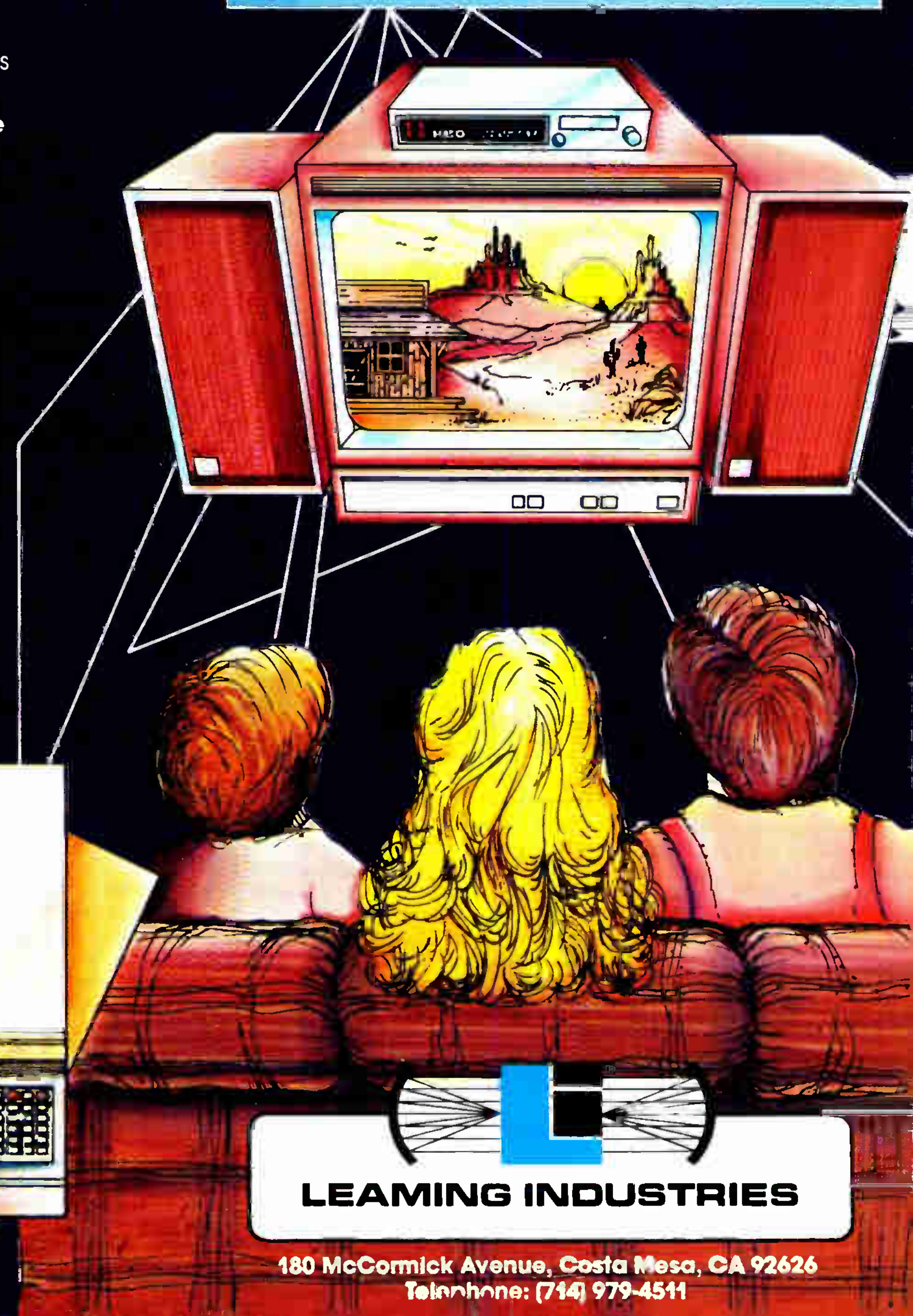


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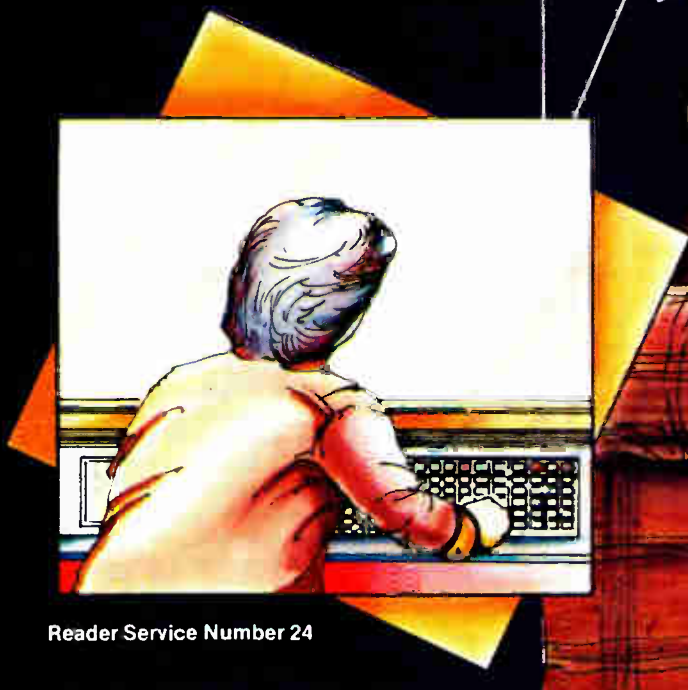

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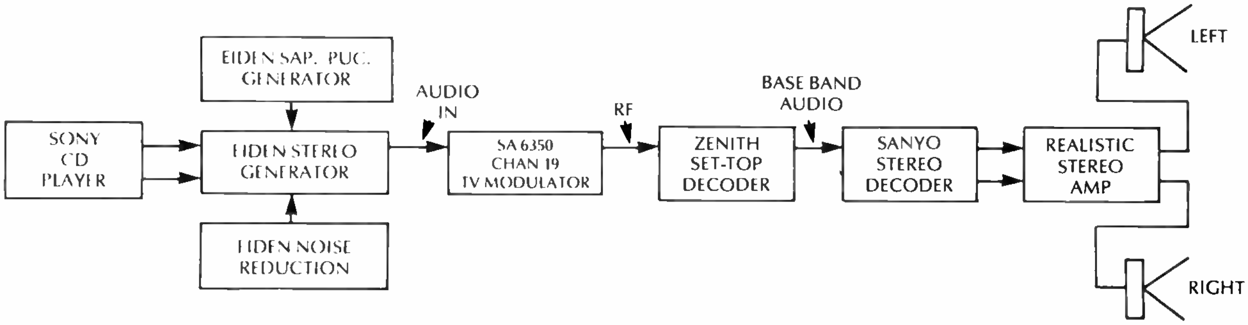
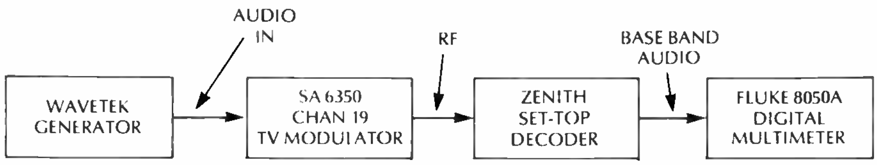
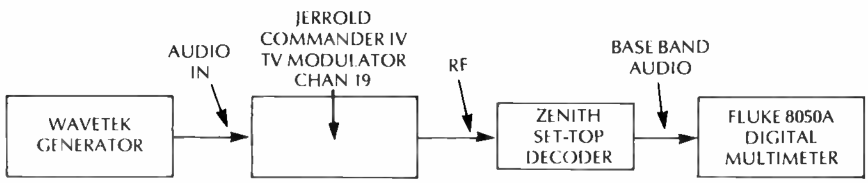
## Figure 3 Test with baseband cable converter




## Figure 4 Measurement of frequency response with first cable modulator and baseband cable converter




## Figure 5 Measurement of frequency response with second cable modulator and baseband cable converter RF




## Figure 5a Frequency response with first cable modulator and baseband cable converter

| Freq. in kHz | Fluke readings in dB | Readings adjusted to 1 kHz in dB |
|---|---|---|
| 0.100 | -17.9 | - 3.1 |
| 1 | -14.8 | 0 |
| 3 | -11.4 | + 3.4 |
| 8 | - 7.5 | + 7.3 |
| 10 | - 7.3 | + 7.5 |
| 13 | - 7.8 | + 7.0 |
| 15 | - 8.7 | + 6.1 |
| 18 | -10.3 | + 4.5 |
| 20 | -11.4 | + 3.4 |
| 25 | -14.0 | + 0.8 |
| 30 | -16.9 | - 2.1 |
| 40 | -23.6 | 9.2 |
| 50 | -31.2 | -16.4 |
| 75 | -45 | -31 |
| 100 | -45 | -31 |

**SA 6350 modulator and Zenith decoder combination**

## Figure 5b Frequency response with second cable modulator and baseband cable converter

| Freq. in kHz | Fluke readings in dB | Readings adjusted to 1 kHz in dB |
|---|---|---|
| 0.100 | -22.1 | - 8 |
| 0.500 | -15.0 | - 0.87 |
| 1 | -14.13 | 0 |
| 3 | -10.5 | + 4.4 |
| 8 | - 6.9 | + 7.2 |
| 10 | - 6.7 | + 7.4 |
| 13 | - 7.18 | + 7.0 |
| 15 | - 8.0 | + 6.1 |
| 18 | - 9.8 | + 4.3 |
| 20 | -11.3 | + 2.8 |
| 25 | -15.9 | - 1.8 |
| 30 | -18.9 | - 4.8 |
| 40 | -23.6 | - 9.5 |
| 50 | -21.6 | - 7.5 |
| 75 | -45 | - 31 |
| 100 | -58 | - 44 |

**Jerrold Commander IV modulator and Zenith decoder combination**

first attempt to insert the stereo format into a standard TV cable modulator. The audio output jack on the baseband set-top converter provided the baseband audio output to stereo decoder. Two types of TV cable modulators were tried, both on channel 19. Poor results were obtained with both modulators.

It was clear that the frequency response of the combined equipment, modulator and demodulator, was insufficient to pass the stereo format. The frequency response of the combined equipment was measured as shown in Figures 4 and 5. The Fluke multimeter was used to measure the baseband converter audio output in dB. See Figures 5a and 5b. These tests were inconclusive with regard to the poor stereo quality but did show that this equipment was clearly inadequate to pass the SAP channel.

Figure 6 shows the substitution of an RF converter and the TV/FM/AM stereo audio receiver for the baseband set-top decoder. The channel converter was needed because the TV/FM/AM stereo audio receiver did not tune the midband channel in use. The substitution was made because the baseband converter/decoder was thought to be responsible for the frequency limitation. In any case, the results were still terrible sound with poor separation.

Figure 7 shows channel-3 modulator #3 substituted for channel 19 modulator #2 so that the TV could tune the channel directly, and the channel converter could be eliminated. More importantly, modulator #3 had a pre-emphasis circuit that could be disabled by a simple modification. This modification resulted in good stereo sound with good separation and good dynamic range.

Next, a stereo amplifier was used as a buffer between the Sony disk player and the Eiden BTSC generator. This is shown in Figure 8. The Sony disk player was not intended to drive 600-ohm inputs such as the Eiden has, and the direct connection was found to cause frequency-dependent loading. The pre-emphasis circuit in modulator #3 remained disabled. The stereo was excellent. The SAP also could be tuned on the Sanyo decoder. Some crosstalk from stereo into the SAP channel was heard on loud stereo passages. This might have been due to bass boost in stereo buffer amplifier.

The final configuration is shown in Figure 9. A second TV/FM/AM audio receiver was used as a buffer to drive the Eiden. The sound was played through a stereo TV receiver as well as through the TV/FM/AM audio receiver. This configuration produced the best stereo sound.

## Scrambling compatibility

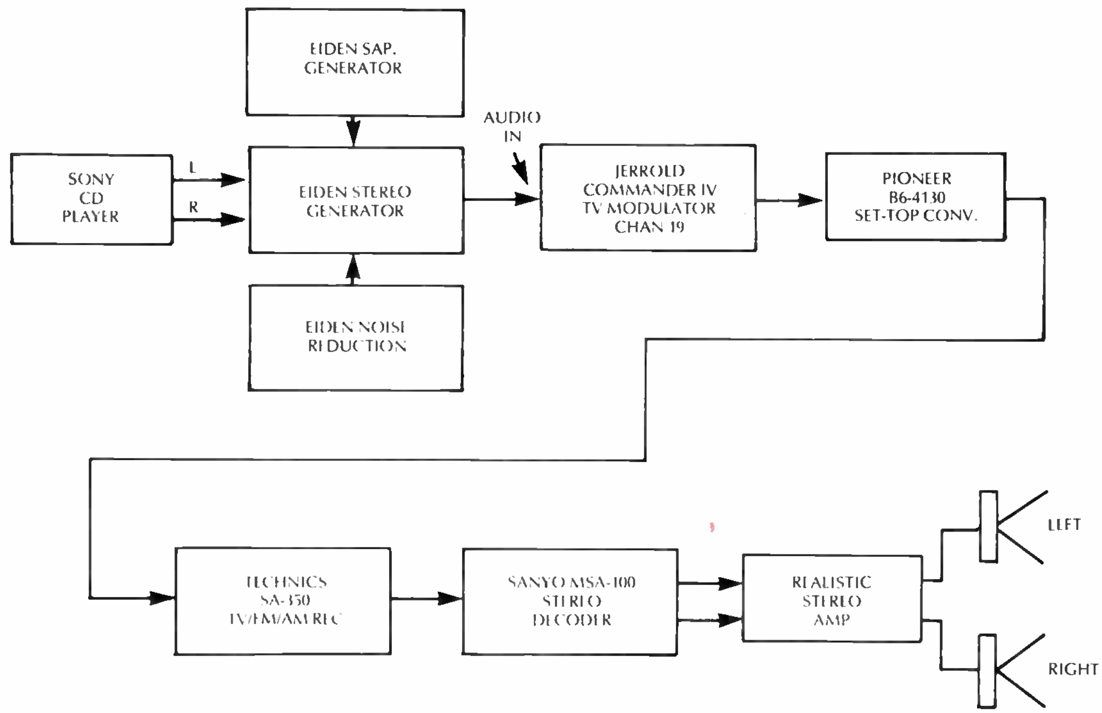
There is a compatibility problem between BTSC stereo and RF sync suppression scrambling such as is used in cable systems.

