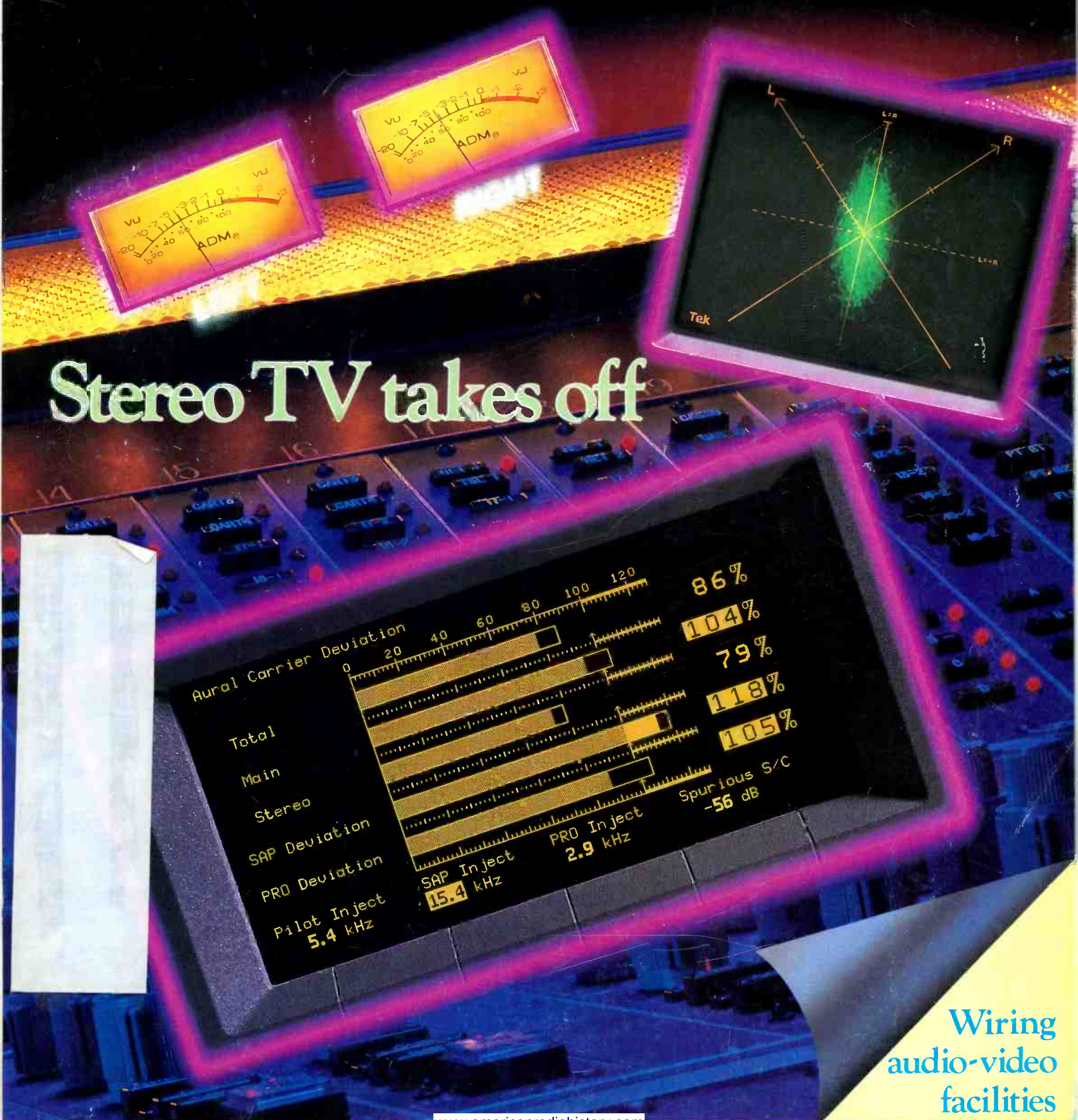
BROADCAST engineering®

September 1986/$3



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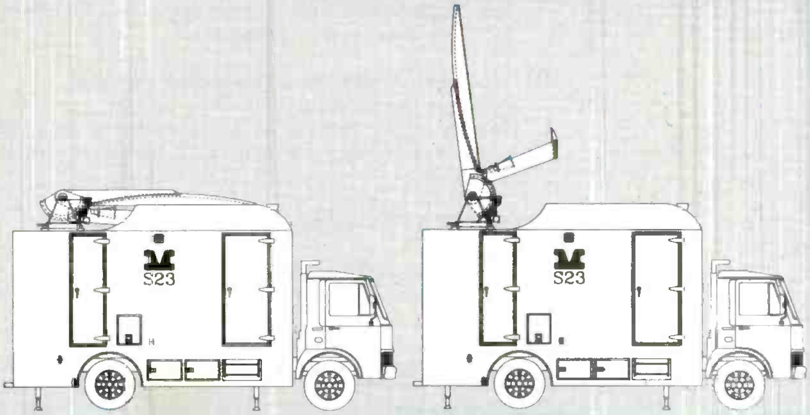

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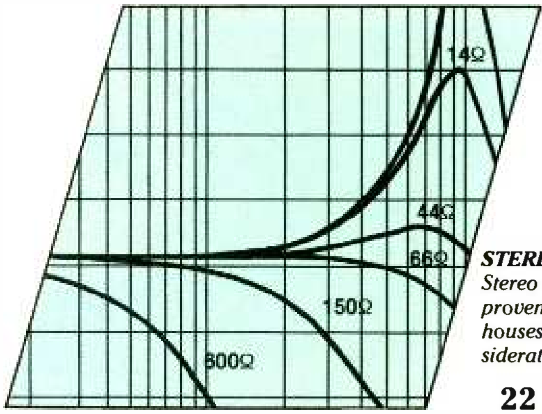

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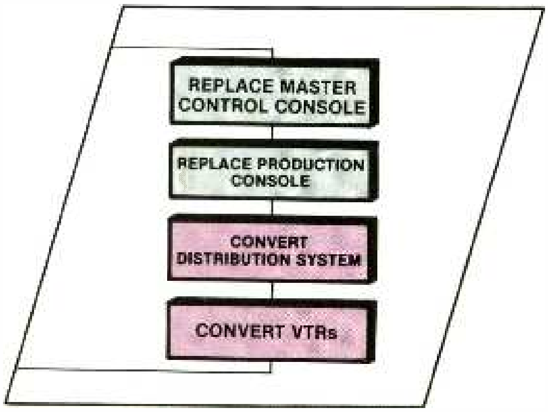

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ON THE COVER
Without a doubt, stereo television is a smashing success. Competition among stations has resulted in strong pressures on mono facilities within stereo markets to make the move as quickly as possible. Our cover this month illustrates some of the primary elements of stereo programming: source origination and program-quality monitoring equipment. The bar graph display in the lower center of the photograph shows a 10-parameter aural modulation monitor readout. The waveform display above the bar graph is a stereo audio monitor. (Photo courtesy of Tektronix.)

BROADCAST engineering

STEREO TV TAKES OFF:
Stereo audio for television is the driving force behind facility improvement efforts at hundreds of TV stations and production houses. In this issue, we examine some of the primary considerations when planning an audio-system overhaul.

AUDIO-VIDEO CONTROL EQUIPMENT:
To keep pace in today's marketplace, facility improvement must be an on-going effort. This month we examine various aspects of keeping current with broadcast technology.

MICROPHONES FOR BROADCASTING:

SHOW PREVIEWS:

DEPARTMENTS

News

NAB extends exhibit hours

Exhibits of broadcast equipment at the 1987 NAB Convention will open Saturday morning rather than Sunday as in the past. This change is in response to recommendations of NAB's Exhibitor Advisory Committee.

Also, the 65th convention will close with dinner and entertainment Tuesday evening. It formerly ended with a Wednesday brunch and entertainment. The convention will be held March 28 to 31, at the Dallas Convention Center.

The Saturday opening and expansion to four days will eliminate Saturday setup overtime costs and provide attendees additional time to visit the exhibit halls. The committee also agreed to provide additional security and bus transportation for the exhibitors which, along with other improvements, requires an increase in the per-square-foot exhibit hall cost from $16 to $17 on the upper level and from $14 to $15 on the lower level.

NAB serves a membership of more than 4,700 radio and 900 TV stations, including all the major networks.

Committee calls for NAB '87 papers

Once again it is time to begin preparation for the 41st annual Broadcast Engineering Conference, which is held each year in conjunction with the NAB Convention.

The conference provides an opportunity for broadcasters and manufacturers to present papers on broadcasting equipment, systems and techniques that would be of interest to broadcast engineers and technicians.

Papers from associate members that relate to notable improvements in broadcast engineering technology, systems design or techniques that do not directly relate to a specific product also are invited. Papers are being sought specifically from equipment users and associate members involved in the latest broadcast technology.

The NAB Broadcast Engineering Conference Committee will meet in October to select the papers to be presented. Anyone interested in presenting a paper should send a 1-page abstract on the proposed subject by Oct. 10 to: Engineering Conference Committee, Science and Technology Department, National Association of Broadcasters, 1771 N. St. N.W., Washington, DC 20036.

All papers accepted for presentation must be completed with artwork and received at NAB by Feb. 13, in order to be included in the *Conference Proceedings*, which will be made available at the convention. For more information call 202-429-5346.

SMPTE forms ad hoc HDTV group

The Society of Motion Picture and Television Engineers (SMPTE) has formed an ad hoc group on high-definition studio systems to document the specification for the current 1,125 line/60 field high-definition TV system.

The SMPTE's engineering effort to prepare a series of documents on the HDTV system is being undertaken in response to requests from the Advanced Television Systems Committee (ATSC), the Canadian Broadcasting Corporation and the CTV Television Network in Canada.

The purpose of the group is to ensure

Continued on page 160

BROADCAST engineering

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Advertising offices listed on page 164.

Editorial

It's for you

In case you've been sleeping for the past couple of years, you might not have noticed the skyrocketing cost of your telephone service. You wouldn't know that the Department of Justice, under the guise of antitrust protection, forced the breakup of AT&T. We were told that reduced telephone rates would result.

When it became obvious that the government was going to win no matter what the effect on the consumer might be, the FCC began restructuring the rates charged by the telephone companies. Remember now, the whole idea of the suit was to avoid an antitrust situation, which supposedly artificially inflates consumer costs. Under the FCC's restructuring process, new and improved (lower?) rates were to take effect.

Well, rise and shine and take a look at your phone bill. Your telephone costs have not only increased, but increased faster than it was thought possible. And even worse, the rates continue to increase.

In April 1985, the new FCC-approved telephone rates went into effect. What followed can only be described as a disaster for broadcasters. A 1985 survey conducted by the NAB showed widely varying costs for broadcast station services. The first NAB survey showed that the average increase in telephone charges was 390%. Some stations experienced increases of more than 2,000%. How much did your telephone costs go up?

Although the NAB conducted surveys and participated in rulemaking proceedings before the FCC, little relief for the broadcaster was forthcoming. Once the decision to break up Ma Bell was made, broadcasters (and most of the other telephone consumers in the United States) were doomed to higher rates.

So what has this got to do with today's conditions?

For one thing, the station engineers are going to have to learn to wear another hat—that of the telephone specialist. In stations throughout the country, station engineers are finding themselves involved in the selection and even installation and maintenance of in-house telephone systems. Broadcast engineers used to be able to rely on a friendly telephone installer to help them with the unique telephone needs of broadcast stations. No more.

Many people now installing telephone equipment know little about (or have no appreciation for) the special needs of radio and TV stations. You may have also noticed that the installers seem younger than before. In AT&T's reorganization, many of the old-timers you came to depend upon have retired. The new installers often don't have the many years of experience that were so helpful to the broadcaster.

This change means that station engineers are required to become knowledgeable about another type of technology. Management may take it for granted that because the telephone equipment looks much like other devices in the station, the engineer should be able to maintain it. For those stations that purchase their own telephone equipment, maintenance by the station engineer may even be a requirement.

These changes mean that you must make the effort to become familar with the changing nature of telecommunications. Learn all you can about telephone systems so you can help protect your station's interests when the time comes to purchase or lease a telephone system. Don't be afraid of the technology. After all, you learned to switch from tubes to transistors to ICs to computers with digital audio and video. You can also learn how your station's telephone system works.