Using modulator #3 on HRC channel 2, modulated with the Eiden pilot carrier at 15,734 Hz, sidebands at 15,734 Hz were produced, as well as at harmonics. With the RF encoder in the "clear" mode there is no sync suppression of the video carrier, but there is pulse-amplitude modulation of the aural carrier that is predominantly 6 dB timing pulses, 3 us long, at a 15,734 Hz rate. The signals at 15,734 Hz and multiples on the aural carrier Hz come from this pulse amplitude modulation.

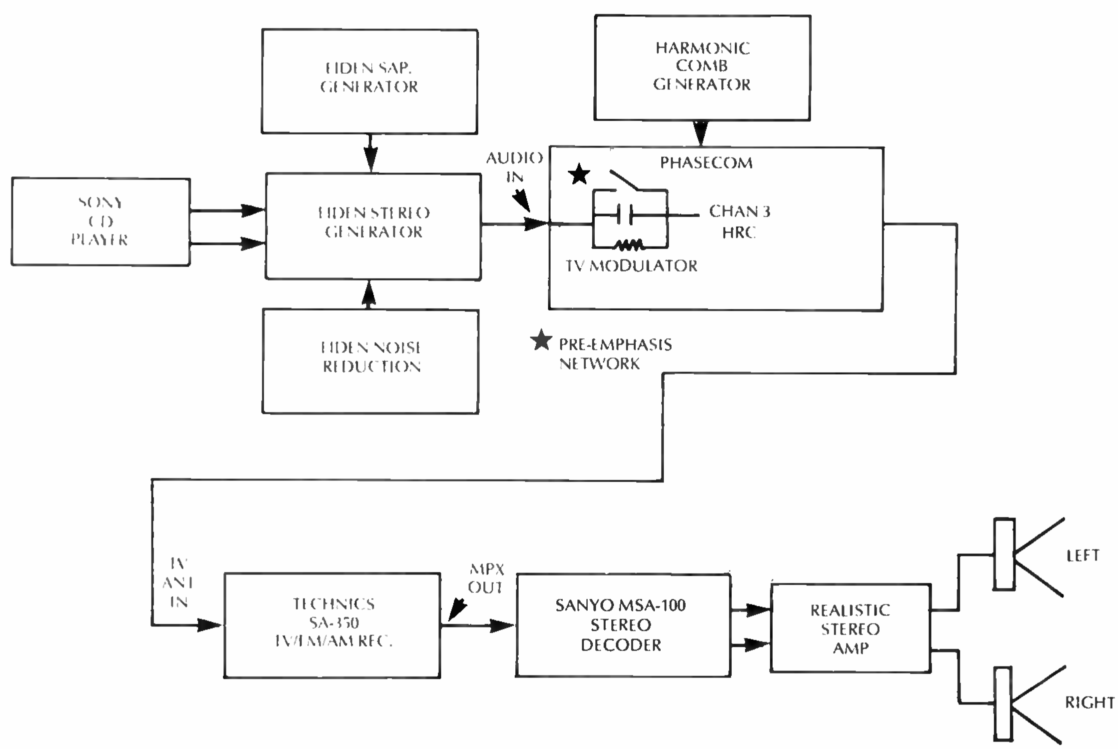
We also tested an RF encoder with 6 dB sync suppression and the decoder restoring the video. The pulse modulation of the audio at the headend was kept the same as before, but the action of the decoder boosted the aural carrier by 6 dB for 10 us, predominantly at a 15 kHz rate. This 10-us, 6-dB pulse overlaps the 3-us timing pulse to produce considerably more energy at 15,734 Hz and multiples from the aural carrier. The pulse amplitude modulation peaks at 12 dB for 3 us.

The spectrum of the pulse-amplitude-

## Figure 6 Test with second cable modulator and RF cable converter




## Figure 7 Test with modified cable modulator

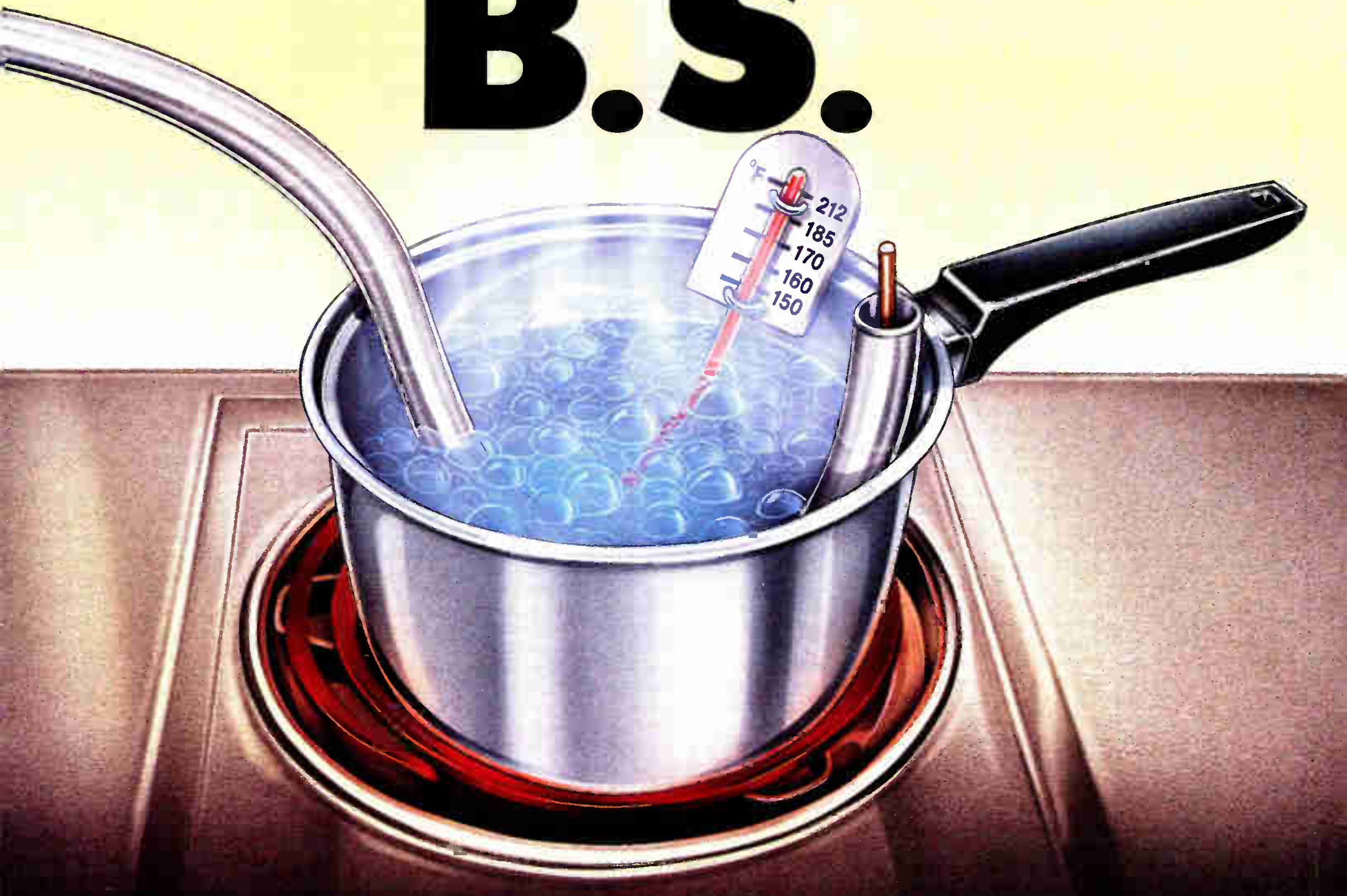


modulated aural carrier appears similar to the spectrum of the BTSC frequency-modulated aural carrier. While in a perfect system, the two modulations can be kept separate and non-interacting, cable systems and TV receivers provide opportunities for the amplitude and frequency modulations to mix, causing interference to the audio, and possibly to the decoding as well. Thus, the carriage of stereo in BTSC form on scrambled cable systems is in doubt.

It also is possible that scrambling as described above can trigger BTSC TV receivers into the stereo mode because the amplitude modulation on the aural carrier is converted to frequency modulation, which then looks like the BTSC pilot. This effect did not occur with BTSC TV receiver #1. That receiver did, however, trigger into tuning the SAP (labeled Audio II) mode when the audio signal from a DBS receiver was put on the cable channel without baseband audio processing. Whether the stereo mode is triggered depends upon the sensitivity of the stereo detector, which may vary widely from set to set, and upon the cable equipment involved.

***"We, as engineers, have to be careful to look for a level of quality and cost that does not exceed the user expectation or need. . . A reasonable goal would be to provide better than 60 dB S/N to all subscribers instead of the 40 dB they now are getting."***

# B.S.

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General Cable Company CATV DIVISION

Based on the data obtained so far from the lab tests, the tests at Skokie and the tests at KYW/Wildwood, we have identified the following problems with BTSC:

1. BTSC affects sin-wave sync suppression by causing amplitude modulation of the picture.
2. BTSC pilot may or may not get through a baseband converter.
3. Pulsed sync suppression may affect stereo more than expected. We thought that Jerrold would only cause noise on a non-stereo channel, but it may reduce or eliminate stereo separation.
4. BTSC is a very sensitive process. The main channel (L + R) is linear while the L—R is nonlinear. Broadcasters are having a difficult time setting up stations to get them balanced. If unbalanced, separation and the value of stereo are lost.
5. The useful audio bandwidth of BTSC out of the TV receiver appears to be about 10 kHz.
6. We have observed significant levels of horizontal frequency in the audio output. With all that horizontal field in a TV set, how is this going to affect the stereo processing?
7. BTSC stereo generators are expensive equipment. We paid $36,000. How are you going to test the performance of your systems? You may need the cooperation of the broadcast station to put out special frequency and level sweeps to help you determine your performance.
8. Even lab testing is not easy. We found that BTSC is a whole new set of unknowns. If you haven't experimented with these signals, you may be surprised. dBX is nonlinear with respect to frequency and levels. It counts on nature to not have very much high frequency energy. A constant level frequency sweep doesn't work. We had to design a filter to preshape the input signal frequency response.
9. BTSC uses a companding process but only on the L—R. For the same signal carrier level, what will the signal to noise be on the L + R component? That same carrier is being spread over 200 kHz, not 75 kHz. Five % of it is used all the time for pilot.
10. BTSC does not make it through most headend processors. We need to test the effects of RF processors and the possibility of incidental phase modulation. Baseband processors need to be reworked. New units were needed at Wildwood and at the lab tests.
11. BTSC may not make it through microwave links. New wideband units were needed at the Wildwood test.
12. The most L—R separation that we have measured is 20 dB.

**Work needed**

The following tests have been proposed for the completion of the Wildwood test program. There will be several quantitative tests for stereo performance. These tests will include separation, frequency response, distortion, hum, dynamic range and others.

1) Common headend equipment.

a) Test with standard cable demodulators and modulators. Is the stereo channel (L—R) stripped? Is the stereo pilot stripped? Will it still trigger stereo TVs into the stereo mode? Is resulting monaural audio up to standards?

b) Test with modified off-air demodulators and modified cable modulators. Determine stereo reception quality.

c) Test with standard off-air RF cable processors.

2) Cable converters.

a) After determining that good stereo can be obtained with 1b or 1c above, measure the performance with various RF converters (no scrambling) in place.

b) With baseband converters, determine whether the stereo is stripped whether the pilot is stripped and whether the TV is triggered into decoding stereo.

3) RF scrambling.

a) With various RF scramblers at the headend and matched descrambling converters at a drop, measure stereo performance with scrambling on and off. Separate tests are needed for:

1. Constant 6 dB pulsed sync suppression
2. Constant 10 dB pulsed sync suppression
3. Dynamic mix of above modes
4. Constant 6 dB sync suppression with advanced timing of pilot pulses on aural carrier
5. Sine-wave sync suppression

b) With the various above RF scramblers and descramblers in place, and with only monaural sound transmitted, determined whether stereo TV receivers are falsely triggered into trying to decode stereo.

4) Effect of full BTSC, stereo-only, mono + SAP and mono + engineering channel on reception of upper adjacent channel.

a) Observe the quality of the picture on the channel just above the channel carrying the stereo modes as the stereo modes are switched on and off. Previous tests showed that the fine tuning is more critical when the lower adjacent channel has stereo.

## W & S approach

The W & S method for MTS delivery uses the broadcast FM format. It is estimated that more than 50% of the cable systems now have FM services offered to their subscribers. It also has been estimated that there are over 10,000 channels worth of FM delivery on cable. Although FM is criticized because it does not deliver compact disk quality, we feel that the quality improvement over standard TV sound makes this approach an excellent logical alternative to BTSC.

We, as engineers, have to be careful to look for a level of quality and cost that does not exceed the user expectation or need. Improved FM formats might work. One example is found in the new hi fi VCRs. They use wide deviation FM and produce signal to noise ratio. Another is noise improvement

**Figure 8 Test with audio buffer amplifier and modified cable modulator**

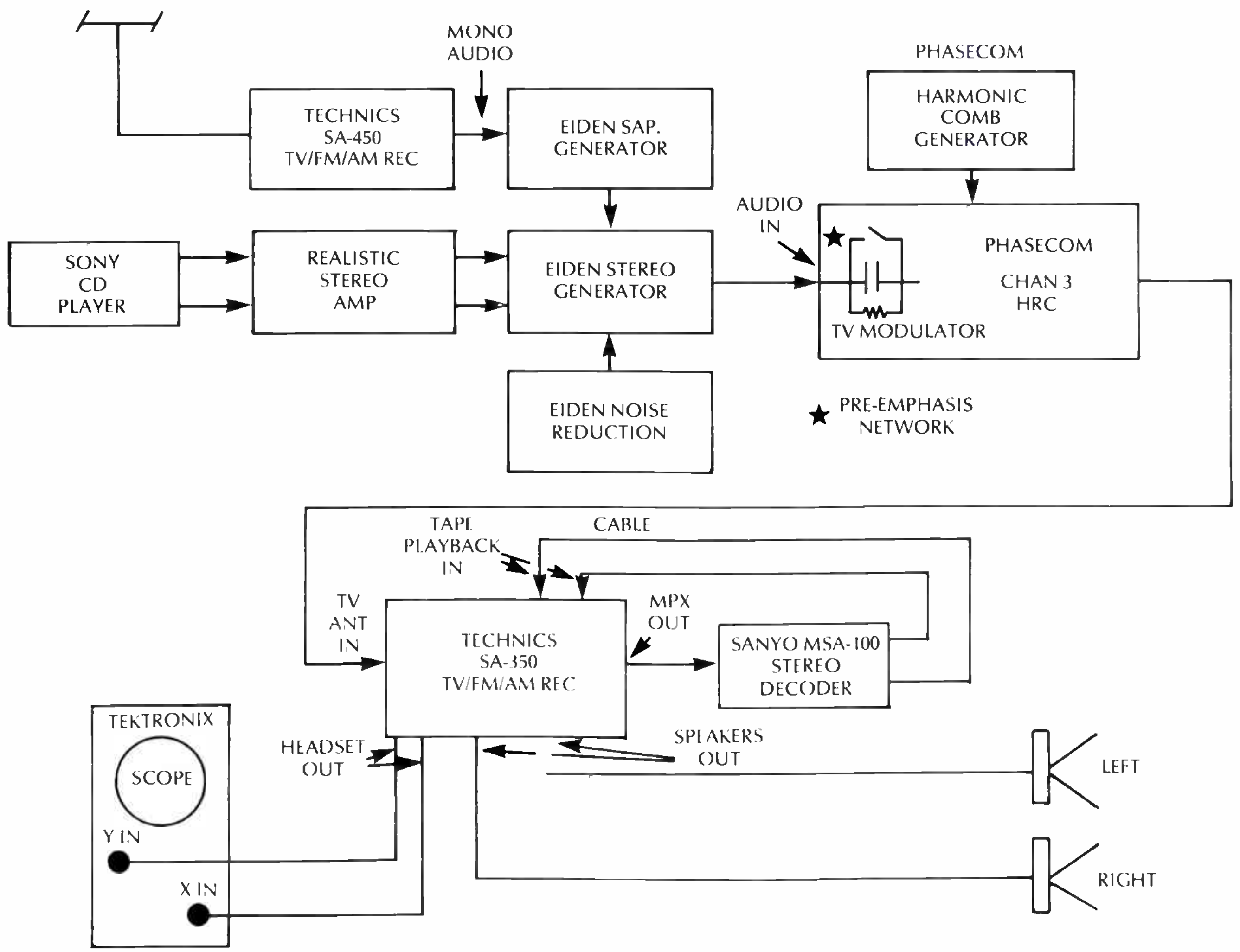
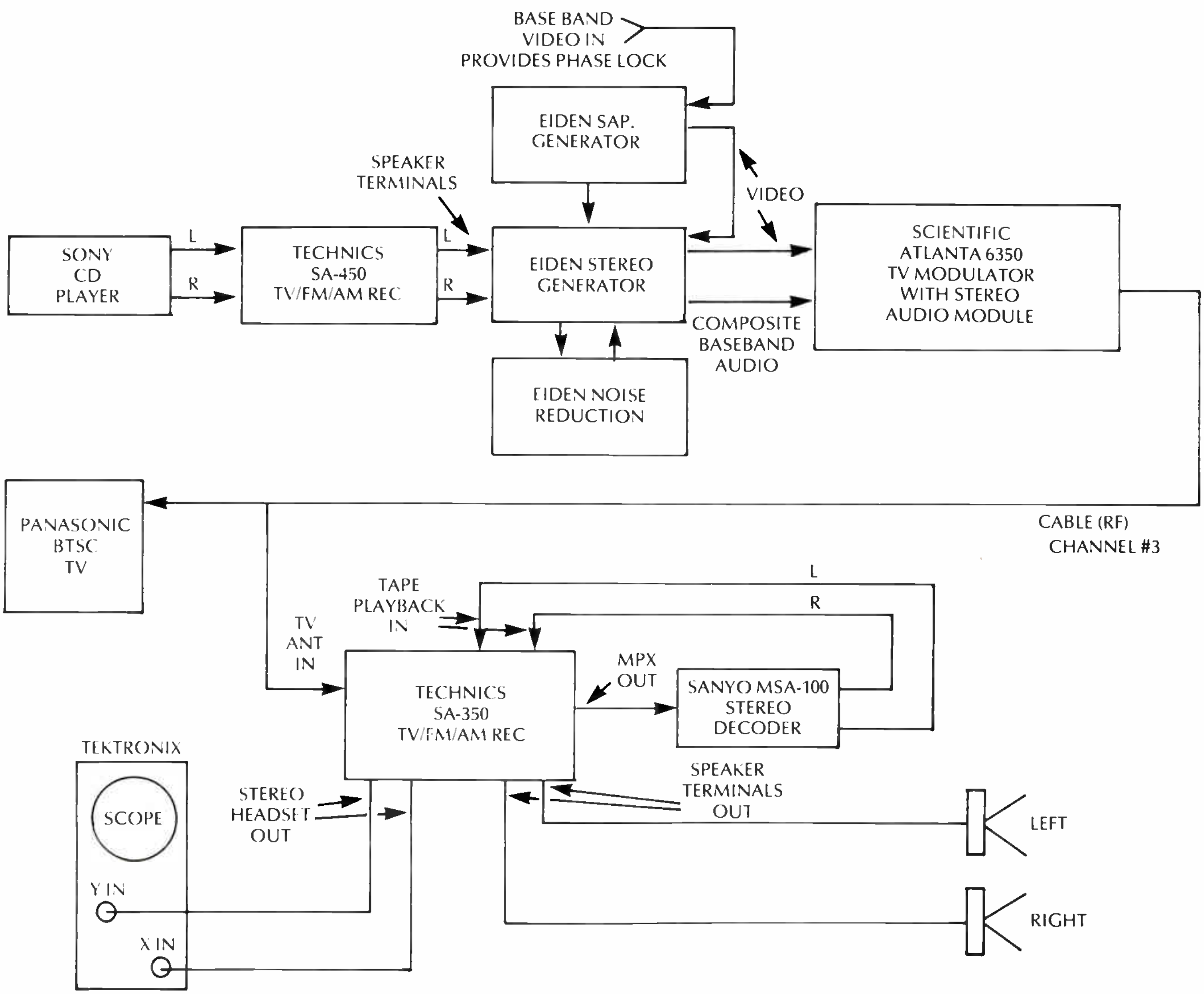


**Figure 9 Test with new stereo cable modulator**




like Dolby or dBX. A reasonable goal would be to provide better than 60 dB S/N to all subscribers instead of the 40 dB they now are getting.

The frequency band that appears most practical is 88 to 120 MHz. We feel that the recent FCC rule on 108+ makes the use of FM in that band more attractive. The basic for the W & S design is to recognize that the standard FM format is the accepted standard today. To date, cable subscribers have needed an FM receiver, amplifier and speakers. Manual tuning of the FM receiver has been necessary. The W & S approach uses the infrared link provided by the IR remote to tune video and audio. Since the remote provided with the converter also controls the audio service—volume control, mute and second language are easily provided.

## Conclusion

In summary, we've tested the BTSC format and discovered a number of problems—some we anticipated and others we didn't. We believe BTSC is not the most workable solution. Why should cable wait for BTSC? A known answer, FM, already is in place in most systems. CED

### Author's note

*I would like to acknowledge the invaluable assistance provided by Westinghouse R & D personnel, George Griffin and E. S. Kohn, and by Group W personnel, Charles Magee, Vince Pombo and Jim Wonn.*

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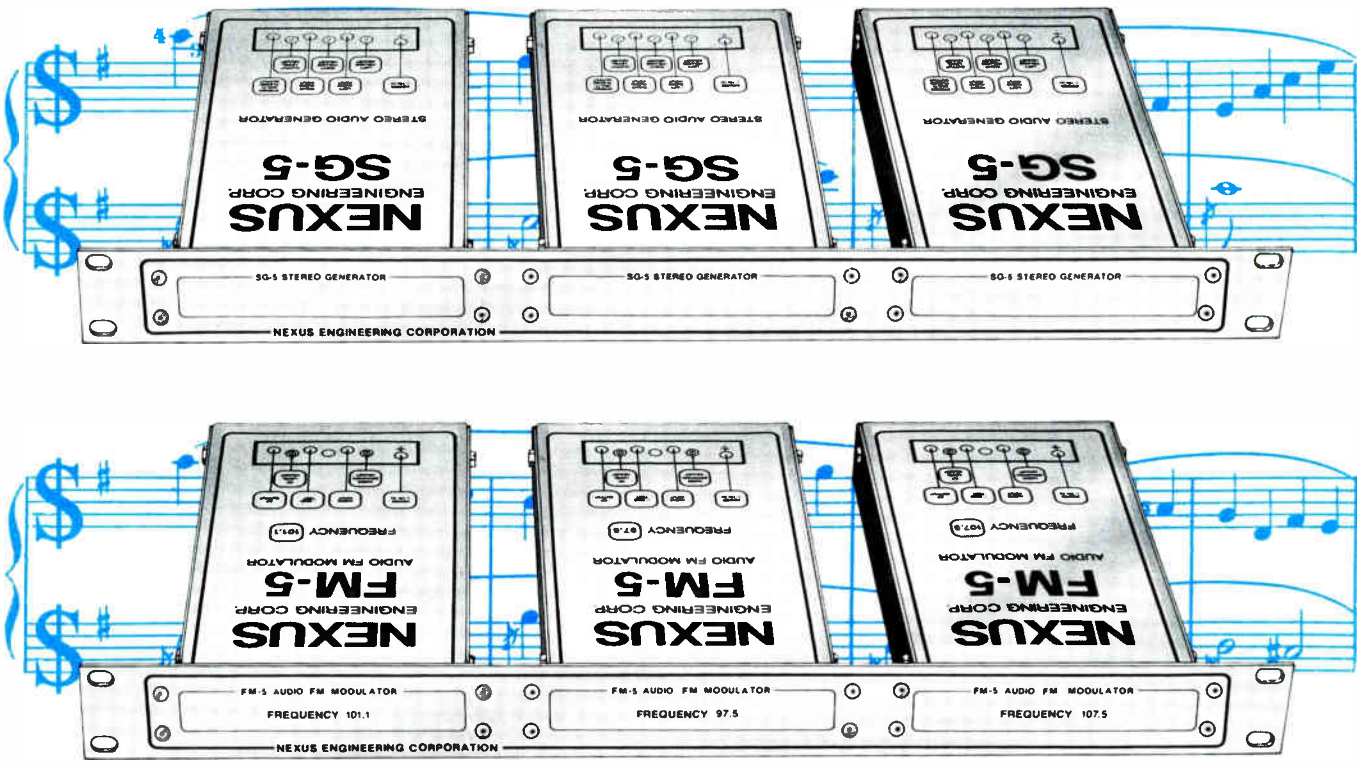


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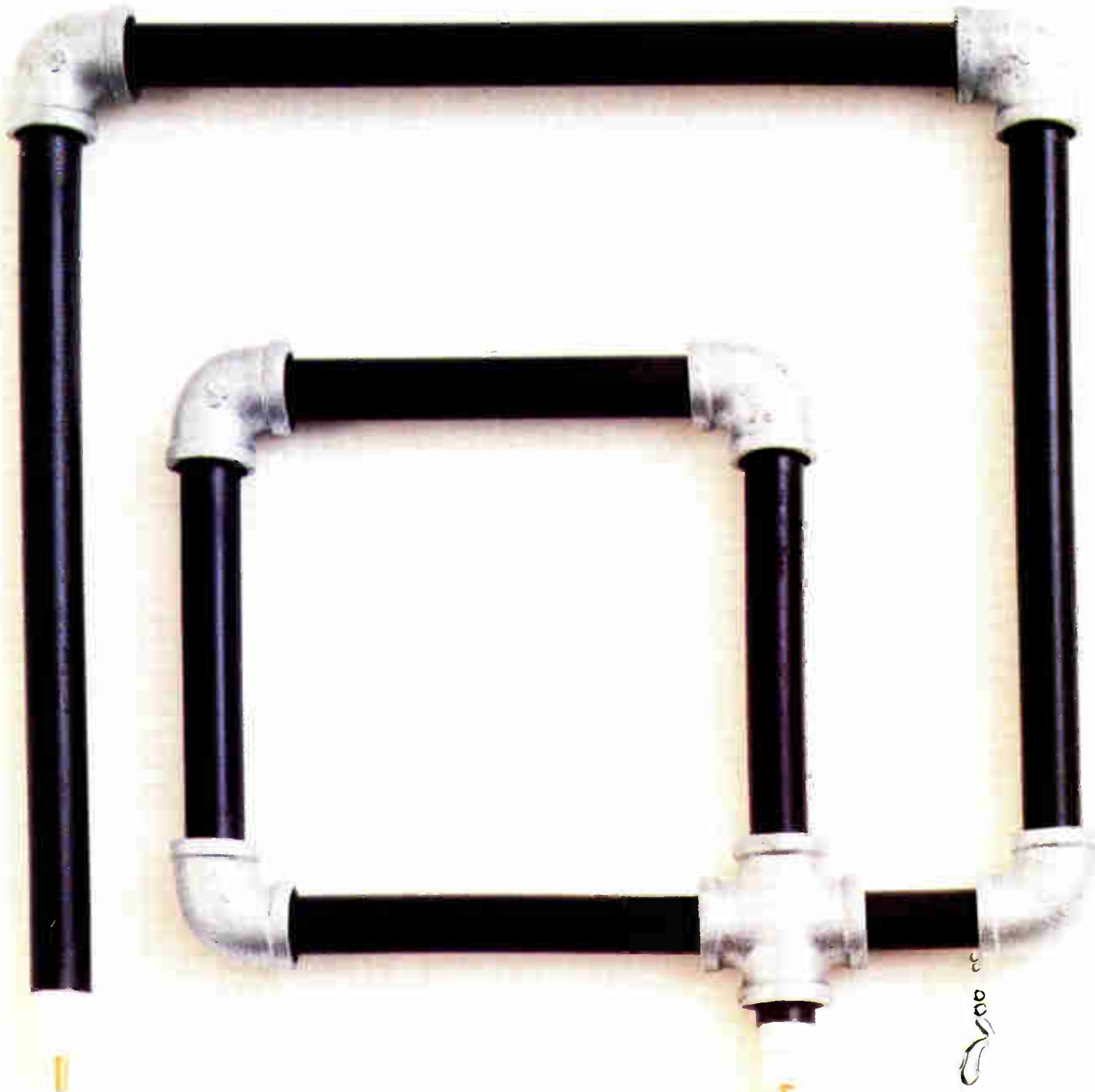