The broadcast engineer can play a key role in helping the station cope with the increased costs of telephone services. Learn the technology. Modern telephone systems are complex, yet rely on devices common throughout most stations. Don't be intimidated by a new telephone system. Computer-controlled or relay-activated, it is just another piece of equipment in the engineer's station. Although you may never have to repair the system, a thorough knowledge of how it works can greatly benefit your station.

There may be a few instances in which the breakup of Ma Bell actually reduced station telephone costs. If so, we'd like to hear about them. The stories repeated in engineering and management meetings usually tell of reduced service at higher prices. It seems a good example of the old adage of getting the short end of the stick. For the broadcaster, it's even worse. You might even say that the broadcasters have been clubbed by the courts and the FCC with that stick.

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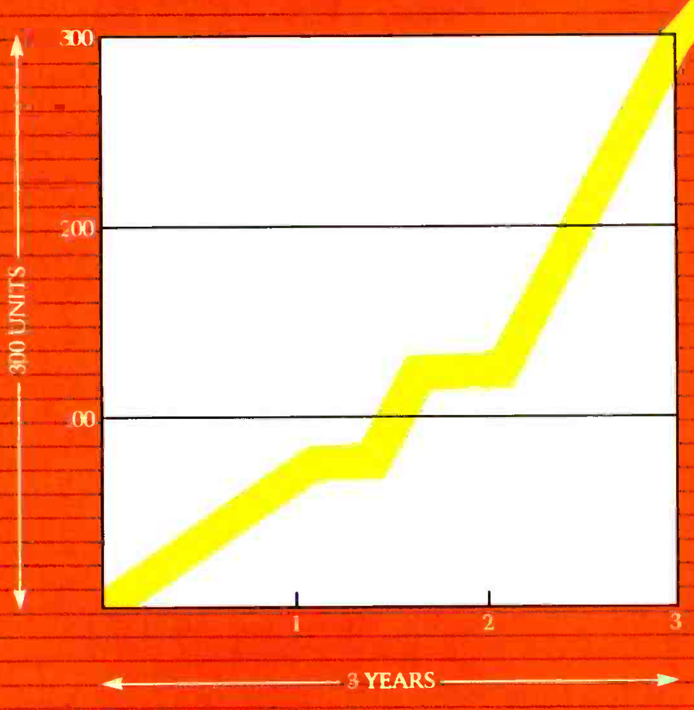

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Must-carry in effect

By Harry C. Martin

In response to broadcast industry and congressional pressure, the FCC has adopted new CATV must-carry rules. The previous mandatory carriage rules were held unconstitutional in July 1985.

Under the 2-part rules, cable systems will be required to provide new subscribers with (A/B) input selector switches for receiving off-air signals at no cost. Existing subscribers could be charged a fee for the switch. A cable operator must offer to supply and install a switch for each separate cable hookup and inform the subscriber that an antenna may be needed for off-air reception.

The second part of the program establishes new mandatory carriage requirements for a period of five years. Cable systems having 20 or fewer usable activated channels are not required to carry any local commercial stations. Systems with more than 20, but fewer than 27, activated channels are required to devote no more than seven channels to qualified commercial broadcast signals. Systems with 27 or more channels must devote up to 25% of their capacity to mandatory carriage. All systems must carry at least one non-commercial station, while those with 34 or more channels must carry at least two.

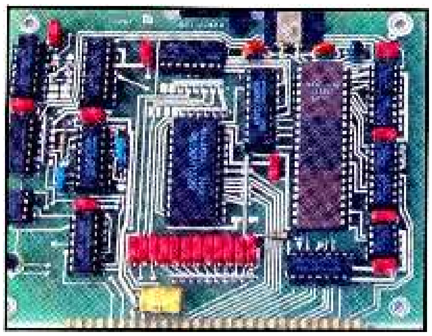
To qualify for carriage, a station must be licensed to a community that is within 50 miles of the cable community. The station must show that it has a 2% average share of total viewing hours and a net weekly circulation of 5% in non-cable homes where the cable system is located. New commercial stations will be exempt from this requirement and will be carried regardless of market share for their first year of operation.

A cable system will not be required to carry more than one station affiliated with the same commercial network. Also, systems will not be required to carry an otherwise qualified station that would be considered a distant signal, for copyright purposes.

Additionally, where the number of qualified stations exceeds the maximum number of channels that a cable system is required to devote to must-carry signals, the cable system has full discretion to select the stations it will cover.

Modification rules reviewed

The FCC has begun a review of its rules



concerning modifications of transmission systems. The proposal, which would affect all 10,000 broadcast licensees, would allow stations to make minor electrical and mechanical modifications to their authorized transmitters without having to first obtain commission approval.

Under present rules, certain transmitter modifications can be made without prior approval. However, if a modification could cause the equipment to operate beyond tolerances specified by the commission, then prior approval is required. The commission now views these rules as too narrow.

The proposal would require licensees who wish to modify or improve their transmitters to make the appropriate tests to ensure that the modified equipment is operating within commission-specified parameters. Therefore, it would be up to each station to ensure that its equipment will transmit signals within the proper bandwidth and that excessive emissions will be suppressed. To help minimize harmful interference, the commission proposes that broadcasters should take measurements and keep them for as long as the modified equipment is being used.

The proposed rules would not permit AM stations to install stereo without prior approval. The commission believes that deregulation of AM stereo, which is still in its infancy, would be premature.

New rules on FM upgrades

FM operators are now allowed to upgrade their facilities on their existing or adjacent frequencies without having to face competing applications. However, the rule, which became effective on June 5, applies only to existing and newly instituted rulemaking proceedings.

Although previous rules encouraged the upgrade of FM stations, upgrades generally occurred only when at least one other equivalent higher class of channel could be found to meet the interests of other parties. If no channel was available, FM stations would not seek an upgrade because they risked losing their existing authorizations in comparative hearings. The commission believes the amended rules will benefit public interest by expediting expanded FM service.

FM technical rules reviewed

This past spring the commission began a review of its FM technical rules to clarify and correct inconsistencies and to simplify procedures that have become overly complicated as a result of Docket 80-90. In that docket, the FM rules were amended to make room for more stations in the FM band by increasing the number of station classes from three to six and by changing mileage separation requirements.

The commission is now preparing to replace the minimum power and antenna height restrictions with equations that would represent a continuous range of facility options. The existing rules present a list of the minimum and maximum power and antenna heights permitted for each class of station.

There are certain combinations of power and antenna heights that do not conform to any defined station class. Because Docket 80-90 granted existing stations three years to expand their facilities to meet the minimum requirements of the docket's classification scheme, the commission stated that review of allocation requirements is necessary to provide guidance to those stations subject to reclassification on March 1, 1987.

The commission recognized that its proposal could have a negative impact on the 49 stations currently in the process of expanding their facilities to avoid the reclassification deadline. However, the impact would be minimal because affected stations will retain the classifications they originally anticipated.

The commission also proposes to allow higher classes of stations on the Class A channels, as long as such upgrades would be consistent with the permitted distance separation rules. Although the commission presently allows Class A stations to be licensed on all commercial channels, it does not allow the use of designated Class A channels for higher classes of stations.

Finally, the commission has proposed that an FM station's class be determined by the location of the city of license rather than the location of its transmitter. The current rules are not consistent as to whether transmitter site or city of license determines classification.

Martin is a partner with the legal firm of Reddy, Begley & Martin, Washington, DC.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Advanced TV displays the big screen

By Ben Crutchfield

One of the main objectives of advanced TV systems is the capability of displaying a larger-screen picture. The current system looks good on screens up to 30 inches diagonal and can look impressive on a 19-inch or smaller set with good filtering. On a large projection screen the weaknesses begin to show—scanning lines are noticeable, and resolution looks soft.

At typical viewing distances, the TV picture often covers less than 10° of the eye's field of view. A 19-inch diagonal picture is about 11 inches high. At about 6½ feet, the picture covers a vertical angle of about 8°. One of the people who has studied viewer perceptions and preferences is Dr. William Glenn, director of the New York Institute of Technology research into advanced television. Glenn notes that viewers will typically choose a viewing distance of about 7x picture height for television and about 3.5x the picture height for film or high-definition TV systems.

The viewer tends to choose these distances because of the eye's response to the resolution of the picture. Sensitivity to a static image actually increases with resolution up to a point and then decreases. Within the field of view, the eye has its best resolution in the central 1%. As a result viewers tend to back away from a picture in order to get as much in that small area as possible. The viewer stops backing away when detail

becomes too small for the eye to resolve. The viewer subconsciously maximizes the amount of information.

As image resolution increases, the viewer tends to move closer, settling at the optimum point for the improved image. For 35mm motion picture film and HDTV systems designed to equal 35mm film, this point is about 3.5x the picture height. Halving the distance to the screen doubles the effective image height and width; the image area is then four times as large.

In his work, Glenn analyzed several systems and has determined the relative image size that could be achieved for the same resolution in the eye of the viewer (see Figure 1). Currently the smallest is NTSC. Second is NTSC with improvements such as progressive scanning and revised derivation and processing of luminance and chrominance information, including removal of cross-color and cross-luminance.

The next step is to a multiplexed analog component (MAC) system—in this case, a wide-MAC system. Finally, the largest frame is that which can be achieved with a high-definition system such as Glenn is developing or the one developed by NHK in Japan.

Resolution is neither a simple concept nor is it the only aspect of advanced TV systems. In general, the eye is more sensitive to fine detail in static rather than moving images. The decrease in sensitivity is not directly related to speed of movement; sensitivity actually increases with speed, then drops off. The eye also is more sensitive to fine detail in luminance information than in color.

The system on which Glenn is working is interesting in a number of ways. At the current stage, the system uses two channels, one of which is an improved but fully compatible NTSC channel. This channel may be transmitted and received with existing equipment. The second channel, less than 6MHz wide, carries detail information and has no particular relationship to the first.

The camera for the system is a 3-tube, 525-line (interlaced) color camera with a component output. In addition, the optical system has an output for a fourth, high-resolution tube that progressively scans 1,050 (2x525) lines at 15 frames per second.

The progressively scanned, low framerate signal obtains high-resolution information. The 525-line, interlaced signal is not as good for fine detail but, because of the higher frame rate, provides luminance information on moving parts of the picture, as well as most of the color.

The NTSC part of the system includes several improvements, two of which would help existing receivers:

- Midrange detail (200- to 500-line range) is extracted from the progressively scanned tube output, converted to interlace and mixed with the NTSC signal. Low frequency (0-200 lines) information, more sensitive to motion and less to detail, is derived from the NTSC section of the camera, and is updated at the 60-field rate.
- Motion is temporally enhanced at the transmitter end by increasing the frequency-dependent gain. This compensates for loss in contrast due to camera-tube target integration.
- Color and luminance are processed so that a frame comb in the receiver removes cross-color and cross-luminance artifacts without limiting the chroma bandwidth or leaving gaps in the luminance spectrum.

The system, still under development, was demonstrated at the 1986 NAB Convention in Dallas.

Crutchfield is project director for the Advanced TV Terrestrial Broadcast Project, a joint project of NAB and the Association of Maximum Service Telecasters.

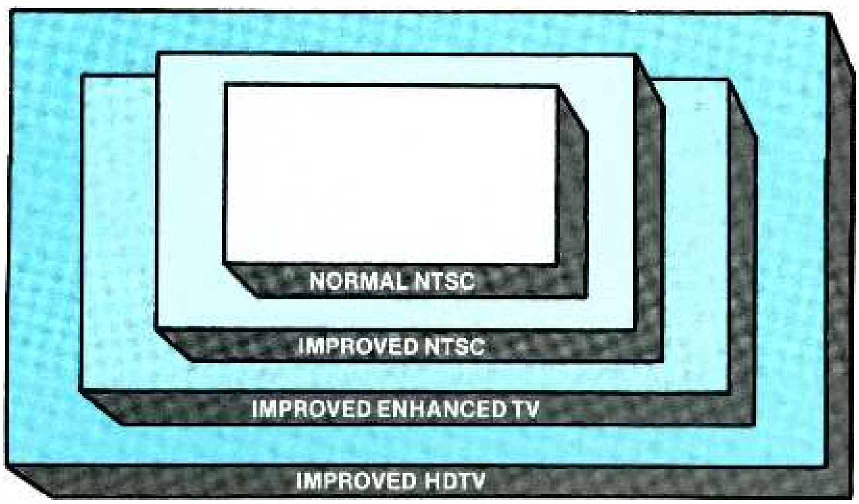


Figure 1

Editor's note: This article concludes a 3-part series prepared by Ben Crutchfield.