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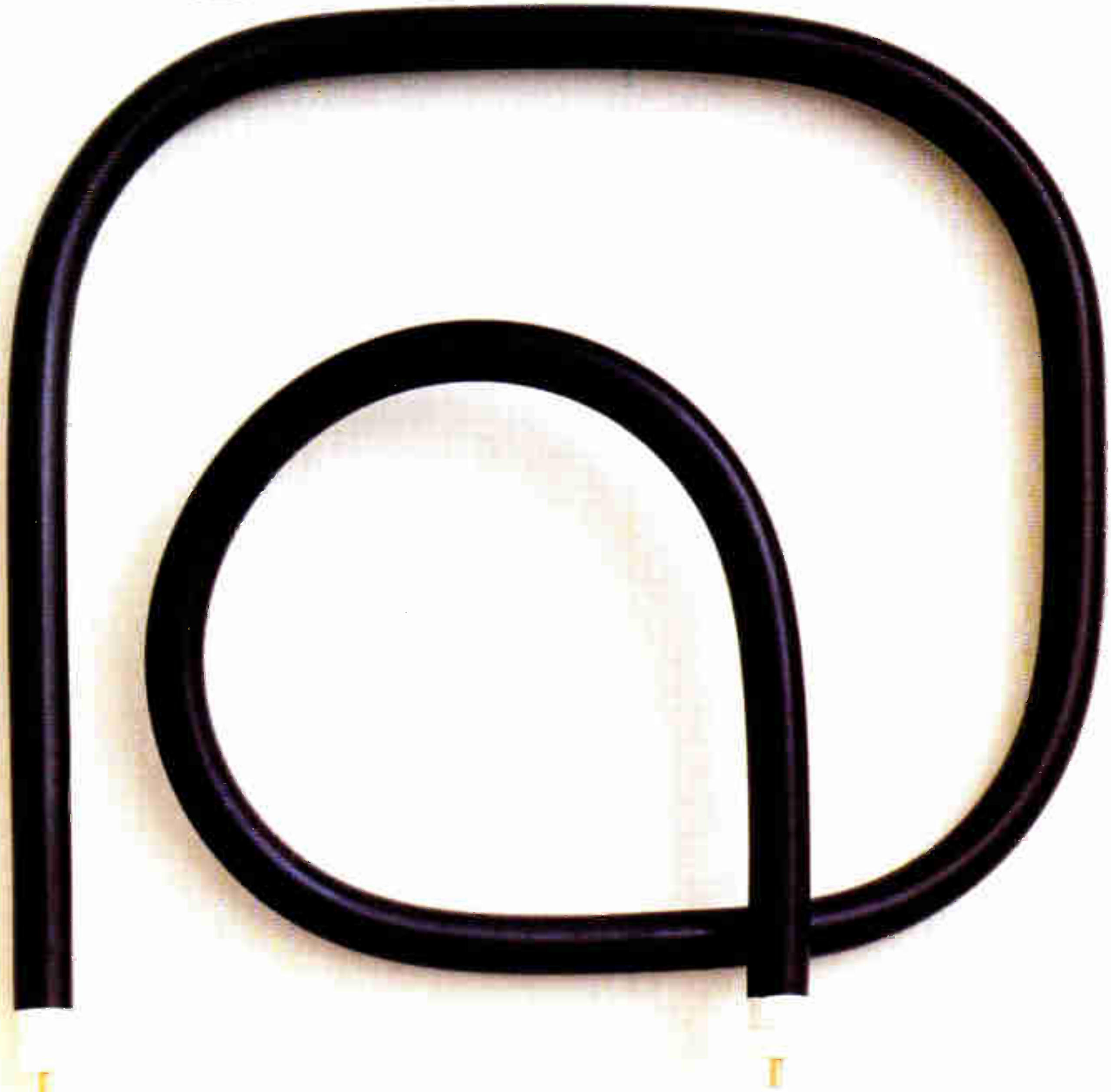

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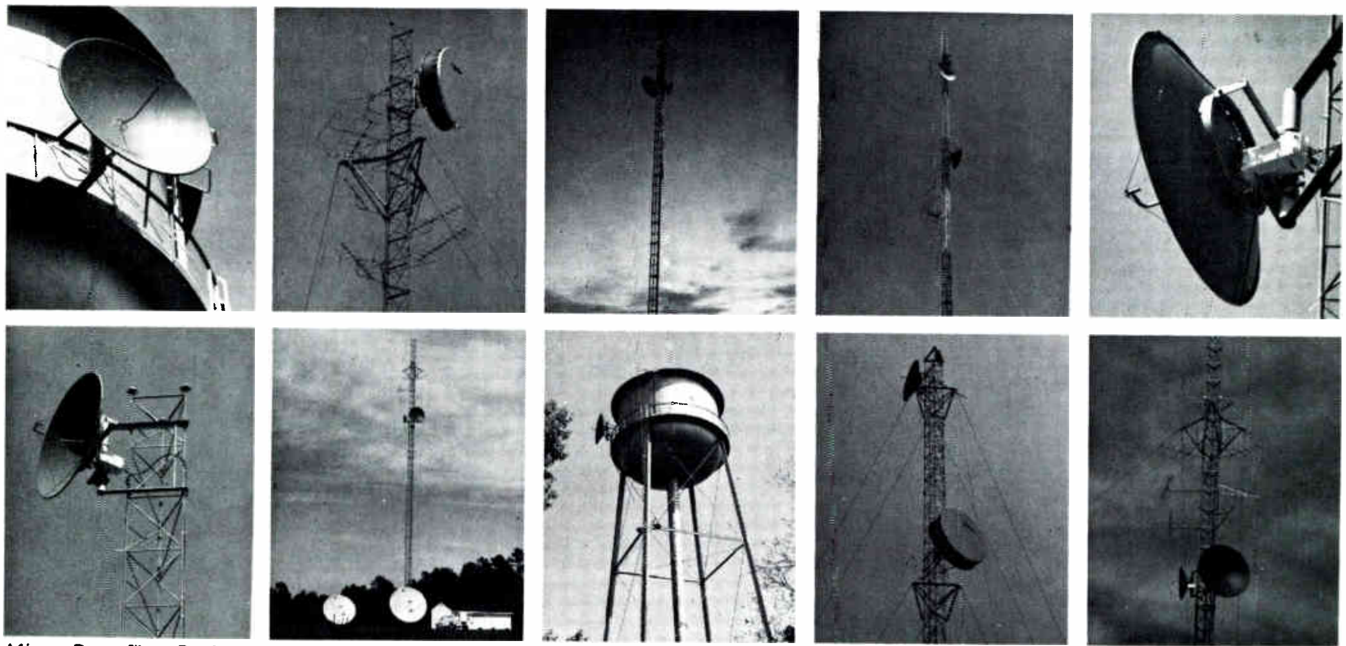

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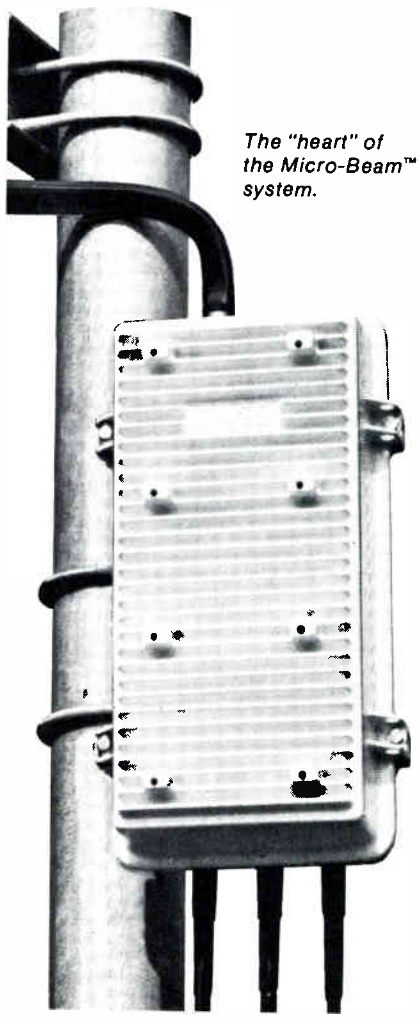

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# Super quality MTS stereo

*By Frank McClatchie, Learning Industries*

Existing standard FM multiplex stereo technology can deliver super quality multichannel stereo sound in all respects except signal-to-noise ratio (S/N) and stereo separation, and S/N is the most glaring defect in cable systems. In systems with large numbers of tandem line amplifiers, the noise can become so overbearing that subscribers prefer to switch to monaural reception just to reduce the noise level, even at the *loss* of stereo.

A super quality transmission system is one that does not degrade (and does, preferably, enhance) all other transmission parameters as compared to standard multiplex stereo FM, while also expanding the dynamic range to the 85-95 dB range and stereo separation to at least 60 dB.

## Analog vs. digital

Good digital disc players can play back recorded music with fidelity unrivaled by any other home-type tape or record system. In fact, the improvement over LP discs or commercial tapes borders on the spectacular. No wonder then that many people are lead to believe that if it is digital, it must necessarily be better and, therefore, digital *transmission* also must be better than analog transmission. But is this really so; are recording and transmission considerations the same?

It turns out that for the transmission of music, nothing could be further from the truth, the popular press to the contrary notwithstanding.

Why should transmission be any different than recording when deciding between analog and digital processes? Both are degraded by noise introduced within the medium, but in recording no one really cares what power density or bandwidth is required to lay down and retrieve the music from the record medium, whereas power density and occupied bandwidth are a prime concern when transmitting music over cable systems.

When it comes to comparing various transmission processes, information theory is as fundamental as you can get and is, thus, the best place to start. A fundamental theorem that applies directly to the subject at hand states: *Given* that both transmission processes are limited to the same power level, and *given* that each must encounter the same noise level (equal C/N), and *given* that each must occupy the same bandwidth, and further *given* that the two processes have equal signal energy distribution efficiency, then *consequently* both systems will have an equal signal-to-noise ratio.

In other words, on a level playing field, there is no "digital advantage" at all and, in fact, neither system is superior merely because of the type of process used. We must be more discerning and look carefully at the relative advantages and disadvantages of each system, particularly with respect to the bandwidth available in cable systems.

What we are left with is a choice between two systems that are basically equal, given equal transmission parameters. However, the digital system is by nature a wideband beast, while analog is at home both in wideband and narrowband facilities.

Wideband channels occupy two or more orders of magnitude greater bandwidth than the baseband audio bandwidth being carried. This means that a wideband system would occupy about 3 MHz to carry stereo 15 kHz program audio.

Narrowband channels occupy significantly less than two orders of magnitude greater bandwidth than the audio signal. In general, narrowband signals will occupy about one magnitude greater bandwidth than the audio signal. This means that a narrowband signal will occupy about 300 kHz of bandwidth.

Almost all cable systems have used up most of the spectrum available on cable amplifiers. This means that if wideband channels are used, some TV channels must be given up, whereas if narrowband processes are used, about ten times as many stereo channels can be transmitted, provided that the power level of each channel is kept quite low.

With the advent of stereo TV audio, the near future may see a need to carry all TV channels in stereo, as well as a number of stereo music channels. Wideband processes cannot be considered unless the cable operator is willing to drop a number of TV channels from his system to make way for the audio requirement. This virtually requires that narrowband systems be used in a cable system.

## Narrowband digital

Such systems must reduce word size (sampling levels) to reduce occupied bandwidth. Dibit, quadbit and higher digital bit compression require higher power levels to overcome noise unless some other parameter is given up. So reducing sampling frequency gains very little since the sample frequency is already near minimum on wideband systems.

The consequence of reducing the number of sampling levels is higher quantizing noise and waveform distortion, particularly at low audio levels. Attempts to reduce these effects with digital companding (i.e. graduated step levels, with small steps at low levels and large steps at high levels) result in even worse effects in which small high frequency components superimposed on large low frequency sounds are tuned on and off at the low frequency rate because the sample levels cannot discern the high frequency components as the waveform reaches the highest positive or negative peaks.

The impact of narrowbanding a digital system is on waveform distortion of the audio signal on a continuing basis.

## Narrowband analog systems

These must apply companding processes to achieve "super quality" sound transmission. Modern analog companding systems do not alter the waveform of the music on a continuing basis, but only during times of average (or RMS) volume level change. These transient alterations of wave shape are confined to within 20 milliseconds. This is a crucial consideration since the human ear is not sensitive to waveform alterations of less than 20 milliseconds duration. You may consider that the ear is deaf to these effects. Thus, analog companding processes are not perceived as distortion to the ear, but digital bandwidth reduction is.

## State-of-the-art analog

Analog systems using FM modulation and modern companding processes can deliver super quality stereo through channels with bandwidths considerably less than digital systems without creating perceptible processing artifacts. This is because, unlike digital encoding for narrowband transmission which alters the actual waveform of music, analog companding alters only the average (or RMS) level while leaving intact the exact original wave form. In a modern analog compandor, only changes in average level require processing and, when that is done within 20 milliseconds, the ear is unable to perceive that a change took place on the transmission facility. An excellent example of this new companding process is the Telefunken HIGH-COM technology that employs a very fast attack time and a variable "soft-switched" release time. This patented system takes advantage of the characteristic of the ear that prevents these rapid changes in the rate of companding from being heard.

This new technology is embodied in the Studioline music distribution system. This system delivers digital audio disc sound quality through a satellite distribution system and also carries this process on through to the subscriber's stereo set. This enables a subscriber to listen to super quality audio at home, no matter where he is in the cable system. The transmission bandwidth in the cable system is only 300 kHz (as compared to 400 kHz in standard FM stereo multiplex) and enables stereo transmission on the cable system at a power level 10 dB lower than TV audio (25 dB lower than TV carrier). This system delivers a 46 dB improvement over standard FM stereo multiplex while occupying less bandwidth and less transmitted power.

Therefore, a cable subscriber with a Studioline cable audio terminal will be able to receive stereo music at the same quality as though he had a digital audio disc player in his home, even if he resides at the very end of a cable system where standard FM multiplex stereo would be of only fair to poor quality.

The very narrow band occupancy and very low operating power level enables the Studioline system to provide up to 69 channels of super quality stereo. Nine channels are transmitted in the 72-76 MHz band, and 20 channels each in the A-2, A-1 and A bands. The frequency plan and operating power levels meet the new FCC carriage rules for the A-1 and A-2 bands. The system also has been tested and found compatible for transmission over Hughes AML microwave distribution systems.

The Studioline system is tierable and addressable and also will autotrack television channels through any TV set-top converter, either baseband or RF conversion. Models also are available that allow remote control volume changes when used with baseband converters equipped for this option.

Off-the-air TV stations are carried in stereo by decoding the BTSC stereo and second audio program, then encoding into the Studioline system for transmission to the subscriber. This ensures that the stereo signal gets through the cable system completely unimpaired. CED

## Correction

The gremlins got us. In our January profile of taps and traps, we omitted the Regal line of taps and the Arcom traps.

The Regal series includes both 500 and 600 MHz products. The 2-, 4- and 8-way taps feature minimum return loss of 20 dB at 450 MHz, 18 dB at 500 MHz and 17 dB at 600 MHz. All pass power at 6 amps, AC or DC.

Maximum insertion loss with tap value of 32 is 0.6 at 450 MHz and 0.9 at 600 MHz. At 500 MHz, minimum tap-to-output isolation at tap values of 8-32, 11-35 and 14-38 is 20-40 dB, 23-43 dB and 26-48 dB respectively. At 600 MHz, minimum tap-to-output isolation at the same tap values is 20-42 dB, 23-45 dB and 26-50 dB respectively.

Regal products are available exclusively from Anixter Communications.

Missing from our listing of traps was the Arcom line. Minimum channel rejection depth is -70 dB, lower adjacent video attenuation is less than 1 dB; lower adjacent sound attenuation ranges from -4 to -25 dB. Upper adjacent video attenuation runs from -2 to -15 dB with insertion loss of less than 1 dB at tempereratures from -40° to +140°F.

Arcom traps are available from Northern CATV Sales.

# Cable isolation

*By Dr. Raymond G. Capek,*
*Zenith Electronics Corp.*

The National Electrical Code (NEC) requirement of Article 820, Community Antenna Television and Radio Systems, mandates bonding between all power and communication facilities where they enter premises. To satisfy this requirement, the shield of a cable must be connected to the same ground as the neutral of the power line. As a result of the regulation, all cable installations become potential ground return circuits for power line currents caused by high resistance neutral returns. The problem of currents in the cable shield must be solved by interrupting the cable shield as opposed to interrupting the ground wire. Figure 1 depicts the power drop and three possible shield grounds at a house.

Separate grounding of the cable with a ground rod, as shown in part A, is not bonding. To comply with the NEC, a wire not smaller than #18 must be run from the cable ground to the power ground.

An interruption of the ground wire, as shown in part B (for example with a metal oxide varistor), renders the ground broken and the system both non-bonded and non-grounded. Even though the system has continuity at elevated potentials, it is unacceptable because of danger to individuals in the home with the discontinuous ground.

Interruption of the cable shield, as shown in C, will prevent power line currents from flowing through the cable shield. However, interruption of the cable shield must not impede current flow at communication frequencies,

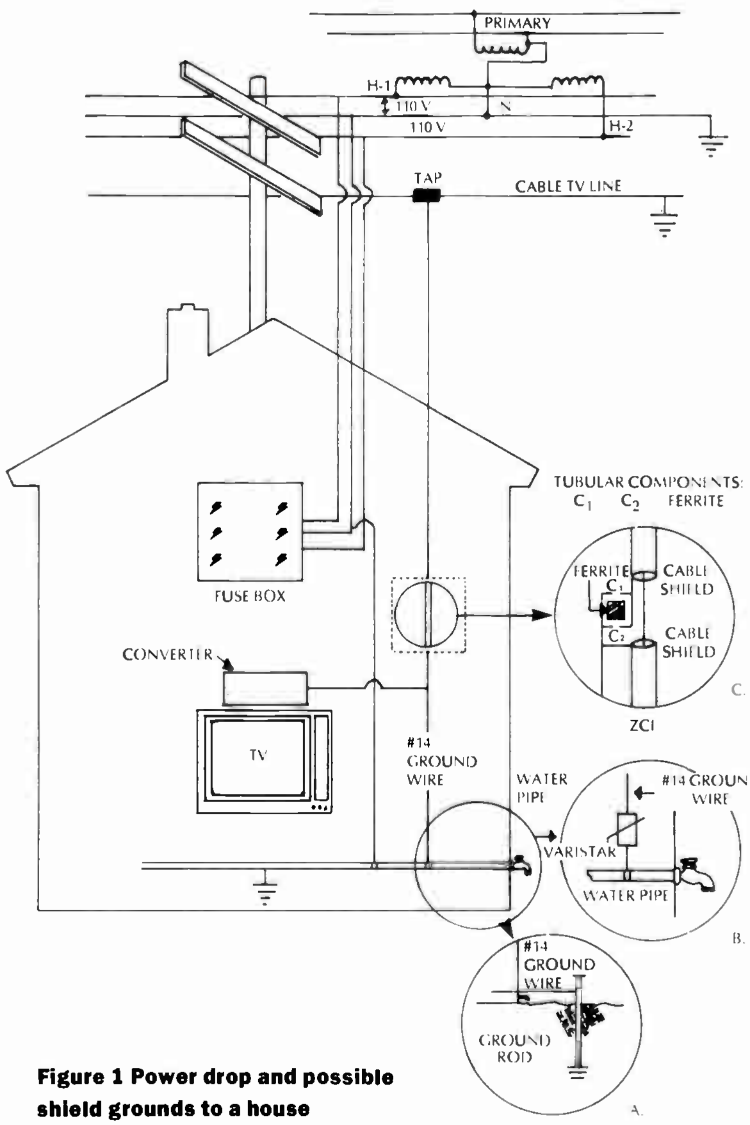


**Figure 1 Power drop and possible shield grounds to a house**

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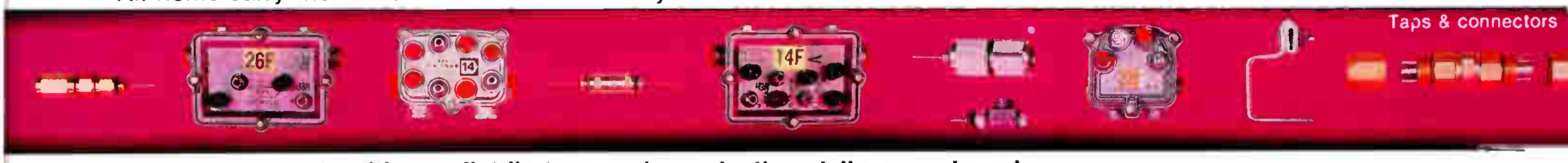


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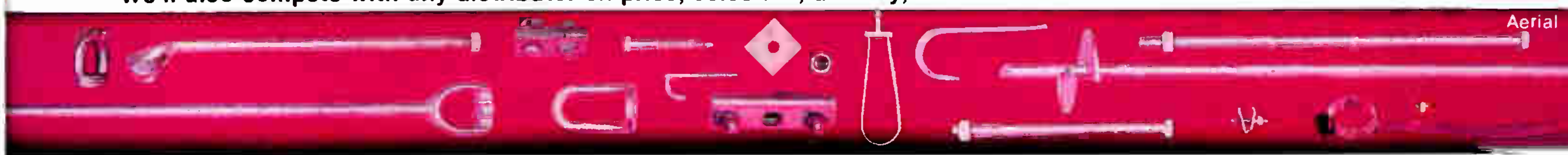


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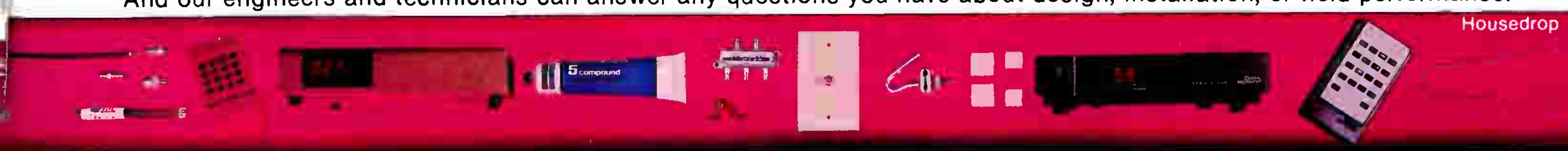


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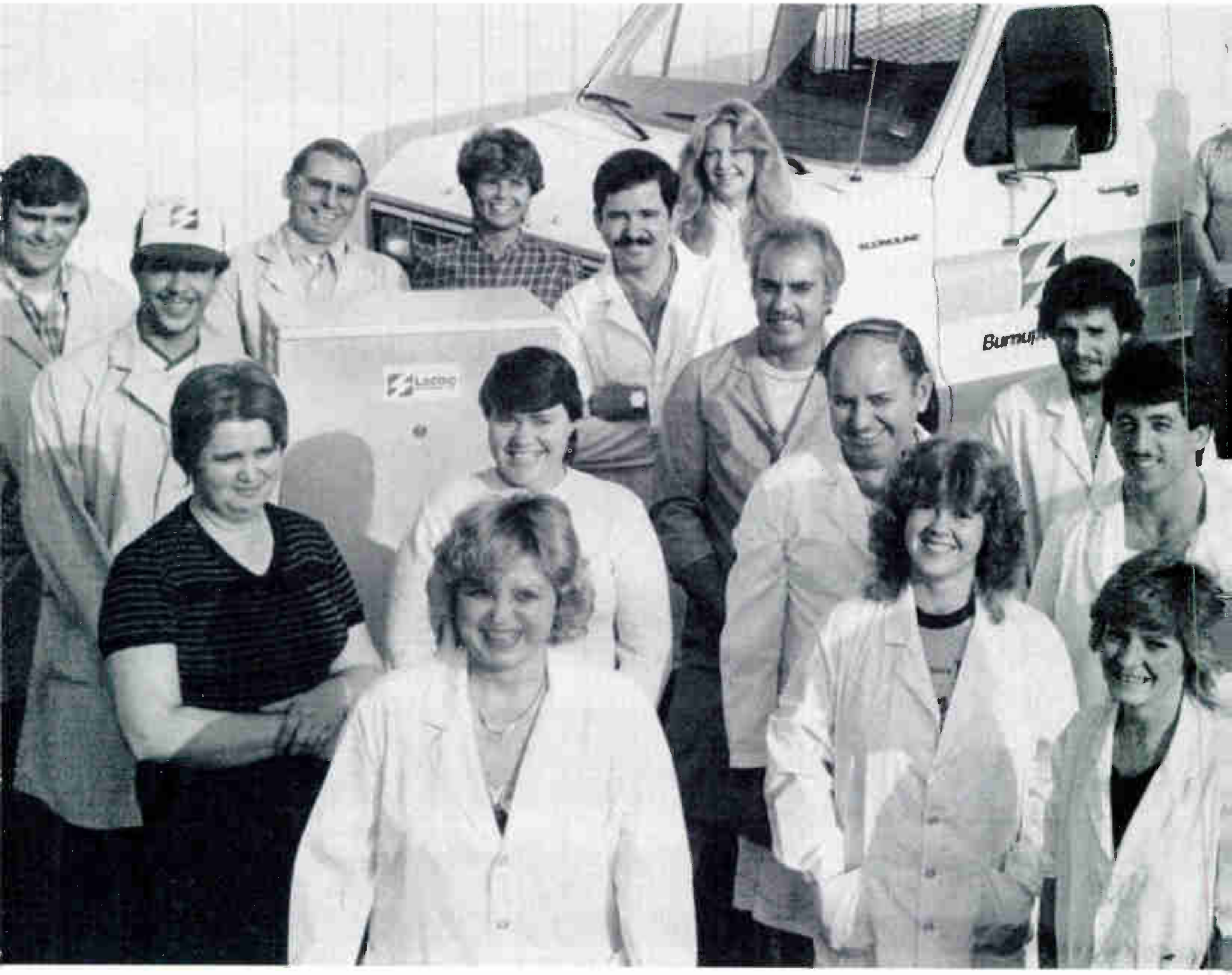


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**Figure 2 VSWR test set-up**

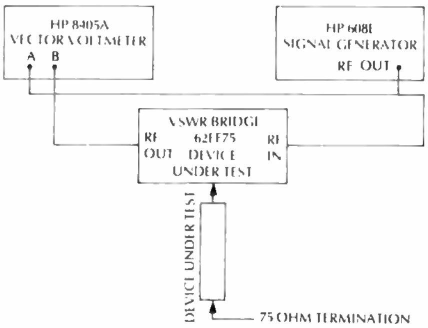



**Figure 3 Insertion loss test set-up**

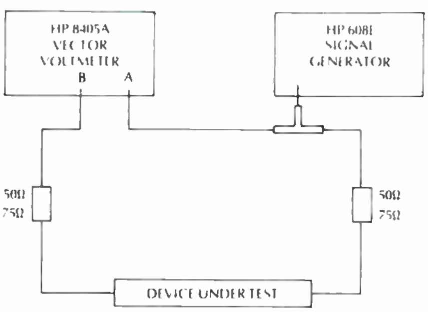
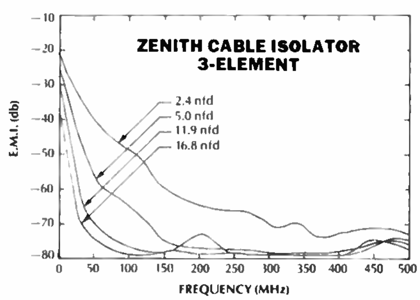



**Figure 4 Effect of capacitance value on EMI attenuation**




nor must shielding at these frequencies be compromised. This is of primary importance to multiple service operators since signal loss and co-channel pickup are unacceptable. (Special steps to ensure signal integrity will be discussed.)

This concept allows the system within the home to be safely bonded to the proper ground and the users protected. The cable system is protected to the extent of the isolation. Since such protection is the object of the NEC regulations, these regulations permit isolation systems of the type described. Article 820-7 (b), Shield Protective Devices, permits grounding of a coaxial drop cable by means of a protective device that does not interrupt the grounding system within the premises. Installing the isolator outside of or at the entrance to those premises does not interrupt the grounding within the premises.

## TV receiver isolators

A system that has been under development and evaluation for two years at Zenith will illustrate the limitations and problems of cable isolation. At the 1982 Western Show, Jim Stillwell discussed a Zenith TV receiver isolation system as a possible solution to cable isolation. It consists of a tubular ferrite bead and two tubular capacitors that provide signal coupling between the two shields as well as DC isolation. Together, these components constitute a pi filter for EMI attenuation. The two capacitors in parallel have a 3000 to 4000 pf capacitance value with a minimum 0.0625 inch conductor spacing as required for U.L. listing. For the device shown, centerline isolation is realized by a series capacitor in the tuner of the receiver. However, it also has been incorporated in the connector.

A typical unit for TV receivers has a U.L. listing, a capacitance of 3000 to 4000 pf, a dissipation factor (df) of 0.01 to 0.08, a ferrite bead with an impedance at 50 MHz having a real component greater than 15 ohms and an imaginary component less than 17 ohms, an impedance at 17 MHz having a real component greater than 7 ohms and an imaginary component less than 17 ohms, and a voltage breakdown in excess of 1200 VAC. The units can have a bleeder resistor of 1 to 4 M ohms (thus the 0.08 df). The EMI attenuation is adequate over the frequency range, and the attenuation increases with frequency as is characteristic of pi networks. The attenuation values at frequencies above 200 MHz are close to the limit of the measuring equipment.

The EMI attenuation measurements were made using a method similar to the Belden SEED (Shield Effectiveness Evaluation Device) system. The VSWR measurement is shown in Figure 2. The insertion loss was measured with the system shown in Figure 3. It was less than ½ dB for all devices.