Learning the basics

By John Battison

Last month, we discussed some of the basics of broadcast engineering. Because of the number of questions that have been raised on antenna units (ATU), let's take a close look at what they are and how they are used.

Figure 1 depicts a typical tee network that might be used in an ATU. This discussion will consider only tee networks. Even though the L network design uses fewer components, it is difficult to apply to directional antenna systems. The tee network, on the other hand, is capable of being used with most antenna designs and, with a little study, most engineers can understand the tee network.

Why are they needed?

Why do you need an ATU? It would certainly seem more straightforward to simply connect the transmitter to the antenna. After all, isn't that how it's done in FM?

Unfortunately, AM systems are a bit more complex than most FM installations, so you usually have to provide some *matching* system between the transmitter and antenna. Although some AM systems may not have any network, most installations have some form of a matching network.

A non-directional shunt-fed system is one example in which a network might not be required. If the shunt feed line happens to be adjusted so that the antenna *resistance* matches the transmission line *impedance*, then only a small amount of reactance, capacitive or inductive, may be required to drop the j component.

Shunt example

Assume you have an antenna impedance of 51Ω with a −j43Ω reactance and a feed line with a 50Ω impedance. It's usually possible to tune the transmitter output so it will properly operate in this configuration. The capacitive reactance can be eliminated by a simple coil placed in series with the shunt feed line. The coil is adjusted to approximately +j43Ω, which takes care of any stray reactances within the feed system. An antenna impedance of 51Ω is used and the antenna drive current is adjusted for the correct power.

In actual practice, most engineers would readjust the shunt feed position on the tower so that the resistance becomes 50Ω. Then any adjustments would be made in the reactive component. In this case, you would add a small coil to cancel the −j reactance.

If the reactance had been +j, normal practice would dictate using a small coil in series with a capacitor that would then be adjusted to cancel excess +j.

Battison, BE's consultant on antennas and radiation, owns a radio engineering consulting company in Columbus, OH.

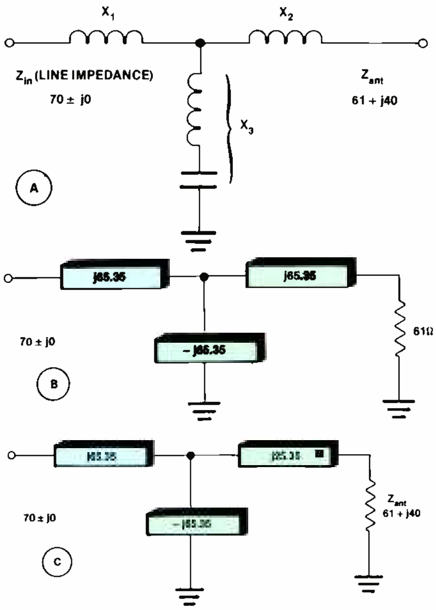


Figure 1. Typical tee network ATU as shown in a. In b, same network showing matching impedances with 90° phase shift. In c, a matching network is developed by adding +j25.35Ω reactance in series with Z_{ant}.

Calculations

Although most engineers have been exposed to the equations for calculating the reactance of coils and capacitors, it's still difficult to do. Unfortunately, the equations are cumbersome and often lead to mistakes, but there are computer and calculator programs to calculate these values. One of the easiest ways to solve these problems is with a frequency/reactance nomogram, which calculates the equivalent reactance in microhenries or microfarads. These nomographs are published in many handbooks, so look around for one.

I use an HP-65 calculator to derive the values I need. If you would like a copy of the calculator program, I will make it available on request. The program calculates all the legs for a tee network and also gives the equivalent values in microhenries and microfarads.

Look again at Figure 1(a). You want to transform the antenna's 61Ω base resistance to match the 70Ω transmission line. There are literally hundreds of leg value combinations that will provide this match, but each combination also produces another important characteristic—phase shift. In the case of a non-directional antenna, it used to be said that phase shift didn't matter. However, with the increased interest in fidelity and antenna characteristics, phase shift, even in a non-directional system, should be considered.

The easiest tee network calculations involve a phase shift of 90°. Figure 1(b) shows the results of this equation:

$$Z_1 = Z_2 = -Z_3 = \sqrt{70 \times 61} = j65.35\Omega$$

Thus the reactance of each leg is 65.35Ω, with both series legs being +j and the shunt leg being −j.

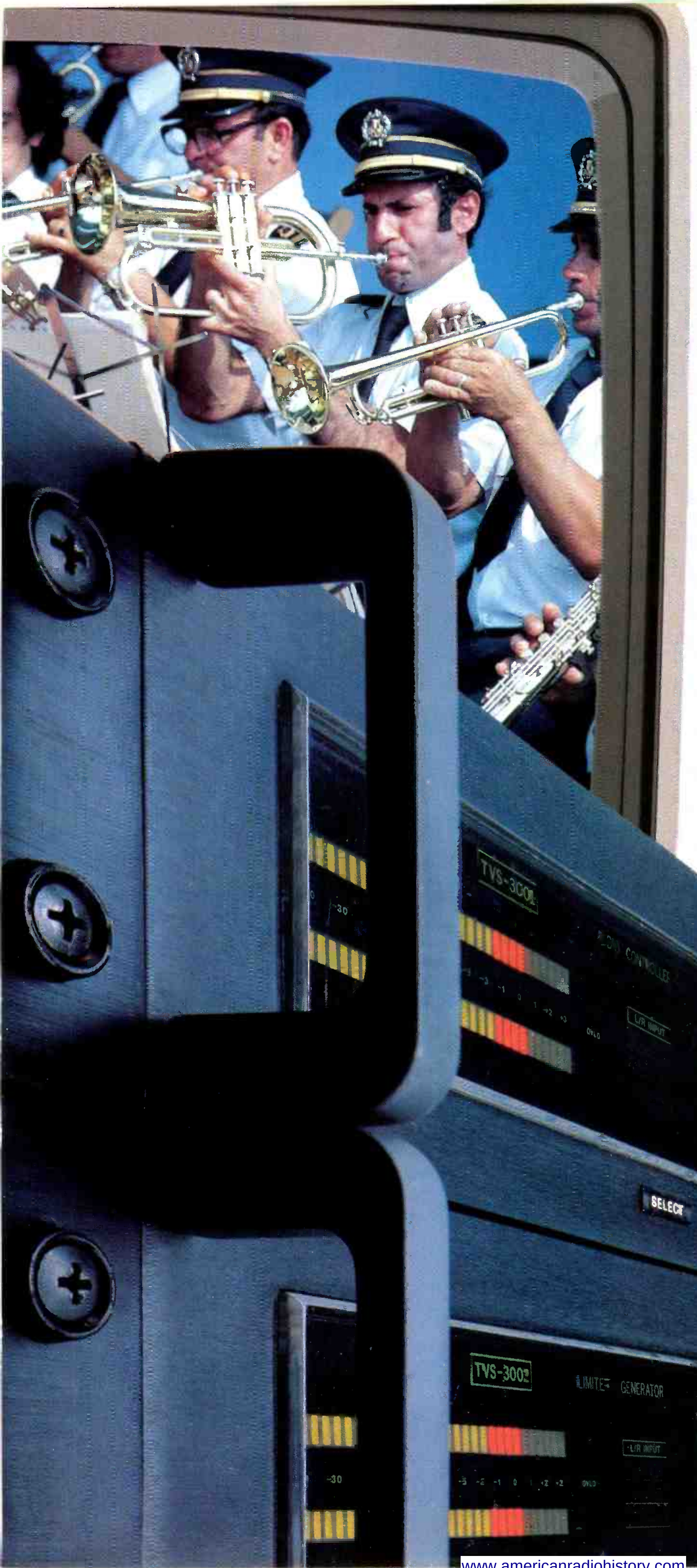
The antenna leg already has +j40Ω of reactance from the antenna itself. This means you need only +j25.35Ω (65.35 − 40.0) of reactance in the series leg X_2. This is because j components in series add, just like series resistances.

You may come across tee networks with series legs (X_1 and X_2) that use capacitors in series with inductances. This configuration is an indication that the sign of the series reactance is negative. In this case, the inductances are used in series with the capacitors to form the familiar *variable capacitor* by tapping down the coil to cancel out some −j reactance.

Sometimes a pure capacitive reactance in the shunt leg provides better antenna matching than the coil/capacitor combination. This is often the case with a folded unipole being used for stereo operation. In this case, replacing the shunt capacitor and coil with a vacuum variable capacitor may result in superior audio quality.

Next month we'll look at the currents and component ratings in the various legs of the ATU network.

Editor's note: For a copy of the calculator program, write to John Battison, 890 Clubview Boulevard North, Columbus, OH 43085.



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Circle (9) on Reply Card

Rating earth-station systems

By Elmer Smalling III

Let's consider two important, but often misunderstood, equations used in connection with earth-station design and operation. The first is:

$$G/T = G - 10 \times \log_{10}(T),$$

or the *figure of merit* of an earth station is equal to the antenna gain less 10 times the common logarithm of the sum of the noise temperature components of the system.

The second equation is:

$$C/N = G/T - L_D - L_M - K - 10 \times \log_{10}(B) + EIRP.$$

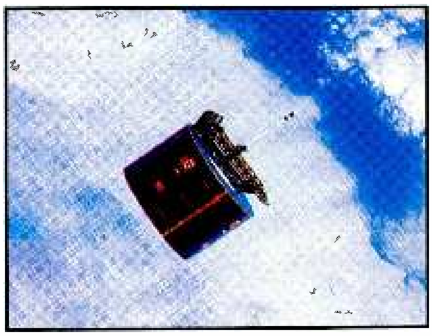
or the *carrier-to-noise* ratio of a system is equal to the system G/T less the path loss from the satellite to receiver less miscellaneous system losses less Boltzmann's constant less the receiver noise bandwidth plus the effective isotropic radiated power of the satellite.

G/T

The figure of merit was devised to easily compare performance figures of different earth-station receivers. An earth station might combine a large, high-gain antenna with a mediocre amplifier. Other systems might use medium or small dishes with high-gain amplifier systems. You cannot tell the performance of the system simply by examining a single component such as the antenna, LNA or receiver. Because the combination of available components is quite varied, the G/T or figure of merit is used to *handicap* any system with respect to its signal-gathering power.

Equation 1, the figure of merit ratio, is easily calculated. The gain figure is the gain of the earth-station antenna measured in dBi (decibels above the value of an isotropic or imaginary dipole in free space that emits equally well in all directions). This figure can be requested from the antenna manufacturers or calculated using common reference sources. For these purposes, use 43dBi for the gain figure G, which is the approximate gain value of a 4.5m diameter parabolic antenna at 4GHz.

Smalling, BE's consultant on cable/satellite systems, is president of Jenel Systems and Design, Dallas.



Determining the noise temperature figure is a bit more difficult. You must find the total noise contribution of the system. The three main contributors are the antenna noise temperature, the LNA noise temperature and the passive equipment noise temperature. You can find the antenna noise temperature from the antenna specs or from the manufacturer. For this example, the antenna has a noise temperature of 22°K (Kelvin).

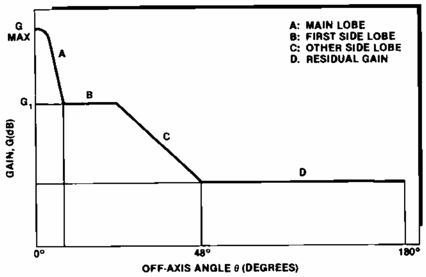


***Figure 1.** Related to the figure of merit of the antenna is the side lobe performance. Gain must be controlled according to the formula $G=32-25\log_{10}\Theta$ for $1° < \Theta 48°$. Although the gain restriction applies to transmitting antennas primarily, it also affects receiving performance.*

The LNA is sold according to its noise temperature, so it can be found on the label. In this case it is 100°K. The passive equipment noise temperature of the feed system is 3°K (an average system figure).

Now you can apply all of these factors to the equation:

$$\begin{aligned} G/T &= G - 10 \times \log_{10}(Tn) \\ &= 43 - 10 \times \log_{10}(22+100+2) \\ &= 43 - 10 \times \log_{10} 124 \\ &= 43 - 10 \times 2.09 \\ G/T &= 22.1 \end{aligned}$$

You could make the equation more detailed by adding precise passive noise temperatures or system losses, but because the noise temperature calculations are logarithmic, it would take large changes to affect the video quality. Keeping everything else fixed and changing the LNA to a superior 85° unit buys only 0.6dB/°K. This might make a difference in a fringe reception area or where the antenna is of marginal size.