## Cable isolators

As a result of interest from the cable industry, the TV receiver isolator was modified for insertion into a line or as a retro-fit for existing ground blocks. All units utilize termination by means of F connectors, either male or female. Because of two-way cables and system coupling, the cable industry requires greater EMI attenuation at the lower frequencies than are used for TV receivers.

The EMI attenuation of an isolator is improved by using higher capacitance values. Figure 4 shows that capacitance increases to 17 nf will provide EMI attenuation of 60 dB at 20 MHz. The problem is that this capacitance increase would decrease the impedance and incease the leakage current at 60 Hz. To obtain U.L. listing, the leakage current must be less than 0.5 ma at 125 V - 60 Hz. To realize this, the capacitance must be less than 10 nf.

In addition to greater EMI attenuation, higher voltage breakdown values can be realized. The voltage breakdown of the isolator is dependent on the gap between electrodes; and if values higher than the 1200 VAC potential for the TV receiver isolator are required, potting and thicker capacitors are necessary. To maintain the same EMI characteristics for the high voltage unit, the capacitance value must be maintained. This requires a higher dielectric constant material or a unit of greater length. The present units utilize a material with a dielectric constant of 6,000. Further increases in dielectric constant are achieved with a degradation in dielectric strength, temperature coefficient and dissipation factor.

Units with very high voltage isolation have been developed which will isolate a 7½ KV dump from a 0.5 $\mu f$ capacitor. These units must have center line isolation to prevent breakdown to the center conductor. As higher isolation potentials are achieved, all of the components of the system must be reexamined to assure that other parts of the system are able to withstand the potentials. However, very high voltage isolation may create a safety concern because it could create a potential hazard to individuals inadvertently contacting an unprotected isolator. Therefore, the voltage across an isolator should be limited to a maximum value, although a protective insulating barrier may enclose the unit.

To obtain U.L. listing on an isolation

device, a spark gap has been proposed that will ensure that the voltage breakdown will not exceed 1200 VAC but will not be less than 700 VAC. For this unit a 10-15 K ohms resistor is in series with the spark gap to extinguish an arc initiated by a high voltage burst when the potential across the unit drops below 700 VAC. The spark gap limits the potential sustained across the isolator and insures that the discharge will occur across the gap and not elsewhere in the unit. Samples of these units are presently being evaluated by U.L., and completion of testing is imminent.

Additional EMI performance can be realized with multisection pi filters. Rather than utilize capacitance values that exceed the limit allowed for 60 Hz leakage current, a three capacitor, two ferrite network provides improved EMI attenuation as shown in Figure 5.

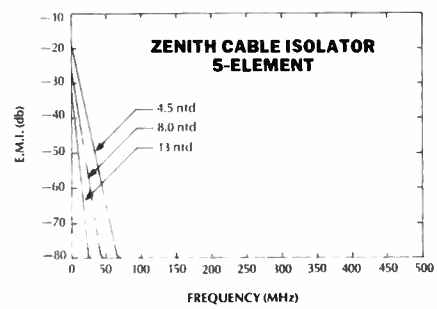
For European installations where the capacitance limit is 5 nf with the 240 volt power systems, a more complex multisection filter provides the EMI attenuation required for two-way cable systems. For these units three capacitors totalling 5 nf with two ferrites between them comprise a dual pi filter and provide attenuation similar to a 10 nf, three element unit.

Over 40,000 units are in service, and no problems with co-channel pick-up or signal loss have been associated with the isolator. Tests made with the New York Cable Commission mobile unit at 25 MHz signals found no detectable interference.

## Spurious ground loops

The advantage of the pi filter is that radiation (egress or igress) is greatly minimized. In addition to the benefit of providing isolation from ground fault currents, these devices have proven adequate for isolating components from each other and preventing spurious ground loops, the possibilities of which have greatly increased with the popularity of VCRs and decoders. To block such loops and prevent radiation, devices with adequate EMI attenuation are required. Male-female F connector units were designed for use in lines between components as opposed to the line coming into a premises.

**Figure 5 EMI attenuation of five element isolators with capacitance values of 4.5 to 13 nf**




## Summary

Cable isolation can be achieved by interrupting the shield and bridging the gap capacitively. EMI attenuation is enhanced with a lossy ferrite bead complementing two capacitors to form a coaxial pi filter. Significant EMI attenuation improvement is realized by increasing the capacitance value, but that value is limited by the allowable leakage current. The voltage breakdown potential can be increased by increasing the dielectric thickness of the capacitors, but the amount of voltage isolated by a device can be a safety concern. The NEC and U.L. have recommended that the voltage across an isolator be limited, and a spark gap has been found to be the best method of accomplishing this.

EMI attenuation depends on how the capacitive and inductive elements are distributed. With a given total capacitance, a multi-section pi filter has attenuation superior to a single pi filter. CED

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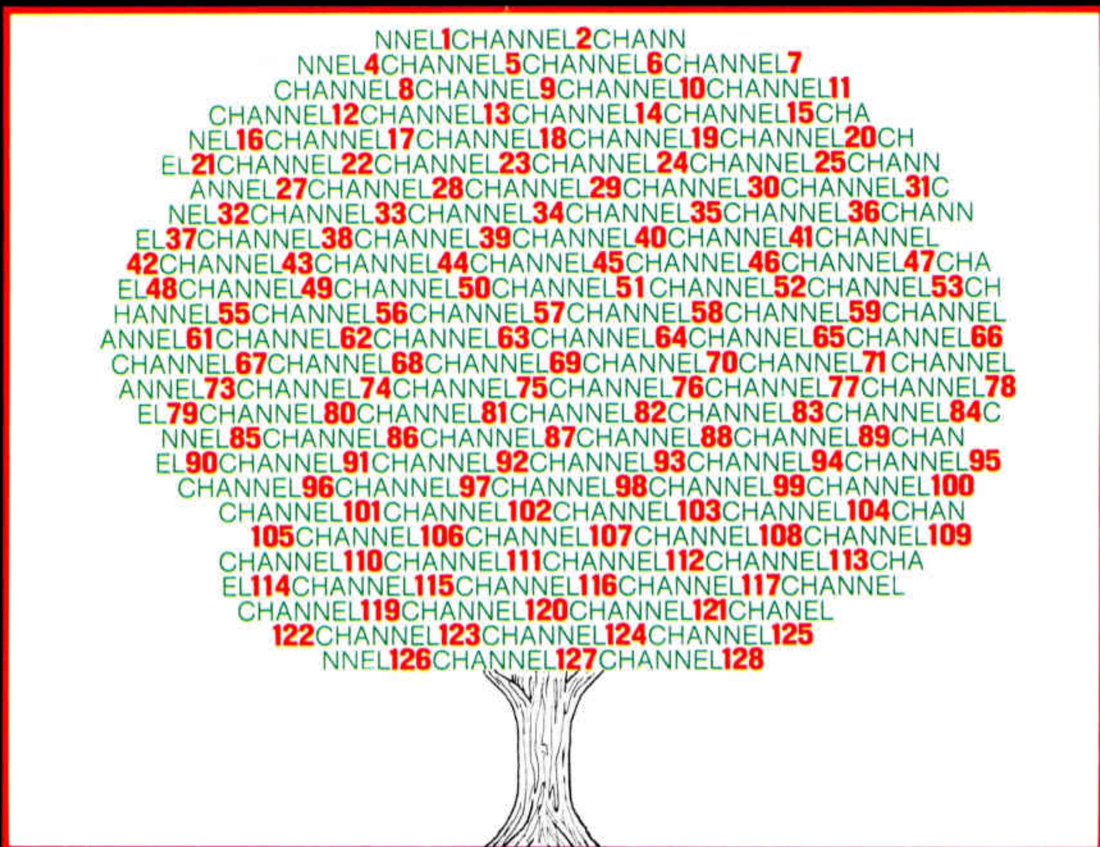


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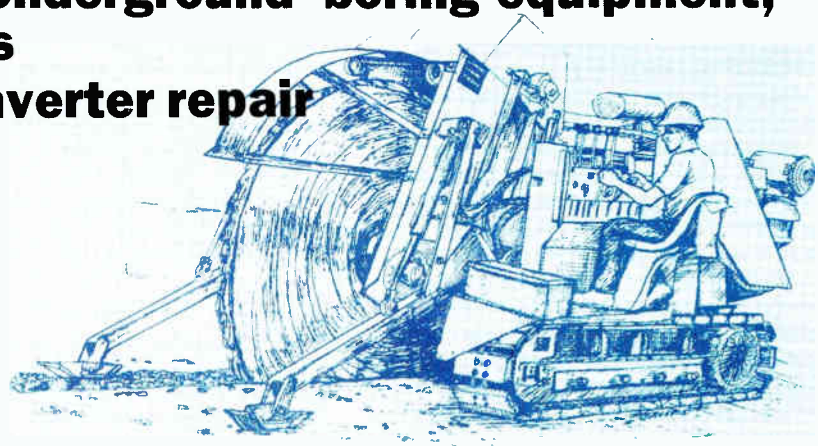
Communications Engineering & Design

# TECH II

CED's feature supplement and Product Profile

March 1985

- **Broadband basics**
- **Product Profiles: Underground boring equipment, trenchers and plows**
- **Service Profile: Converter repair**



to poles are usually jacketed. Cables buried or placed in conduits should use corrosion-resistant flooding gel between the outer jacket and the aluminum shield. The gel protects the aluminum from corrosion if the jacket is cut or damaged. Armored cable with flooding gel is mandatory where the cable is buried underground without further protection and where it is mounted in underground vaults and might be damaged by water or rodents.

Cables with messengers are available for suspension between buildings or on poles. This feature provides protection and eliminates the need for strand lines.

### Feeder cables

Smaller-sized trunk cables are used for feeder cables. These indoor cables are selected according to the following criteria.

- The physical constraints of the building: smaller cables are easier to install.
- The required signal level of the distribution network: larger cables have less signal loss.
- Local and national building codes.

In general, jacketed or unjacketed 0.500-inch aluminum cables are used for trunks and feeders.

### Drop cables

Drop cables connect feeder cables to network outlets. These cables need not be very large, since only one cable is used for each outlet. They range from RG-11 and RG-6 to RG-59. Each type incorporates foil and braid shielding to prevent radiation and pickup of RF energy. The outer jacket is made of an insulating material.

Drop cable lengths vary from 10 to 50 feet. They can be installed above ceilings and through walls. A drop can connect directly to a wall outlet or to a device such as a television receiver, modulator, demodulator or data modem. To minimize pickup of noise and broadcasted RF signals, the best quality and best shielded cable should be used for drops.

### Installation

Cables can be installed throughout a facility with or without conduits. This choice depends on the type of insulation used by the cable and on building codes. Fire codes might prohibit PVC-coated cables in ceiling plenums or computer floors because toxic fumes could be circulated if a fire occurred. In these cases, PVC cable can be placed inside a conduit, or cable with a fire-retardant jacket (such as Teflon) can be used.

Installation of Teflon cable is more expensive than PVC cable because of special connectors and longer labor time to install these connectors. A rule-of-thumb states conduit installation cost, including materials, to be around $1 per foot. Conduit provides additional physical protection for the cable and additional shielding from radiated signals.

During construction, buildings can be piped with conduit for cables. Passive components and amplifiers should be installed inside enclosures appropriate for the environment. Each enclosure should be located to provide access for alignment and maintenance.

Proper ventilation should be provided for components mounted inside enclosures. It is important to maintain the temperature inside the amplifier housing as close as possible to the temperature experienced by the cable. Enclosures installed inside buildings might require fans to prevent heat build-up. Enclosures installed outdoors might not need fans, depending on the amplifier's operating temperature range and environmental conditions.

Although coaxial cable is durable, it

is not invulnerable. When transporting and installing coaxial cables, always handle them carefully. The cable should be left uncut and fastened securely until it is required for installation. During installation the cable should not be kinked or bent beyond the specified limits.

### Cable attenuation

The attenuation of a coaxial cable is often quoted as a single number, such as 10 dB per 100 feet. This is the attenuation of the cable at the highest frequency of interest for the system (usually 300 or 400 MHz). However, cable attenuation is not constant and changes with both frequency and temperature.

Cable attenuation increases with increasing frequency in a nonlinear (exponential) manner. This characteristic is due to the composition of the cable and is called cable slope or cable tilt, and it must be considered when designing a distribution network.

Figure 6 shows the attenuation change with frequency for a 20 dB length of 0.500-inch cable. Figure 7 shows attenuation per 100 feet versus frequency for several different sizes of cable. This graph shows that as cable diameter increases, cable loss decreases, which is why larger cables are preferred for long cable runs. The smaller coaxial cables have more loss, and only short lengths of them are used in drop cables.

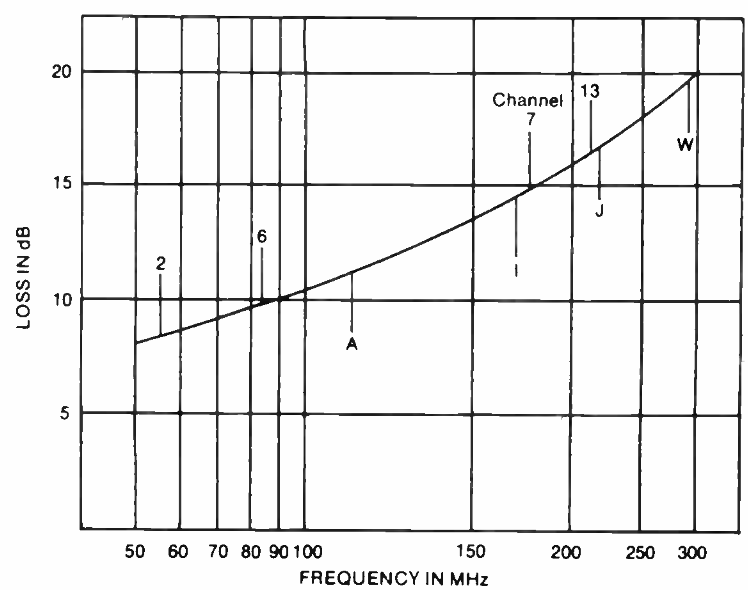
Cable attenuation also is directly affected by temperature variations. The attenuation of coaxial cable increases with temperature at the rate of 0.11% per degree Fahrenheit. This amounts to an overall change of about 15% over the temperature range of -40 to +120 degrees Fahrenheit. The accepted rule-of-thumb is 1% change in cable attenuation for every 10 degree Fahrenheit change in temperature at a given frequency.