C/N

Equation 2, the carrier-to-noise ratio, involves several factors besides G/T. The second and third elements are simple losses measured in decibels. The first, L_D, is the path attenuation from a geostationary satellite at 22,000 miles above the equator. This loss is approximately 196dB.

The second loss, L_M, is the total of many small miscellaneous losses, including atmospheric absorption, rain attenuation, satellite earth-station pointing error, FM threshold margin, polarization loss and long-term satellite degradation. Each of these losses is small (< 1dB each) and, for these purposes, may be lumped together as 2dB.

The third element, Kelvin (or K), is a physical constant that was discovered by 19th century scientist Ludwig Boltzmann which relates molecular activity to temperature. When converted for this use, Boltzmann's constant is −228.6dBW/°K.

The next factor is 10×log(B), or 10 times the common logarithm of the receiver bandwidth. For this example, the bandwidth is 36MHz.

The last figure is the effective isotropic radiated power of the satellite you wish to receive. Although isotropic refers to a lossless, omnidirectional, free-space dipole, it is used in most literature for satellite ERP. For this example, assume an ERP of 34dBW.

The C/N equation now becomes:

$$\begin{aligned} C/N &= G/T - L_D - L_M - K \\ &\quad - 10 \times \log_{10} B + EIRP, \\ &= 22.1 - 196 - 2 - (-228.6) \\ &\quad - 75.5 + 34, \\ C/N &= 11.2dB \end{aligned}$$

To ensure a noise-free system, make certain that your C/N level is always at least 3dB over the receiver threshold level. This level can be found in the receiver specifications. A simple way to improve G/T or C/N ratios is to increase the size of your antenna and/or use a low-temperature LNA (60°K to 85°K).

Part 3

Circuits

Synchronous AM in FM systems

By Jerry Whitaker, editor

The amount of synchronous AM in an FM transmission system is a function of bandwidth and carrier deviation. As discussed in last month's column, an FM system can be tuned for optimum performance by observing the amplitude and frequency of the synchronous AM component. The effect of bandwidth on overall system performance for synchronous AM is plotted in Figure 1. Notice that as the −3dB points of the RF system passband are narrowed below 400kHz, a dramatic increase in synchronous AM occurs.

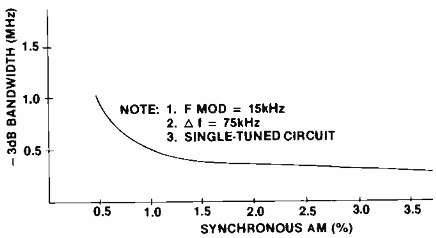


Figure 1. *Typical synchronous AM content of an FM signal as a function of system bandwidth.*

The data presented in Figure 1 is applicable to any bandwidth-limited FM system, including FM broadcast transmitters, TV aural transmitters, STL systems, diplexers and transmitting antennas.

Bandwidth also affects the distortion floor of the demodulated audio signal of an FM system, as plotted in Figure 2. The data applies to a test setup involving a single-tuned circuit fed by an FM signal with a deviation of ±75kHz at a modulating frequency of 15kHz (no de-emphasis is applied to the output signal). Remember that FM is a non-linear process and that interpretation of distortion numbers for multiple signals, such as stereo, is not accurate. The Figure 2 example, however, illustrates how the bandwidth of the RF channel can set a minimum performance limit on system total harmonic distortion (THD).

Effects of bandwidth

Bandwidth restrictions that result in the generation of synchronous AM and increased THD also affect other elements of the broadcast FM or TV aural signal. For reference purposes, consider an FM transmission system with a −3dB passband of greater than 2MHz as a *wideband system* that presents essentially no degradation to the air signal. At bandwidths below 2MHz, however, degradation can be observed.

According to research on the effects of bandwidth restriction on FM transmission system performance (see the bibliography), three basic classifications of degradation can be identified: *moderate*, *narrow* and *very narrow* bandwidth systems.

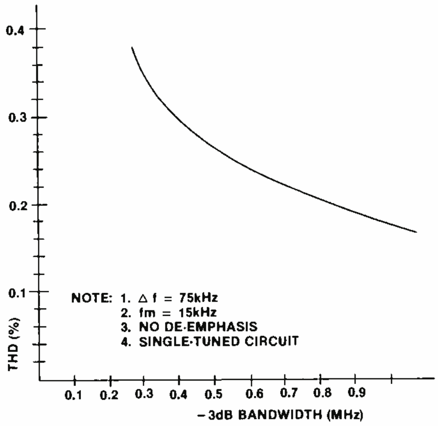


Figure 2. *Typical total harmonic distortion (THD) content of a demodulated FM signal as a function of transmission-channel bandwidth.*

A moderate bandwidth system is defined as a transmission channel exhibiting a −3dB passband of from 1MHz to 2MHz. Effects on stereo performance include increased stereo-to-SCA crosstalk and reduced stereo separation relative to the wideband (greater than 2MHz) system. From the standpoint of practical performance, however, a moderate bandwidth system is essentially transparent to program audio.

A narrow bandwidth system is defined as a transmission channel exhibiting a −3dB passband of from 0.5MHz to 1MHz. Typical performance limits are:

- stereo-to-SCA crosstalk 50dB to 60dB,
- intermodulation distortion (IMD) approximately 0.2%,
- THD approximately 0.2%,
- stereo separation approximately 50dB and
- synchronous AM approximately 1%.

A very narrow bandwidth system is defined as a transmission channel exhibiting a −3dB passband of less than 0.5MHz. Such a system will experience performance degradation and a noticeable loss of quality in on-air sound. Furthermore, the system may be unstable with time and temperature. Critical parameters include:

- stereo-to-SCA crosstalk 40dB or less,
- IMD approximately 0.5%,
- THD approximately 0.5%,
- stereo separation 30dB to 40dB (because of composite rolloff),
- synchronous AM approximately 5% and
- increased SCA-to-stereo subchannel crosstalk (typical figures difficult to estimate).

Because infinite bandwidth is required for perfect performance from an FM system, any reduction in bandwidth will only degrade the demodulated program signal. All physical systems, however, limit bandwidth to some extent and so the requirement for infinite bandwidth is compromised. The extent to which it is compromised is more or less under control of the user. A properly designed transmitter can provide wideband performance if properly tuned. Figure 3 shows an actual plot of an FM transmitter passband using a cavity-type PA circuit. Note that the −3dB passband is 2.2MHz, which places the system into the wideband category discussed previously. Modern transmitters are capable of such performance. It is up to the engineering staff to achieve it.

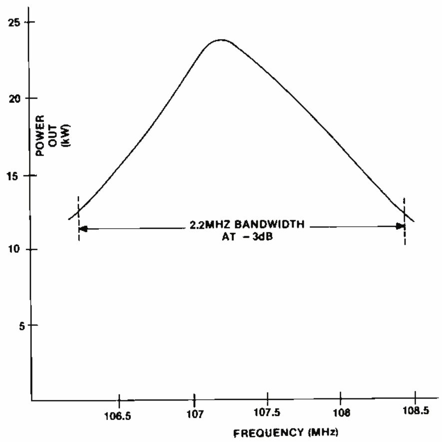


Figure 3. *The measured overall bandwidth of a 25kW FM transmitter.*

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Hershberger, David, and Robert Weirather. "Amplitude Bandwidth, Phase Bandwidth, Incidental AM, and Saturation Characteristics of Power Tube Cavity Amplifiers for FM," Harris Corporation, Quincy, IL, 1982.

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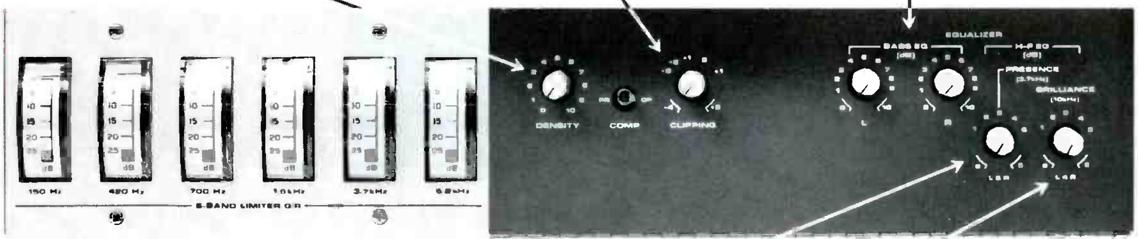

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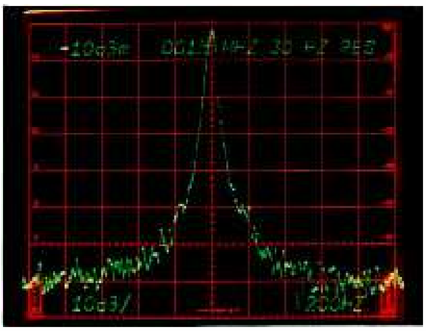
Part 1

Troubleshooting



Repairing digital systems

By Martin Plude

Maybe you've run into the following situation: You're servicing a digital circuit, and have located the section of the board where the problem exists. You've identified a suspect IC. It's a 20-pin TTL (or CMOS) device that has been conveniently wave-soldered solidly into place. The only way you can think of to test your hypothesis is to swap ICs, so out comes the soldering iron. You spend a considerable amount of time removing and gingerly replacing the device. You take a deep breath and apply power to the unit. The problem is still there.

There's a better way to track down problems, without unsoldering anything. Instead of pulling out the IC (and your hair), you can use a device called a logic comparator to test the IC in-circuit.

Logic comparators

Logic comparators are available from a number of manufacturers. They are similar in operation and offer a quick way to identify a bad (or good) IC. As the name suggests, logic comparators use a comparative principle to check a known-good reference IC against a questionable IC in the circuit under test. This method involves placing the known-good IC in the comparator, clipping a connector over the in-circuit IC and observing a go/no-go indicator.

Before using a logic comparator, first determine the type of IC technology being used in the circuit—either TTL or CMOS. Because of the difference in voltage requirements for TTL (+5V) and CMOS (+5V to +18V) ICs, instrument manufacturers offer different models to meet the operational requirements of each technology.

When the IC has been identified, check an IC data chart (usually supplied with the logic comparator) to determine the Vcc and ground configuration of the device used in the circuit. Most ICs use the standard Vcc and ground arrangement shown in Figure 1, but there are just enough special configuration devices in use that the IC chart should always be consulted. DIP switches allow non-standard configuration of Vcc and ground to be selected.

Typical setup of a logic comparator involves locating a source of Vcc and ground on the circuit board for connection to the logic comparator. Logic comparators draw their own small power requirements from the circuit under test, mainly to light up the LED pin indicators.

After hooking up the logic comparator to power on the board, attach the test clip to the suspect IC. Remove the known-good reference IC from its anti-static case and place it in the logic comparator. Push the *test* button to initiate the comparison.

If the IC under test is good, the tester will indicate it. If the logic states do not agree, a fault indication will be displayed. LEDs adjacent to the known-good IC will light at those pins where the logic state of the device under test is different from the reference IC. This information may direct you to another IC or suggest another test, such as logic state activity.

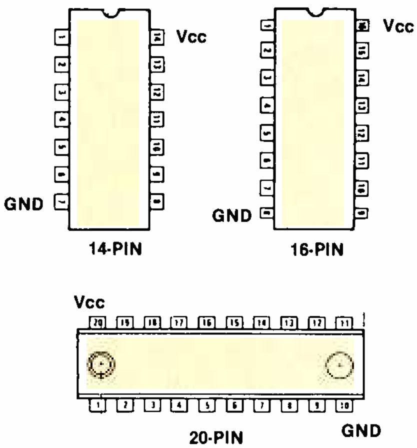


Figure 1. *Typical power and ground pinouts for 14-, 16- and 24-lead ICs.*

Versatility

The logic comparators that are available on the market can handle standard and non-standard Vcc and ground pin configurations. For non-standard power configurations, the appropriate connection is engaged via a toggle or dip switch on the comparator.

Because of the small size of logic comparators, they can be used both on the bench or in the field for on-site replacement of ICs. Logic comparators can save servicing time, because the questionable component is analyzed with the equipment in its dynamic, normal operating condition.