The network must function properly despite any RF signal level changes caused by frequency and temperature variations. In bidirectional systems there are two different variations that must be considered: one for the forward path and one for the return path. The design must take into account cable tilts for both of these frequency bands. These variations affect the operation of the amplifiers (because they determine equalizer selection and setting) and the overall peak-to-valley response of the system. Amplifiers must compensate for the combination of cable loss, tilt, and temperature variations experienced in daily operation. Proper compensation keeps system gain and signal levels reasonably constant under all possible conditions.

### Amplifiers

Because of the parameter variations caused by frequency and temperature changes, only small systems can successfully transport signals without requiring compensation circuitry. Modular amplifiers in the distribution system can include various equalizers, gain blocks, filters and other circuits that make up for cable-caused variations. Signal level gain corrects for attenuation caused by the cable and by other

**Figure 6 0.500-inch cable loss**



components. Frequency compensation (equalization) corrects for cable tilt.

Amplifiers are differentiated by their cost and performance. The cost factor is straightforward: the more expensive units usually provide better performance. The cost of a unit can depend on the following characteristics:

- Gain is the increase of signal level occurring from input to output of the amplifier. Amplifier gains are usually 20 to 30 dB.
- Output level is the maximum signal level that the amplifier can deliver.
- Noise figure is the amount of noise contributed by the amplifier.
- Distortion is the amount of unwanted modification of the input signal done by the amplifier (this includes intermodulation products, which are often specified separately).
- Gain control of an amplifier can be either manual or automatic. Automatic gain control units are more expensive.

When evaluating the gain specification of an amplifier, the design engineer should include any associated passive loss. The usable gain of an amplifier is the gain available from a fully configured unit and it equals total gain less the insertion loss. A configured unit might contain additional modules such as filters and equalizers. These modules have an insertion loss that must be subtracted from the total gain of the amplifier. This loss is generally between 1 and 3 dB, depending on the configuration of the amplifier.

### Amplifier gain control

Two different types of gain control for an amplifier are available, manual and automatic.

The gain of a manual gain control (MGC) amplifier mainly is adjusted by hand. Variations caused by temperature changes can be accommodated automatically by an internal thermal compensator circuit that changes the amplifier's gain. This combination of MGC with thermal compensation suits broadband local network applications because most of them do not exist in harsh environments. (Amplifiers for outdoor CATV networks must accommodate wider signal level changes found in that environment.)

MGC amplifiers primarily are used on short-range, high-signal-level distribution trunks. Their cost per unit is less than that of automatically-controlled amplifiers.

The thermal compensation provided by MGC units is desirable only when the amplifier is subjected to the same temperature variations as the cable. A problem can arise, for example, if the amplifier is installed in a pedestal above ground and the cable is underground.

In that case, the amplifier would probably experience greater temperature variations than the cable. To eliminate possible overcompensation, the thermal circuit should be removed from the amplifier. In most cases, doing so requires no special tools or training.

The automatic gain control (AGC) amplifier maintains a relatively constant output level regardless of input level variations. It can accommodate changes of 3 dB above or below the nominal input value. When used properly, AGC amplifiers can provide constant signal levels to all outlets in facilities that experience varying environmental conditions.

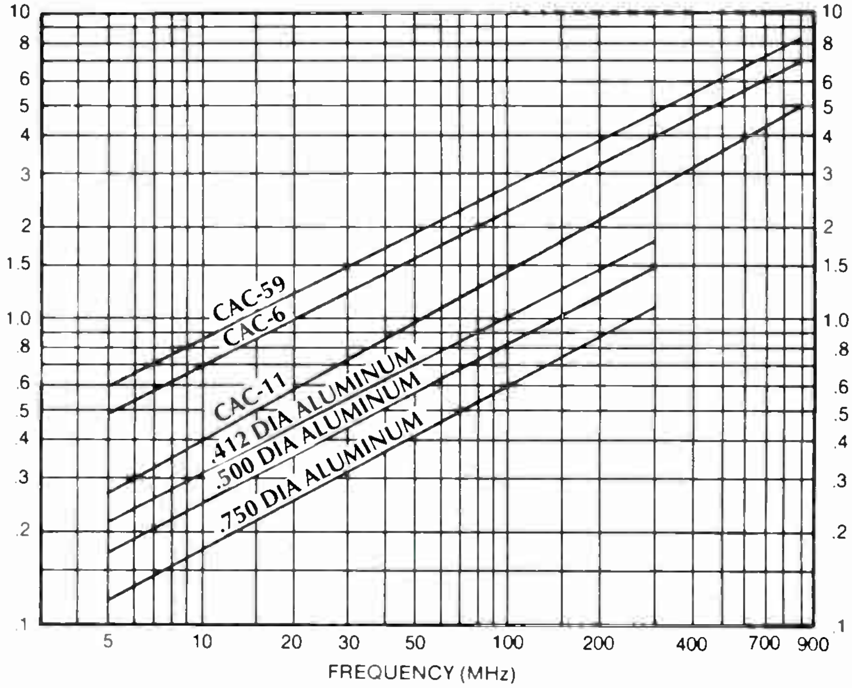
A general rule-of-thumb is that a 6-dB change in the input signl of an AGC amplifier causes a 1-dB change in its output signal.

### Types of amplifiers

Four main types of amplifiers are used in broadband systems: trunk, bridging, line extender and distribution amplifiers. Each offers different characteristics, performance, and features, and each is appropriate in different applications.

Trunk amplifiers are high quality, low distortion units capable of being cascaded into long chains to distribute sig-

**Figure 7 Cable attenuation versus frequency for various sizes of coaxial cable**



Reader Service Number 53

nals throughout a large geographic area. Amplifiers are cascaded, or connected in series along the trunk cable, to make up for losses and variations encountered in long cable runs.

Trunk amplifiers typically are operated at 22 dB gain, with input levels of 8 to 10 dBmV and output levels of 30 to 32 dBmV for 35-channel systems with 20 amplifiers in cascade. Where fewer amplifiers are cascaded, output levels can be increased up to +45 dBmV. When any amplifier is to be operated above its suggested output level, the manufacturer should be consulted for advice.

A rule-of-thumb for cascading amplifiers is that each time the number of amplifiers in series is doubled, the output level of each unit must be reduced by 3 dB from its rated output. For example, the output level of each amplifier in a cascade of two units should be 3 dB below the rated output of the amplifiers or less. Doubling the number of amplifiers in series up to four requires that the maximum output level be reduced to 6 dB below rated output or less. With eight units in cascade, the maximum output level should be 9 dB below rated output or less.

The bridging amplifier, or bridger, provides high level signals for distribution on the branch or feeder lines. They can be installed inside the same housing as the trunk amplifier. The output signal level of a bridging amplifier is usually +47 dBmV at the highest operating frequency.

A bridging amplifier receives its input signal from the tap of a directional coupler connected to the output of a trunk amplifier. One to four output lines are available for distribution.

In a broadband network, a common truck line can feed several buildings. The bridging amplifier can drive distribution cables that feed the individual buildings. With this approach, trunk amplifier levels can be adjusted to CATV standards, allowing easy cascading and future expansion.

Figure 8 illustrates an example of signal levels for a trunk and bridging amplifier combination. Return path signal levels, when not given on the drawings, are equal to or slightly greater than the forward path signal levels.

Test points are provided at both the input and output points of the amplifier. The input test point is used to sample the signal before the input filter, pad and equalizer modules. The output test point is used to sample the signal after the amplifier, directional coupler and filter sections.

Line extender amplifiers, or line amplifiers, are used when the signal level provided by the bridging amplifier is insufficient to drive receiving devices. These amplifiers cost less but have higher distortion and noise figure specifications than trunk and bridger units. Line extender amplifiers should be limited to a maximum cascade of three to provide acceptable quality signals to the users.

Some smaller two-way networks use line extenders as their only amplifying device. Such systems have the following characteristics.

- Cascades of three or less
- Many outlets located within a small area
- Coverage of a limited geographical area

Line extender amplifiers are available in the subsplit, midsplit and highsplit formats for two-way applications, as well as in dual cable versions.

Internal distribution amplifiers are high gain units used for signal distribution. They can be used where several high level feeder legs are required, for example, over several floors within a building. Cascading is not recommended because of their higher gain.

One advantage of such amplifiers is that they have built-in 110-Volt ac

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power supplies and do not require ac power to be transmitted over the cable. Currently these amplifiers are available in subsplit and midsplit versions only.

### Amplifier modules

Several additional circuit modules that can be included inside amplifier housings. These modules can provide signal attenuation, return channel gain, frequency equalization and remote control. When the input signal amplitude is too high, a pad can be installed inside the amplifier module, in series with the amplifier's input, to reduce the level.

All four types of amplifiers can be used in bidirectional networks by adding appropriate filters and a second amplifier module for the return path. Return path amplifiers usually have less gain (19 to 26 dB) than forward path amplifiers since cable attenuation at the lower frequencies (return direction) is less than at the higher frequencies (forward direction).

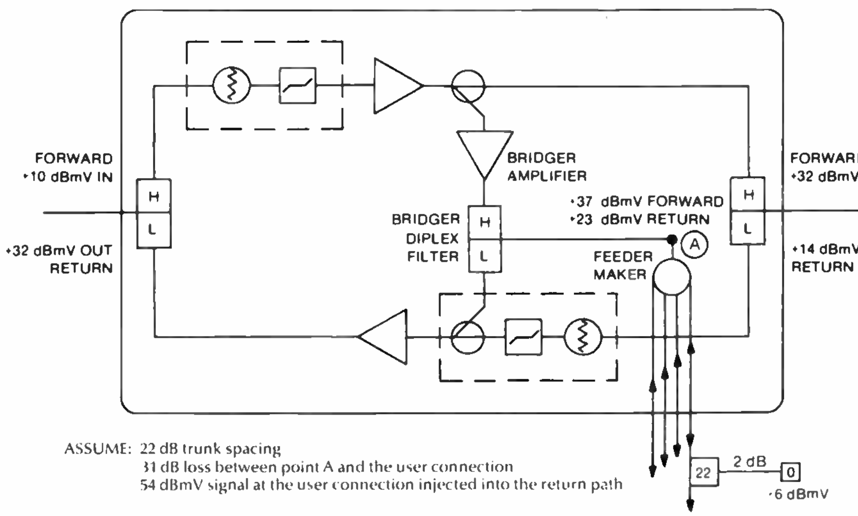
Variable equalizers to compensate for cable tilt can be installed in each amplifier housing. These circuits provide a frequency response that is the inverse of the response of the coaxial cable. The combined effect of the cable and the equalizer is to provide equal attenuation to all signals regardless of their frequency.

Adjustable equalizers can accommodate different cable lengths. A single equalizer circuit can be used inside all amplifier housings, which needs only to be adjusted for the length of cable between it and the previous amplifier.

A feeder disconnect circuit can be added into an amplifier housing, usually a bridging amplifier. This circuit permits disconnection of a feeder line from the trunk, either remotely or locally, which can help when troubleshooting and repairing the network.

■ When noise or unwanted signals are entering the system from an unknown point, disconnecting one feeder

**Figure 8 Trunk and bridging amplifier**






line at a time can help to isolate the source of the problem.

■ When aligning the system, disconnecting branches from the trunk can help to check and match the signal levels coming from all branches.

Control signals for feeder switching originate at the headend and are generated by status monitoring systems and intelligent amplifiers. The state of each module (on, off or remote) can be selected individually. Placing the module in the on or off state connects or disconnects the feeder and trunk. In the remote state, a signal sent from the headend controls feeder switching.

### Power supplies

All amplifiers require ac power. The internal distribution amplifier contains its own power supply and can connect directly to a 110-Volt ac outlet. All other units run on either 30 or 60 Volts ac that are delivered over the coaxial cable by power supplies. Distributing power in this manner eliminates the need for 110-Volt ac outlets at each amplifier location and allows greater flexibiltiy in amplifier placement.

Thirty-Volt power is used mostly in older systems. Sixty-Volt power is used widely in modern broadband communication networks.

AC power is coupled to the coaxial cable through devices called power combiners. These devices permit the injection of power in either or both directions with little effect on the radio frequency signals.

Once power is delivered to the cable, multi-taps and amplifiers can control its distribution.

■ For safety reasons, multi-taps pass current along the trunk connections but prevent it from reaching the outlets. Each outlet is electrically isolated from the main network and from other outlets, reducing the possibility of total system failure from accidental or malicious causes.

■ Amplifiers can pass or block ac power travelling on the cable. Power can be passed to other amplifiers or stopped at either the input or the output of each unit.

Observe these precautions when sending ac power over coaxial cable.

■ AC power should not be injected through multi-taps or couplers incapable of passing power. Typically, units unable to pass power have F-type connectors.

■ Use only cables with seamless aluminum shields to convey power.

■ Consider the current-passing capabilities of each device in the network to ensure that limits are not exceeded.

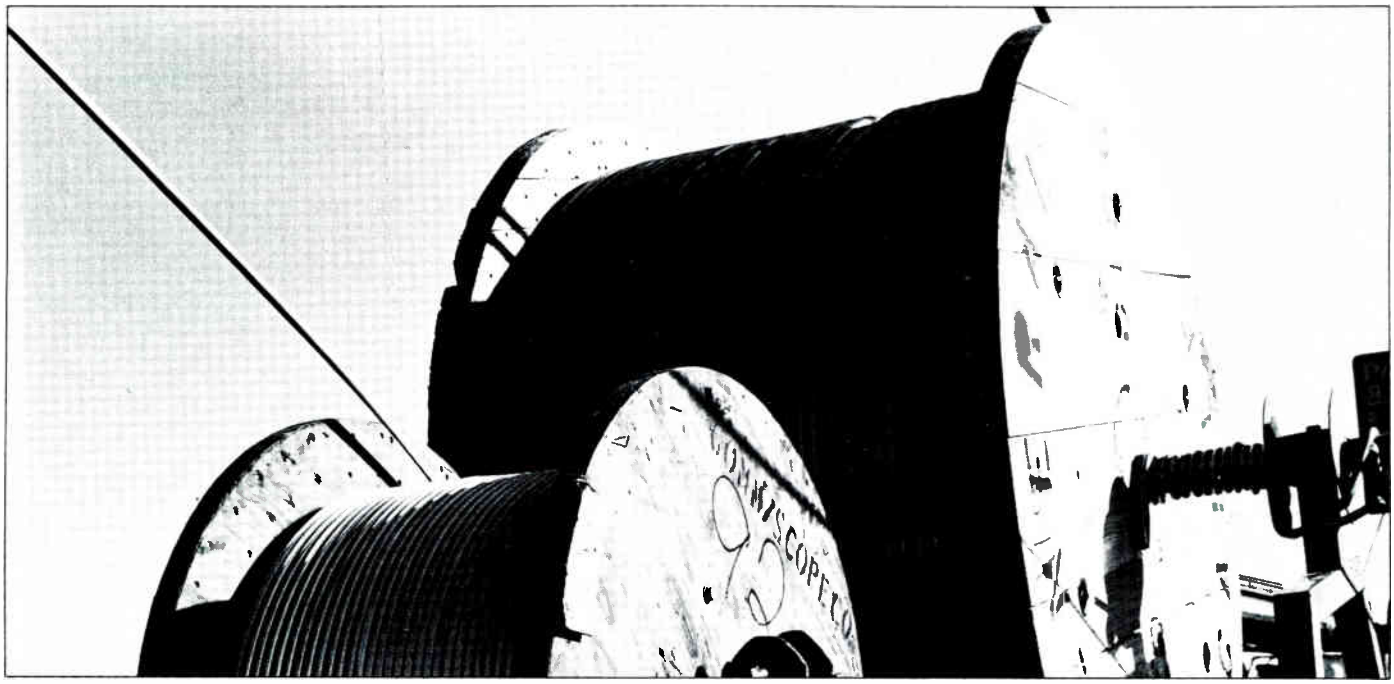
In system design, a general rule-of-thumb has been one power supply for every three amplifiers and cable spans. This quantity depends on cable resistance and amplifier operating current and voltage. Large networks require calculations using power supply voltage and current capacity, amplifier current draw and required input supply voltage, and cable loop resistance. The power available for each amplifier can be found by Ohm's law. These calculations will show where additional power is required.