Some logic comparators also include a logic monitor feature, which displays the full logic state of devices with up to 20 pins at one time. This is significantly faster then individually probing each pin with a logic probe. In addition, this type of instrument provides information unavailable from a logic probe—simultaneous comparison of logic states at two or more pins.

Applications

Although logic comparators are major time savers, they are not 100% effective in every application. For example, counters and shift registers must be reset to synchronize the reference IC with the IC under test. Otherwise, erroneous test results may occur. Also, with some models, high-speed triggered devices cannot be compared. The small propagation time delay of the cable and tester prevents identical timing in both ICs. Other devices may require special consideration for proper testing.

Logic comparators are not intended to replace standard test instruments in the troubleshooter's bag of tricks. Oscilloscopes, digital multimeters and logic pulser probes have their special benefits. In certain circumstances, however, a logic comparator provides a versatile, hand-held device to verify the operation of questionable ICs in-circuit and under power.

Editor's note: With this issue, we begin a series of articles discussing how users can troubleshoot and repair digital-based hardware. The growing use of digital equipment in broadcast stations has dramatically increased the need for engineers to be proficient in the repair of advanced electronic systems.

Plude is manager, marketing planning and communications, B&K-Precision/Dynascan, Chicago.

Dealers' choice!

Management
for engineers

Develop a style to call your own

By Alfred P. Hahn

My first day as a shift supervisor was a flop. It's been 18 years since then, but I still remember it well.

I was 21 years old, not long out of the Army. My boss liked my aggressiveness and put me in charge of a shift, supervising another technician who was far superior to me in experience. The first night, I was King Kong. I tried to order the technician around, and he didn't want any part of it. The next day I stormed into my boss's office insisting that I wanted to fire the technician. His response was, "You can't go around firing people." He moved the man to a different shift.

Looking back, I realize that I acted really foolish. I was overcontrolling. I thought that management meant bossing people, which it doesn't.

My second management job taught me how management can get burned. Determined not to repeat the King Kong mistake, I developed a positive relationship with the engineers and technicians. I was well respected and "one of the boys." Then, one day, the payroll clerk asked me why I had approved overtime for a technician who called in sick.

As it turned out, the technician had been putting in false overtime claims for some time, even before I became his manager. Being the nice guy, I hadn't been paying close attention to the time sheets—just signing them. We were all good buddies, so I thought there would be no problems. Because I was too worried about my relationships with workers, I didn't appreciate that one of my duties was protecting the company by making sure the employees' time sheets were accurate.

Both of these lessons are part of the background I have drawn upon for guidance in dealing with people. The experiences also have been useful in developing my own personal management style.

Developing your own style

Is trial and error the only way to develop a management style that's appropriate for the broadcast business? The short answer is *yes, but.* To speed the process, training in management skills and philosophies helps significantly by heading off many painful mistakes and buying time to grow out of problems.

The long answer requires some self-analysis. That means defining a management style and how if differs from a novice manager's raw instincts.

It's helpful to consider that supervisors and managers must perform in several dimensions. A technician's position, on the other hand, requires competence in only two dimensions: dealing with faulty equipment and interacting with bosses.

Moreover, non-managers (technicians) receive positive strokes almost daily. They are heroes in single combat of me vs. machine. They walk in on chaos and return it to order. If they're really good, they also make the non-technical people feel good about their equipment and the engineering department's service.

The positive strokes for supervisors and managers aren't as generous, nor as frequent. Positive reinforcement, as well as the ability to see the tangible results of a day's work, are two surprisingly important job satisfaction elements. Often, managers rely on other activities, such as hobbies, to compensate for this lack of job satisfaction.

Some novice supervisors perceive their roles as coach or leader and, to some degree, they are. However, becoming the leader of the TGIF club at the expense of other job dimensions is inviting failure. Such managers will be perceived as unable to effectively evaluate or truthfully critique employees.

Management isn't a popularity contest, and it is important for the manager to be results-oriented. Any chief engineer or director of engineering who doesn't understand the *bottom line* is in for a real surprise. Station managers expect their chiefs to understand the value of an efficient engineering department. A chief engineer who fails to direct the engineering staff in an efficient manner, both in terms of personnel and equipment, may be looking for other employment.

Multidimensional behavior

One key to effective management is *multidimensional* behavior. The term simply means that you adapt your responses to problems based on each particular situation. A good supervisor or manager doesn't respond to every crisis in the same way.

Unfortunately, multidimensional behavior is uncomfortable or even impossible for some engineers. This is especially true for engineers who have spent a great amount of time dealing only with equipment and have developed few interpersonal skills. Engineers who have broader backgrounds usually find themselves somewhere in the middle—learning day by day.

Some people perform well in some managerial dimensions, but not in others. They ultimately fail because they can't achieve a balance. For instance, someone may be excellent in dealing with supervisors and subordinates but cannot relate well to peers in other station departments.

A manager needs peer-level respect to effectively communicate with other departments within the station. Without effective interdepartmental communication, the engineering manager is in a continual battle for support in terms of resources and respect.

Engineering managers who are task-oriented often feel inadequate in give-and-take encounters with peers. These managers want to deal on a black-and-white basis—things must be done their way or else. They will even use a little brinkmanship to get their way. When they become uncomfortable with peers, they either try an autocratic bluff or retreat to their offices to hide out for a while. It is the classic *fight or flight* reaction to stress.

On the other hand, no one likes managers who spend all of their time appeasing their bosses or who sacrifice subordinates to make themselves look good. Clearly, a balance is needed. Managers who are not multidimensional can be blindsided. It is necessary to develop techniques for dealing with problems and reaching goals that earn the respect of your subordinates, bosses and peers. A good management style does that for you.

If you are currently in an engineering management position, you may have identified some of your strengths and weaknesses. If you are not a manager, do you hope to become one? In either case, additional training may be helpful.

Hahn is president and founder of Support Technologies, Portland, OR.

Editor's note: This article was adapted from "Personalizing Your Management Style," which appeared in the July 1986 issue of *Microservice Management* magazine, an Intertec publication.

Dazzle 'm with technical brilliance.

Everybody's talking about CD's and digital. It's as if all analog tape technology and the cart machine were obsolete. Although CD's are a terrific new program source, it should come as no surprise that carts are still the best way to handle the huge quantity of individual program elements that comprise a typical day in radio broadcasting.

What else can play spots, promos, sound effects, news actualities, ID's and music so easily?

Carts have been around for thirty years because they're a great package—easy to handle and store, easy to record and re-record, easy to label and identify. Best of all, they're cued-up from the moment you put them in the machine. Try that with a CD, turntable or reel tape!

The engineer's challenge is not CD versus the cart, vinyl LP or reel tape—but improving all broadcast source and delivery systems. Digital audio technology is here with exciting potential for the future. For today's programming needs though, you can't beat the features and performance of our Tomcat and Micromax cart machines.

Tomcat and Micromax are equipped with our Maxtrax® wide-track tape heads which give you nearly twice the stereo track width. This track format, coupled with our superior recording and reproduction circuitry, maintains the fidelity of master quality sound sources better than any other cart machine.

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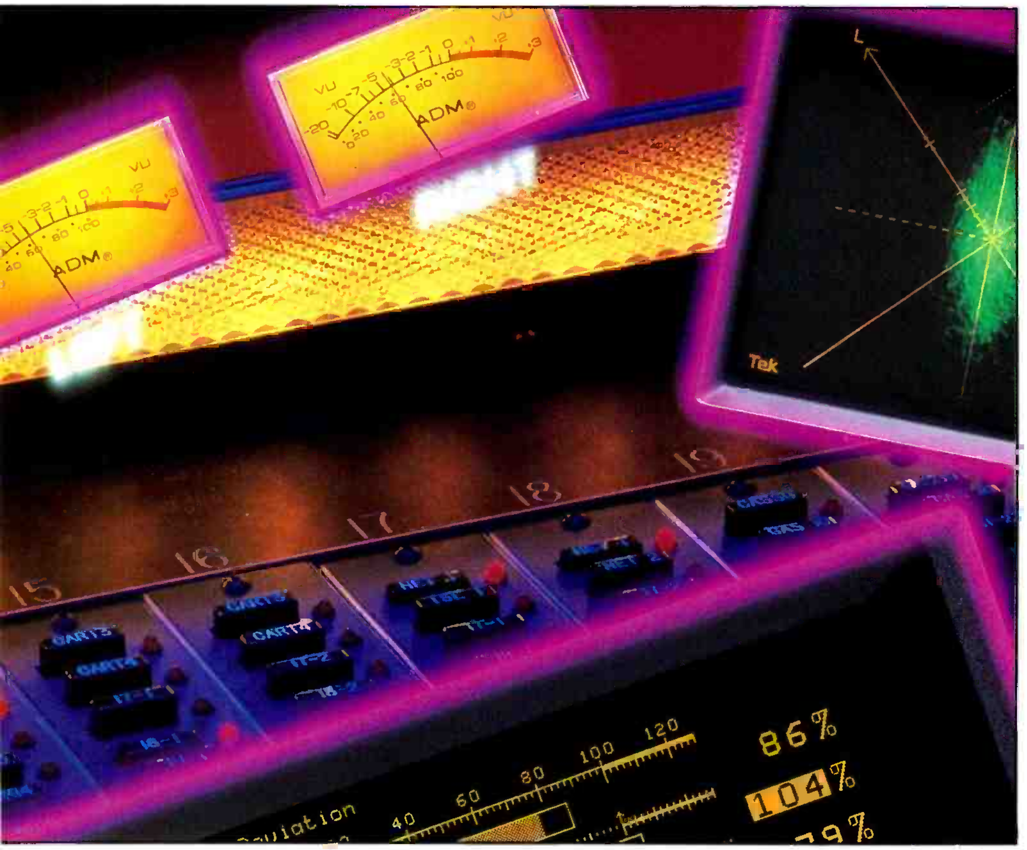
Wired for stereo

By David L. Bytheway

Develop a fresh approach to audio interconnection—without forgetting the traditional methods—and your stereo TV audience will hear the difference.



To many of you, the word *audio* conjures up thoughts of demons, nightmares and black magic. The basics of audio are simple to understand, but in practice, there are many problems to solve on the way to obtaining topnotch performance in a broadcast installation, especially with the new demands of TV stereo.

You don't really have to learn black magic, however, or fumble your way through nightmarish ordeals with the demon audio. Although there are many possible ways to get the most out of your equipment, the simplest methods are the best. The following is a collection of ideas that will help you take a fresh, up-to-date approach to achieving optimum performance from your TV audio facilities.

Voltage matching

The traditional method of interconnecting audio equipment in the broadcasting world is based on 600Ω sources and loads in all audio equipment. This standard comes from the early telephone days, when open wire transmission lines had a characteristic impedance of 600Ω. Because the equipment used with these lines had 600Ω input and output impedances, 600Ω became the standard for audio interconnection, and is still in general use today.

Advances in monolithic technology have made it possible to design both input and output stages with far better performance than older designs, which relied on signal-coupling transformers. Besides providing lower distortion, lower noise and better handling of balanced lines, op-amp-based circuits make it possible to use the technique of *voltage matching* to its fullest advantage.

The basic idea of voltage matching is to use low-impedance sources and high-impedance loads everywhere. In 1978, the International Electrotechnical Commission (IEC) published a standard that stated that all outputs should be 50Ω or less and that all inputs should be 10kΩ or higher. With the exception of some broadcast equipment, the majority of professional audio devices manufactured today conform to this standard. The use of voltage matching is the key to improving audio performance.

The first and most important advantage of voltage matching is the large increase in bandwidth that is possible on a system level. Second, interconnections and terminations are easier. Every output is treated as a voltage or low-impedance source, every input is treated as a bridging or high-impedance load, and no terminating resistors are used. Equipment patching is straightforward and simple. With this scheme, you can feed multiple loads from one source.

Third, because smaller signal currents flow, less crosstalk is produced. Capacitive coupling is also reduced as a result of the lower impedance held on

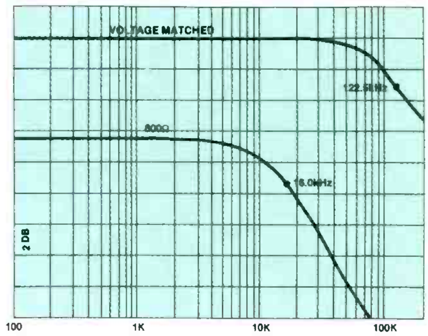


Figure 1. *Frequency response of a 1,000-foot cable when used in both voltage-matched and 600Ω impedance-matched systems. The markers represent the −3dB points.*

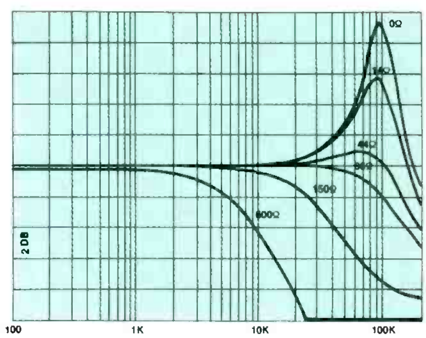


Figure 2. *Frequency response of a 1,000-foot cable with various values of source impedance. The flattest response results in a source impedance of approximately 60Ω.*

Bytheway is an analog circuit design engineer for the Robert Bosch Corporation, Salt Lake City.

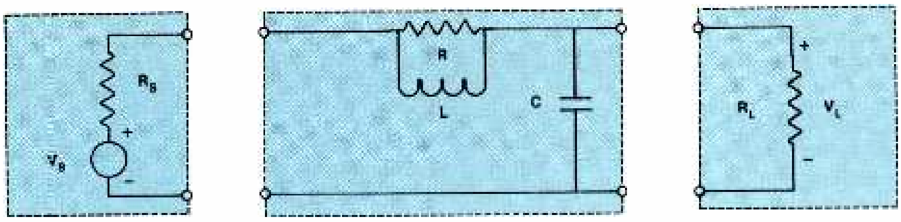


Figure 3. Circuit model used to approximate the characteristics of an audio cable less than one-tenth wavelength long at 20kHz. The frequency response depends on the line's load and source impedances.

the line. Fourth, the reduction in loading provides a more linear operation. Almost all output circuits in general use today have higher distortion when operated into their minimum rated load impedance. Fifth, voltage matching provides greater headroom and dynamic range.

Comparisons

In order to see the relative advantages of using voltage matching, some tests were made on a typical audio cable (a twisted pair with foil shield) 1,000 feet long. These tests were conducted with wideband transformerless balanced drivers and receivers. The source and load impedances used on the 1,000-foot cable were varied according to the test conditions.

The lower plot in Figure 1 shows the cable's frequency response with the typical 600Ω source and load impedances. The upper plot shows the same cable using an optimized voltage-matching technique. There is an increase of almost eight times the bandwidth. Note also, that with voltage matching there is essentially no level loss in the passband from terminating the cable. The 600Ω termination produces more than a 6dB loss in level.

Optimum output impedance

Some engineers believe that the best way to accomplish voltage matching is to use an output impedance that is as low as possible. They think this will overcome the audio cable's capacitance and provide the most bandwidth. Recent research shows, however, that the 0Ω output impedance is not optimum. In fact, it can cause frequency response peaking and transient overshoot.

Figure 2 shows the frequency response of a typical 1,000-foot audio cable terminated with a high-impedance load and driven with various source impedances ranging from 0Ω to 600Ω. The driving impedance that provides the widest bandwidth and flattest response is about 60Ω. Therefore, when a voltage-matched system is used, the best output impedance for driving typical audio cables is from 50Ω to 60Ω. These results have been confirmed by a number of independent sources over the past few years and entire facilities have been built this way.

Circuit model

To show how this frequency response peaking is produced, an empirical circuit model was developed to analyze these audio cables. Figure 3 shows that the circuit formed is essentially a second-order low-pass filter. The filter's frequency response is dependent upon all the circuit values. When the R, L and C of the cable are fixed according to the cable's length, then the response is determined by the source and load impedances connected to the cable.

This lumped circuit model corresponds to the incremental model used to derive transmission line characteristic impedances. At audio frequencies, the wavelength of the signals is much longer than the length of the audio cables. Therefore, the cables do not exhibit transmission line effects.

The free-space wavelength of a 20,000Hz signal, for example, is 15km, which is approximately 9.3 miles. It is generally considered that when a cable is one-tenth of a wavelength or less, the cable does not exhibit any transmission line characteristics such as reflections or standing waves. This makes it possible to use audio lines of 5,000 feet or more without having to consider transmission line effects. One audio system built in 1983 successfully handled cables of 3,000 and 7,500 feet in length with superior results because the cables were driven with voltage-matching techniques and used no transformers.

Alternatives to voltage matching

Some broadcast plants have used 150Ω impedance matching to lower the effects of cable capacitance and to increase bandwidth. Although this does result in some increase in bandwidth, the benefits are still not as great as those of the voltage-matching method. Figure 4 illustrates the difference between a voltage-matched system and a 150Ω system driving the same 1,000-foot cable. The 150Ω load requires much higher driving currents from the output stages, resulting in higher distortion levels. The increased distortion levels result from the difficulty in designing high-current, low-distortion output drivers. Figure 4 also shows increased voltage drop from the cable resistance, which forms a voltage divider with the load. In addition, equipment selection for this type of system is limited because most audio devices are designed for 600Ω loads.

System simulation

To simulate the frequency response of an actual audio system, additional tests were conducted using three distribution amplifiers, a routing switcher and 2,000 feet of audio cable (see the block diagram in Figure 5). These are standard off-the-shelf products, designed for voltage matching with a −3dB point of approximately 160kHz and a frequency response specification of +0, −0.1dB from 20Hz to 20,000Hz.

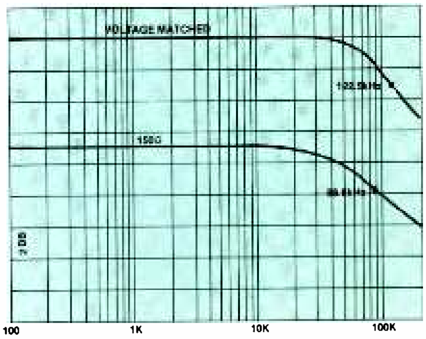


Figure 4. Comparison of frequency response for a 1,000-foot cable when used in voltage-matched and 150Ω matched systems. Markers represent the −3dB points.

The total system response is shown in Figure 6. The upper plot is the frequency response of a voltage-matched system with 66Ω sources and 20kΩ loads. The lower plot is the same system with 600Ω impedances throughout. The results are dramatic. The 600Ω system is approximately −9dB down at 20kHz, while the voltage-matched system is less than −0.3dB down at the same frequency. These results speak for themselves.

Note that the system's frequency response limiting factor is not the

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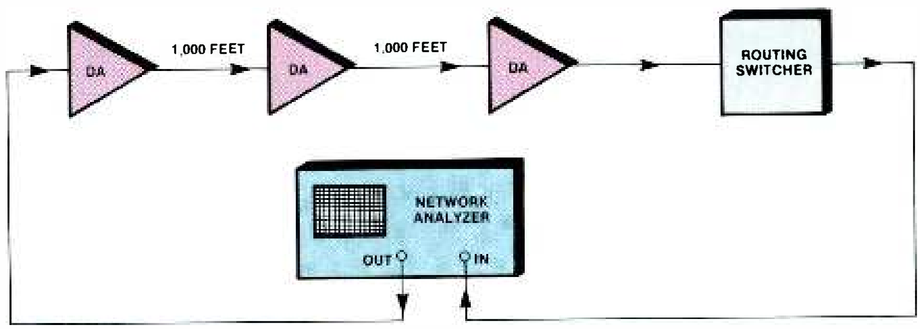
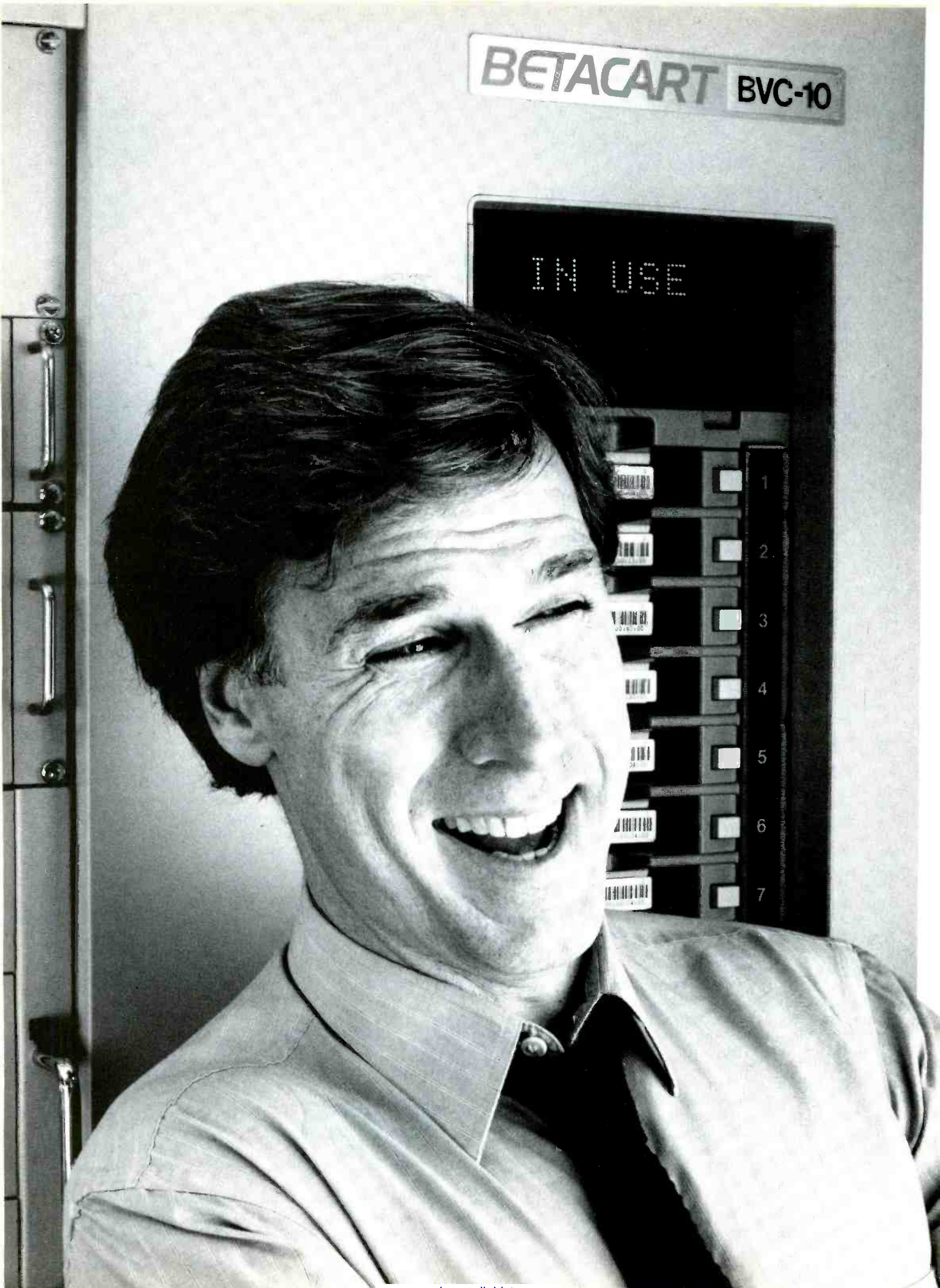


Figure 5. Block diagram for a test setup of 2,000 feet of cable, three DAs and an audio routing switcher.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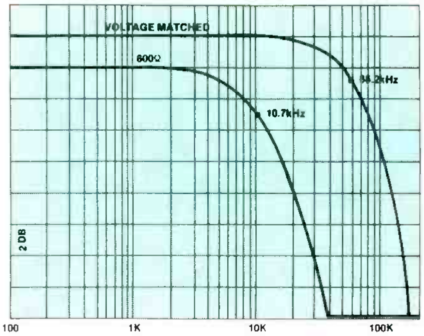

Figure 6. Frequency response of the test system described in Figure 5 when used in both the voltage-matched and 600Ω matched configurations.

Continued from page 23

amplifiers, but rather, the cables themselves. The test was repeated without the routing switcher. The results were indistinguishable from the first test, showing that a system's ultimate bandwidth may be limited by the cables, rather than the equipment chosen. This is true even when using the voltage-matching method.