One result of calculating power requirements is learning that amplifiers are voltage dependent and not current dependent. If the voltage drop across the cable between an amplifier and its power supply is too great, the amplifier operates poorly, if at all. To solve this problem, another power supply can be added to the system, or a cable with less resistance can be installed.

Standby power units can be incorporated into any broadband network. These units provide power when the network's main ac input line fails. CED

# Underground boring equipment

| Model | Maximum cable/pipe diameter | Installation speed | Trench size required | Self leveling | Engine size | Unit dimensions | Unit weight |
|---|---|---|---|---|---|---|---|
| **Burnup & Sims** | | | | | | | |
| **Horizontal earth boring machine** | 2-6 inches | Up to 15 inches per minute | 15 ft. × 18 inches | No | 16 HP | 15 inches (w) × 18 inches (h) × 5 feet (l) | 200 lbs. |
| **Elephant Industries** | | | | | | | |
| **Peanut** | 1-4 inches | N/A | 8 × 32 inches | Built-in jack | 16 HP | 8 inches (w) 32 inches (l) | 160 lbs. |
| **E-4** | 4 inches | Up to 8 fpm | 6 inches wide | Hydraulic stabilizer gates | Optional 18 HP hydraulic power unit | 8 inches (w) × 33 inches (l) | 199 lbs. |
| **JI Case** | | | | | | | |
| **Hydraborer attachment for Mini- & Maxi-Sneaker** | Boring bits: 2-3 inches Backreamer: 4-6 inches | Boring unit speed 0-320 fpm | 4 or 6 inches | Manual | 25 HP: Mini 35 HP: Maxi | N/A | 82 lbs. |
| **Vermeer** | 8½ inches | N/A | T-shaped trench: 6 inches horizontal × 12 inches vertical | N/A | Hydraulic min. 2,000 psi | 48 inches (w) × 26 inches (h) × 36 inches (l) | 186 lbs. |
| | 6 inches | N/A | 6 inches max. | N/A | Hydraulic min. 2,000 psi | N/A | 51 lbs. |



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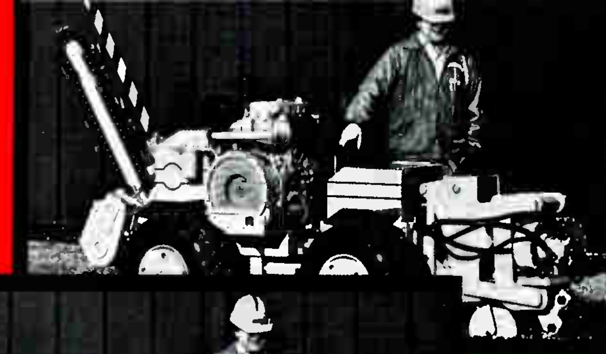


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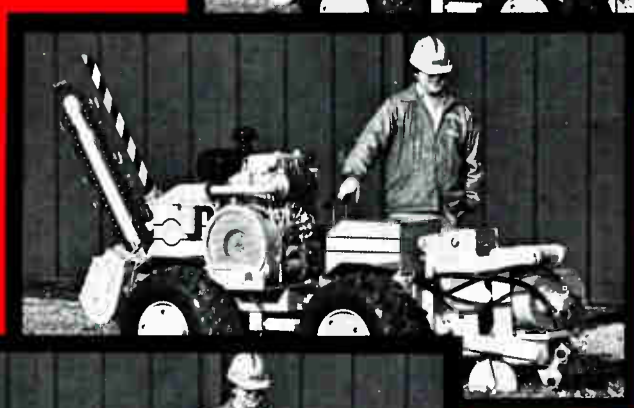

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# Trenchers

| Model | Trench depth | Trench width | Centerline trench to outside edge | Physical dimensions | Trenching speed |
|---|---|---|---|---|---|
| **American Trencher 600 D** | 3 ft. 4 inches; @ 90° angle; up to 9 ft. 4 inches | 6-18 inches in 2-inch increments | (of machine) left: 3 ft., 1.5 inches; right: 3 ft., 1.5 inches | (transport) 16 ft. 6 inches (l) x 7 ft. (w) x 10 ft. (h) | 0-63 fpm |
| **Ditch Witch 1420** | 60 inches max. | 3¼-12 inches | 18-9/16 inch; 16-11/16 inch (standard boom) | (transport) 82¼ inches (l) x 35½ inches (w) x 61½ inches (h) | digging chain speed at 251 rpm: 305 fpm |
| **2200** | 64 inches | 3¼-12 inches | 28 inches, left; 29 inches, right | (transport) 149.5 inches (l) x 57 inches (w) x 66 inches (h) | (max. backfill speed) 2.9 mph |
| **2300** | 63 inches | 5-16 inches | 28 inches, left; 29 inches, right | (transport) 149 inches (l) x 57 inches (w) x 82 inches (h) | (max. backfill speed) 4.1 mph |
| **JI Case 25 + 4 XP** | 26-66 inches | 4-12 inches | N/A | 202 inches (l) x 54.3 inches (w) x 82.2 inches (w) | 0-3.3 mph, forward or reverse |
| **TF 300** | 66 inches max. | 16 inches max. with special/assembly | N/A | 85 inches (l) x 41 inches (w) | 0-16 fpm |
| **TL 100** | 24 inches | 4-6 inches | N/A | 99 inches (l) x 31.5 inches (w) x 39 inches (h) | 1.80-4.82 fpm |
| **Parsons T80** | 24 or 30 inches | 4-6 inches | N/A | 95 inches (l) x 32 inches (w) x 38 inches (h) | 0-25 fpm |
| **T120** | 24-36 inches in 6-inch increments | 4-6 inches | N/A | 115 inches (l) x 32 inches (w) x 38 inches (h) | 0-25 fpm |
| **Vermeer V-430** | 60 inches max. | 5-16 inches | N/A | 140 inches (l) x 58 inches (w) x 82 inches (h) | digging chain speed: 223-606 fpm |
| **T-600D Concrete Cutter** | 31 inches max. | 4-10 inches | N/A | 200 inches (l) x 95 inches (w) x 98 inches (h) | cutter wheel speed: 170-1,070 fpm |

# Plows

| Model | Max. plowing depth | Transport speed | Operating speed | Engine | Dimensions | Weight |
|---|---|---|---|---|---|---|
| **Burkeen B-30 Cable plow** | 24 inches | 2.5 mph | 0-200 fpm | Hatz Z790; diesel, 30 horsepower | 103 inches (l) x 35 inches (w) x 50 inches (h) | 2,700 lbs. (basic unit) |
| **Ditch Witch V252** | 16 inches | 0-2.84 mph | N/A | Onan NHC-MS two cylinder; 25 horse power | (transport) 85 inches (l) x 36 inches (w) x 42 inches (h) | 1,370 lbs. |
| **350 SX** | 27.5 inches | 3.8 mph | N/A | Wisconsin W4 1770 four cylinder; 35 horse power; Deutz F2L511; two cylinder; 3.5 horse power | (transport) 152 inches (l) x 46 inches (w) x 84.5 inches (h) | 3,270 lbs. |
| **JI Case Maxi Sneaker** | 24 inches | 3.5 mph | 0-200 fpm | four cylinder diesel; 35 HP | 139 inches (l) x 37 inches (w) x 77 inches (h) | 2,485 lbs. |
| **DH4** | 24 inches | 7.17 mph | 0-2.92 mph | four cylinder diesel engine; 50 horse power | 63 inches (w) x 94.5 inches (h) | 4,875 lbs. |
| **475** | 36 inches | 3.6 mph | 1.18 mph (low range) | four cylinder diesel engine; 84 horse power | 78 inches (w) x 112.5 inches (h) | 15,480 lbs. |
| **Line Ward Cable Line Layer** | 6-13 inches | 68-140 fpm | 56-98 fpm | 16 horse power Kohler engine | 50 inches (l) x 24½ inches (w) x 44 inches (h) | 800 lbs. |
| **Parsons DP-60 Saber Plow** | 0-30 inches | 0-6 mph | 0-1.3 mph | John Deere Diesel, 80 horse power, 2500 rpm | N/A | N/A |
| **DP-180 Saber Plow** | 0-44 inches | 0-11.4 mph | 0-1.8 mph | Cat 3208 diesel, 175 horse power, 2500 rpm | N/A | N/A |
| **Turfco Pipe Piper 100-A** | 5-12 inches | 50 fmp | 50 fmp | 10 horse power, four-cycle Briggs & Stratton | 60 inches (l) x 34 inches (w) x 41 inches (h) | 565 lbs. |
| **Pipe Piper 180-B** | 5-12 inches | 150 fpm | 150 fpm | 23 horse power, two cylinder Kohler | 78 inches (l) x 36 inches (w) x 54 inches (h) | 1,275 lbs. |
| **Vermeer LM-35** | 18 inches | 235 fpm | N/A | Deutz F2L511 | 122 inches (l) x 35.5 inches (w) x 52 inches (h) | 4,000 lbs. |
| **V430** | 18 inches | 7.3 mph | N/A | VM Diesel Wisc. VH4D Deutz F2L511 | 58 inches (w) x 53 inches (h) | 3,500 lbs. |

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# Converter Rx call list

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**Arena Systems Inc.**
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**Brad Cable Electronics**
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9325 Bay Plaza Blvd.
Suite 209
Tampa, Fla. 33619
813 / 623-1721
4630 Pacific Hwy. East
Suite B7
Fife, Wash. 98424
206 / 922-9011

**C & C CATV Service**
39 B Mill Plain Road
Danbury, Conn. 06811
203 / 748-4488

**Cable Converter Service Corp.**
54 E. Market St.
Spencer, Ind. 47460
812 / 829-4833

**Compu-Trace**
8803 Shirley Ave.
Northridge, Calif. 91324
818 / 886-3551

**Electrodyne Tuner Corp.**
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**Douglas Electronics**
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**215/269-1946**

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## Service Profile

**Howard Electronics**
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815 / 455-6100

**Independence Electronics**
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Independence, Mo. 64055
816 / 836-1094

**Island Cable Electronics**
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Hicksville, N.Y. 11801
800 / 431-5433

**MAI CATV**
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**Northeast Cable Electronics**
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New London, Conn. 06320
203 / 443-7675

**PTS Converter Repair Corp.**
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Bloomington, Ind. 47401
812 / 824-9331
(15 locations nationwide)

**RF Analysts**
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313 / 750-9341

**RT/Katek Converter Services Division**
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717 / 534-1161
800 / 441-1334

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Denver, Colo. 80221
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**Teletronics**
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**Comm/Scope Marketing, Inc.**

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Contact Specialty Cable Sales at
1-800-438-3335

Reader Service Number 69

*Continued from page 11*

## Switzer re: January

Re: Cable/consumer interface issues

I love it! Heller is "singing my song"—subscriber ownership of "terminal equipment," nationally standardized encyphering and addressing, acknowledgement of the wasteful redundancy of the present arrangements.

Re: Living with 21006

A very useful article. I have a few "nits to pick." Roy refers to "standard channels" as "XXX.250 MHz." It's more precise to describe this "standard channeling" as "6N + 1.25 MHz." He goes on to use notation of this kind in his analysis of the FCC rules.

Roy talks of frequency stability of "low grade UHF stations" as "waltzes all over the band." The FCC holds all UHF stations to the same frequency tolerance as VHF stations—assigned frequency ± kHz. I've never had any problems with frequency stability of broadcast stations. I've had problems with low power, low budget "translators." The FCC allows these operations a greater tolerance. Some translators operate in cascade, a chain of "repeaters." Frequency errors of some tens of kilohertz can accumulate. The best way to deal with this problem is to use a demodulator/remodulator. The frequency "waltzes" won't bother the demodulator, and the cable channel frequency is set by the "remodulator" whose frequency is the responsibility of the cable system.

HRC systems can achieve the required frequency accuracy and stability without an expensive rubidium oscillator. High-quality crystal oscillators, in the $500 range, are available and more than adequate. There are frequency calibrators available (phase locked to WWVB's 60 kHz transmission) which will provide more than adequate accuracy for system frequency calibration. These WWVB receive systems cost about $2,000.

I believe "fly overs" will turn out to be the most cost effective way of monitoring medium and large size systems.

Re: Broadband basics

It isn't clear until you get well into this article that it is intended for data technicians, i.e. to give them an understanding of broadband "local area networks."

Page 44—"However when more than 12 channels. . . " This paragraph should acknowledge the present popularity of "cable ready" TV sets that can tune "more than 12 cable channels" without a converter.

Page 45—"inspection of existing coaxial cables. Inspect them. . . " This is an oversimplification of a major upgrade problem.

Page 45—"each outlet in a dual cable. . . "This paragraph should also mention the advantage of a dual cable "I-NET"—twice as much usable spectrum in each direction!

Page 49—Cooper seems satisfied with "mid-split" spectrum allocation. "Mid-split" allocation is not symmetrical. It provides twice as much "forward" spectrum as "reverse." Cooper's design concerns seem to be for "I-Net" (data networks) where symmetrical capacity should be important. It is reasonable to assume that there is as much data traffic in one direction as the other in such applications. Cooper should be advocating, and pressing manufacturers for, "symmetrical" two-way amplifiers for these data networks.

***Israel (Sruki) Switzer***
***Consulting Engineer***