Implementing voltage matching

The vast majority of audio equipment manufactured today can operate in the voltage-matching mode. Many of the more popular videotape machines have back-panel switches that select 600Ω or voltage-matching operation. Many routing switchers, distribution amplifiers, audiotape machines and mixing consoles also are manufactured in accordance with this standard. There is some equipment, however, that will require modification in order to work this way. Devices that have a true 600Ω input impedance can be modified with simple differential buffer amplifiers that are available from a wide variety of sources.

Transformers and voltage matching

Transformer-coupled equipment requires careful consideration. Although it is certainly possible to manufacture equipment with transformers that meets the voltage-matching standard, most broadcast transformer-coupled equipment does not. Most transformer-coupled equipment actually has an output impedance of 100Ω or less. In this case, no modification is required to lower the impedance. However, the transformer may need to be loaded properly in order to obtain correct frequency, level and transient response.

If a device is designed to be terminated in a 600Ω load, simply connect a 600Ω load resistor across the output. The device can then be treated as a voltage source and connected to the system as any other equipment. It is best to make the modification within the equipment cabinet. This prevents the resistor from being altered or removed during normal servicing. After the modification, it may be necessary to recalibrate or reset the equipment reference levels. This is especially true in the case of tape recorders. Fortunately, much of today's equipment is actually designed to be operated into a high-impedance load.

Long lines

When long lines are used, the cable capacitance can present a considerable load to the line amplifier. For example, a 1,000-foot cable with a capacitance of 30pF per foot presents a load of $0.03\mu F$. This capacitance has a reactance of 265.3Ω at 20,000Hz. An output driver that is capable of driving a 600Ω load may current limit when attempting to drive this reactance at high frequencies. If it does, it may produce a nasty sounding distortion that is similar to slew-rate limiting. The solution is to use high-current output drivers to drive cables in excess of approximately 500 feet. Sometimes, low-capacitance cables can be used where it is necessary to run long distances.

Terminating the other end of the line with a low-impedance termination only makes this problem worse. Because this termination is effectively in parallel with the cable capacitance, the termination further increases the loading on the driving source. High-current output stages are available in some routing switchers and distribution amplifiers. These designs should be used whenever you're

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Table 1. *Predicted attenuation from phase shift between two signals.*

forced to feed a long line. Even transformer-coupled outputs are not immune to this effect. Outputs capable of driving loads as low as 150Ω may be necessary. This is true even though the other end of the line has a high-impedance load.

Phase response

What kind of phase response is required to ensure good stereo signal distribution and mono compatibility? The audio signal paths should be the same for both the right and left channels. The signal's ultimate mono compatibility is determined by the *relative* phase response match for the two channels rather than the *absolute* phase response of either channel alone. Table 1 shows the level loss when identical left and right channel signals are mixed and one channel has a phase shift relative to the other. Note that even with a 40° phase shift, the cancellation is just 1dB. If care is taken to see that the left- and right-channel signal paths are the same, there will be far less than 40° of relative phase shift between them.

Stereo or mono DA

Many TV engineers are concerned that they must have a stereo distribution amplifier or switcher in order to properly handle stereo signals. Although it may be more convenient mechanically, there is no need to purchase new DAs when upgrading to stereo, as long as identical DAs are used for each left- and right-channel pair. This is essentially true of all audio equipment with the exception of compressors or limiters. These devices must be operated as a stereo-coupled pair so that L and R channel gain and phase relationships remain constant.

Optimizing phase response

In most instances, the optimum phase response is one that has a constant group delay and is smooth and linear as frequency increases. Although this performance is impossible to achieve in practice, you can come close. The best rolloff shape to produce these results is the bessel or maximally flat-phase response curve. A system will approximate this desired rolloff when it is free from transient overshoot. An easy way to determine a system's response is to apply a square wave. When viewed on an oscilloscope, the output square wave should have smooth rise and fall edges with a logarithmic shape. Also, there should be no evidence of slew-rate limiting or overshoot.

This criterion was used when choosing the best output impedance for driving audio cables in the voltage-matching tests. Voltage matching, done properly, not only extends frequency response, but also produces a more linear phase response as well. In addition, like frequency response, the ultimate phase response may be determined by the interconnect cabling rather than the individual amplifiers.

Distortion and noise performance

A quick comparison of professional audio equipment and high-grade consumer equipment shows that the professional units often have much higher distortion levels. It is now possible to design signal-distribution equipment with THD levels that are at or below the device's noise level. Table 2 compares percentages of THD to equivalent noise level. When you purchase equipment, compare its performance to this chart. Top-quality equipment will have noise levels close to the THD equivalent noise levels shown on the chart.

When a complete facility is designed with this kind of equipment, a signal from any source could be passed through the entire distribution system with no audible degradation in noise or distortion. This makes it possible to build a signal-distribution system that can pass the signal from the best digital source without degradation. A compact disc player, for example, is capable of distortion levels lower than 0.002% and a dynamic range of 96dB.

The simulated distribution system used in the voltage-matching tests had a measured noise level of −93.5dBv (referenced to 0.775V) in a 20kHz bandwidth and a measured THD of 0.0018% at 1,000Hz through the entire system. In addition, the maximum signal level was +27dBv, which gives the system a dynamic range close to 120dB. This system could, therefore, pass a compact disc signal essentially without degradation, because its noise level is more than 25dB better than the disc player and it has lower distortion levels. This performance level is available from a number of manufacturers today, but careful equipment selection is needed.

THD	EQUIVALENT NOISE LEVEL
1.000%	−40dB
0.3162%	−50dB
0.1%	−60dB
0.03162%	−70dB
0.01%	−80dB
0.003162%	−90dB
0.001%	−100dB

Table 2. *Comparison of noise and THD percentage levels. Equipment should have THD percentage levels close to the noise level.*

How much headroom?

Experience in the recording industry has shown that a minimum headroom of 20dB above zero-reference level is needed throughout the entire signal chain. This is because the human voice can have a peak-to-average ratio of 20dB. Newer digital music signal sources require even more headroom, as much as 25dB or more. As a result, the broadcast plant zero-reference level must be carefully chosen to provide adequate headroom.

A +4dBv reference level usually is preferred. Because most of today's equipment has a maximum output level of +24dBv, this leaves a minimum of 20dB headroom. This means a +8dBv system will have only 16dB of headroom and may be driven into clipping on many occasions. In order to obtain the 20dB margin for a +8dBv system, the equipment must be able to handle +28dBv signal levels.

Although some equipment is available that can handle these high levels, it is not common. With the heavy demands of music, the +4dBv reference, along with equipment that can handle levels of +28dBv or more is the preferred option. This combination gives approximately 24dB of headroom. The lower noise levels present in today's equipment make the +4dBv reference level practical, giving a wide dynamic range with low noise. Most equipment manufactured today can run at either +4dBv or +8dBv reference levels, so it is not difficult to convert to the +4dB standard.

Balanced and unbalanced connection

Connecting balanced equipment to the broadcast chain usually is straightforward. However, interfacing to unbalanced equipment can be troublesome, especially when transformerless equip-

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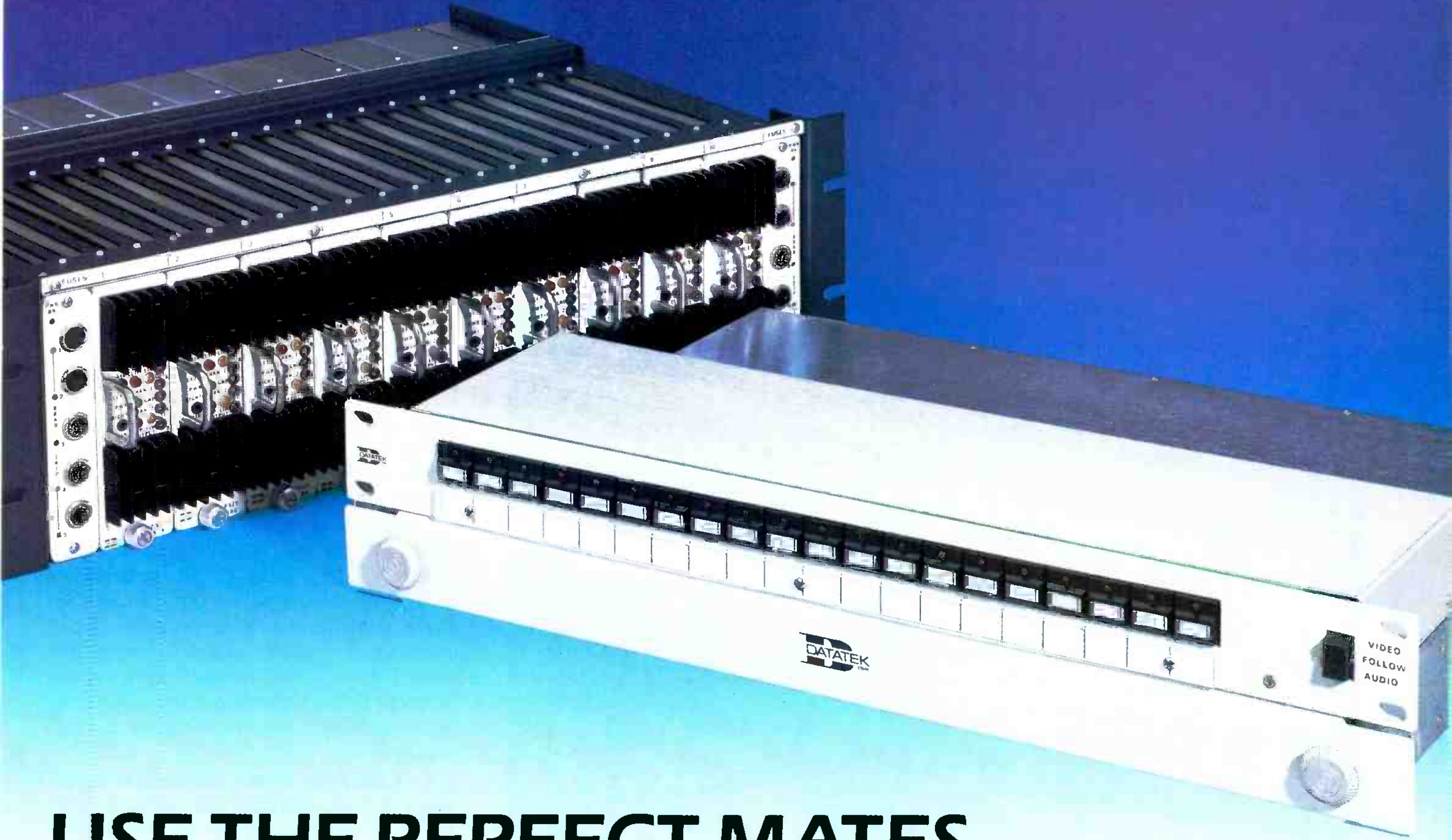

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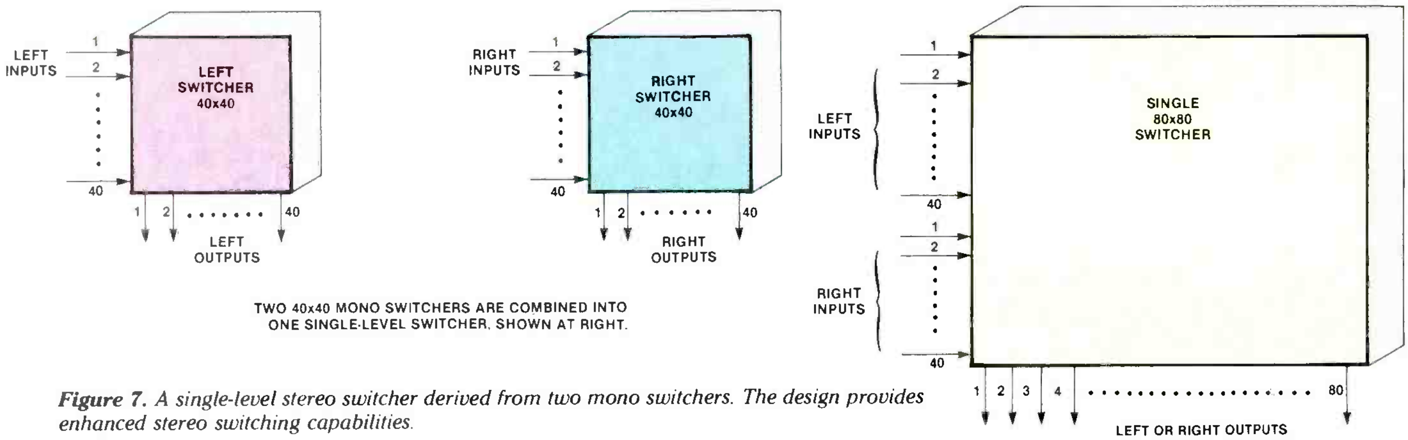

Figure 7. *A single-level stereo switcher derived from two mono switchers. The design provides enhanced stereo switching capabilities.*

ment is used. The advantages of transformerless equipment are many and varied. The greatest advantage is that well-designed transformerless systems simply sound better. Entirely transformerless facilities have been built with great success, and the trend seems clear.

The major objection about transformerless systems is that there is no way to break ground loops. In fact, a transformer is not connected into the grounds at all. A ground loop can exist in either type of system. Careful grounding techniques are important to ensure the success of transformerless systems. Their performance often exceeds that of similar transformer-coupled systems in terms of noise, distortion, hum rejection, bandwidth and, most importantly, sound quality.

A transformerless differential-input stage can be driven from either a balanced or unbalanced source. When unbalanced outputs are used, the grounds should be tied at the source. Tie the signal to the differential inputs and leave the grounds unconnected at the load. This enables the common-mode rejection of the differential inputs to reject any noise induced in the cable, even though the source is unbalanced.

The only time input transformers are needed is when there is a large amount of common-mode voltage present or when a specific terminating input impedance is needed, such as with telco lines. Within the broadcast plant, however, transformers are seldom required, and are actually undesirable. In practice, the common-mode rejection of a well-designed transformerless input stage can easily exceed the best transformer designs.

Transformerless output stages, however, require special attention when connecting to unbalanced loads. Many balanced transformerless output stages use two amplifiers, one for each side of the line. If one of these amplifiers is connected to ground, which is what happens in an unbalanced load, large short-circuit currents can flow. At worst, this will destroy the output stage. At the least, it will cause increased distortion and crosstalk levels. Unbalanced loads should

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be driven from only one side of such a balanced output driver. The other side should be left unconnected. This configuration typically results in a level loss of only 6dB.

Floating output drivers

There is a new kind of driver available, called a *floating output* driver. It operates like a transformer-coupled output in that it delivers the correct signal level between the + and – output terminals no matter what kind of load is connected, whether balanced or unbalanced. This driver has the additional advantage of automatic adjustment of the signal level so that if an accidental short circuit takes place, shorting one side of the line to ground, the shorted output shuts down and the other side increases its output to deliver the correct signal level without interruption or distortion.

Single-level switching

The flexibility and productivity within a broadcast facility can be increased through the use of a central routing switcher. This is a large switching matrix to which all the sources within a facility are wired as inputs, and outputs are provided in all the production areas. This design allows any signal to be routed to any location within the facility without using a patchbay. There are even TV master control switchers that use the central switching matrix rather than a separate matrix, making all sources within the plant available to the operator without patching or wiring changes.

Traditionally, when stereo signals are distributed, two identical routing switchers are used, with one switching level for the left channel and another level for the right channel. Usually, any mono sources or destinations are wired into the left channel, although they could be paralleled to both channels. This method limits the flexibility of feeding mono signals to stereo destinations, because the switching levels are separate.

One way to simplify the central switching of audio in which stereo signals are involved is to use *single-level* switching. This is done by placing all audio signals within a single level of the audio switching matrix. Both left and right channels, and mono signal sources and destinations, are connected to the matrix.

The main advantage is that it is now possible to do stereo channel reversals, mono to left and right, as well as left-to-stereo and right-to-stereo feeds without special outboard mixers or hardware. With the addition of a few dedicated active mixing amplifiers, it is also possible to do re-entry left and right to mono mixing within the routing switcher. Even phase-reverse amplifiers with re-entry could be accommodated. These features greatly increase the flexibility of any signal-distribution system and can be built with current equipment.

TRADITIONAL METHOD

LEFT CHANNEL	RIGHT CHANNEL
30 LEFT INPUTS	30 RIGHT INPUTS
10 MONO INPUTS	10 MONO INPUTS
40 OUTPUTS	40 OUTPUTS

TOTALS: 32 10x10 MATRIX CARDS
8 OUTPUT CARDS

SINGLE-LEVEL METHOD

30 LEFT INPUTS
30 RIGHT INPUTS
10 MONO INPUTS

70 TOTAL INPUTS

80 OUTPUTS

TOTALS: 56 10x10 MATRIX CARDS
8 OUTPUT CARDS

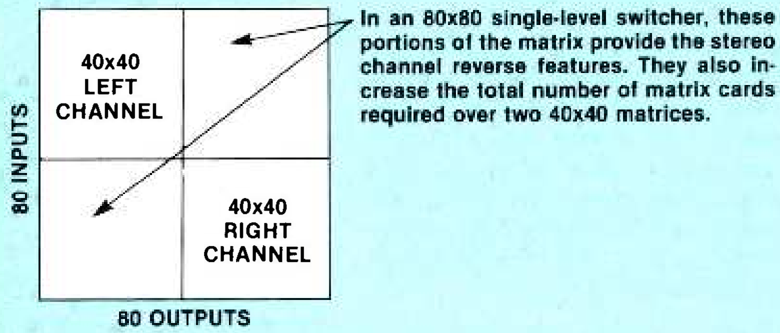

Table 3. *Comparison of the number of matrix cards needed to build a single-level switcher and a 2-level switcher. The single-level design is more flexible, but requires more matrix cards.*

The control of such a matrix can be accomplished in many ways. With the sophisticated microprocessor-based systems available today, it is possible to make the actual control of such a system essentially transparent to the operator using standard equipment.

One disadvantage of this system is that it does require a single, large audio switching matrix instead of two smaller matrices. The large matrix may cost more than the two smaller matrices, but the larger matrix is a much more flexible way to configure a system. Figure 7 shows how a matrix such as this would be configured.

It should be noted that if mono mixing is desired, some dedicated inputs and outputs are required to feed an outboard mixer with re-entry provisions to develop the stereo-to-mono mix. The same design would be required for phase reversal. These features are optional, however, and the basic features can be configured in a straightforward manner.

Table 3 compares the two methods of configuring a matrix. The design provides 10 mono and 30 stereo sources and destinations and the switcher is constructed with a commonly available 10 x 10 matrix card.

The realization of a truly high-performance stereo audio signal-distribution system is now possible using these and other high-performance techniques. Many of these techniques have been used in the recording industry for years.

Providing your TV audience with high-quality audio is certainly worth the effort. In actual practice, when high-quality transformerless systems are used, the audio difference can be discerned even on a 4-inch TV speaker. Don't short-change your audience. They can hear the difference.

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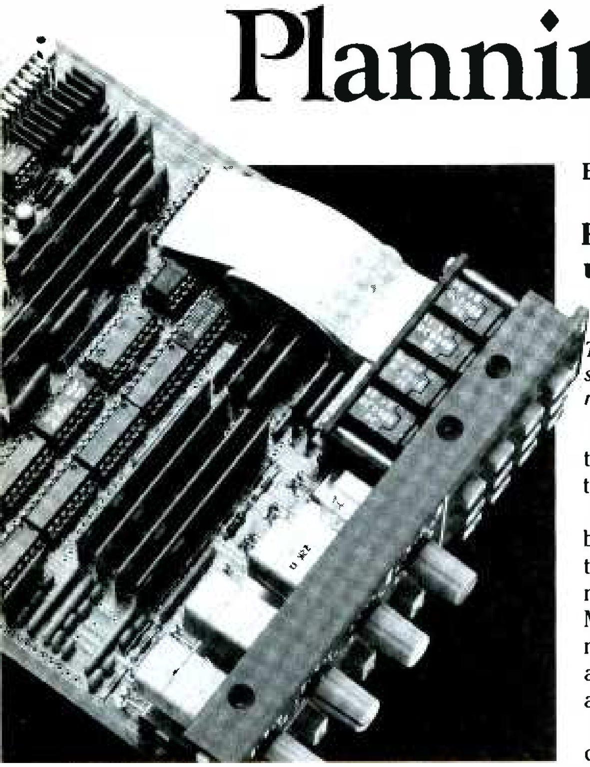
Planning for TV stereo

By Douglas Dickey

Planning for a new console involves more than counting up the number of knobs you think you'll need.



Today's LSI chips make complex modules, such as the combination input/output module, small and versatile.

When it comes time to specify and install a new audio console, you and your staff can look forward to an exciting experience. You can also expect it to be one of the more problematic projects you'll ever undertake. Careful selection and proper installation of a new console is a highly visible accomplishment for a radio or TV engineer, and one that will be appreciated by your colleagues for years to come. On the other hand, an inadequate system or an unstable installation will be a constant irritant and a source of wasted time for the entire production staff.

Fortunately, there are many excellent consoles available today. Some of these have features found formerly on only the largest multitrack recording consoles. For instance, it is no longer uncommon for both air and production consoles to incorporate sophisticated audio processing such as dynamics control and parametric equalization and multiple output groups. Although once considered unnecessary or extravagant, such facilities are increasingly in demand by today's broadcast operators. Their integration within the console can speed and simplify installation and operation.

One area receiving considerable attention these days is multichannel television sound (MTS). Both the producers and the consumers of TV programming are demanding more creative and sophisticated soundtracks, and greater audio quality. As TV engineers across the country are discovering, the stereo transition involves a separate level of complexities that are beyond the problems of distribution and transmission.

The competitive station must not only be capable of distributing stereo audio throughout the broadcast plant, but also must have stereo production capability. Moreover, it must achieve stereo quality matching that from the network. TV audio engineers are finding out this is not an easy task.

Stereo audio on its own is far more critical and less forgiving than monaural sound. The marriage of multichannel sound and TV pictures is an even more difficult process. Add the requirements for mono compatibility, and the fact that the existing audio chains of many TV facilities have been largely neglected for years, and the scope of the task begins to become clear.

On top of all this, ways must be found to handle stereo production in roughly the same time frame as is presently allowed for mono. Otherwise, production costs will rise, program output will slow, and the nationwide transition to stereo will stop dead in its tracks.

Conceptually, the key to these problems is simple. The increased technical and creative requirements of MTS must be matched by gains in operation ease and speed. In other words, the TV audio plant must be optimized for both artistic flexibility and engineering efficiency. In practice, this achievement involves many different disciplines.

Studio acoustics

Unlike transmitter conversion, upgrading production facilities for stereo is a process that can take place over a long stretch of time. A good place to start improvements is in the studio itself. The value of proper acoustics is too often overlooked in the rush for the latest equipment. Yet, if the goal is efficient operation and a clean output, the importance of a trouble-free and easily manipulated input is obvious.

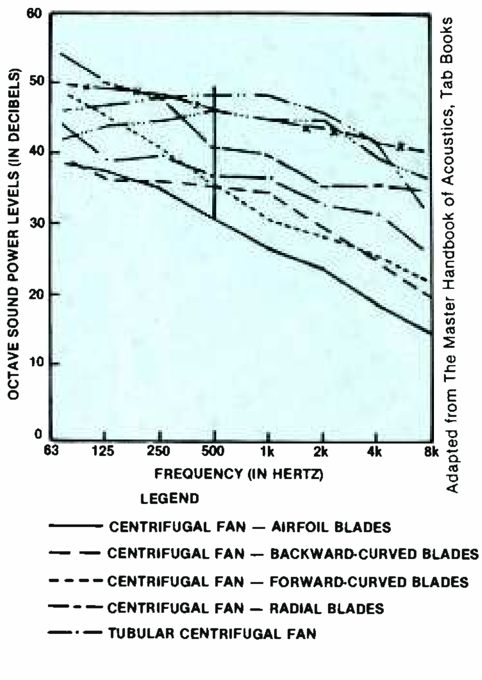
The basic goals should be to eliminate unwanted noise, to reduce or eliminate leakage or acoustic crosstalk into the various microphones on the set, and to capture a natural and appropriate blend between the direct and the reflected (or ambient) sound present on the set.

The cost of achieving full recording-studio acoustics can range from $50 to more than $100 a square foot. This price does not include the cost of the basic structural shell. Although this expensive approach may be unnecessary or impractical in many situations, there are a number of acoustic elements to consider before you wire up that new console.

Air-conditioning systems are the most common offenders. To reduce the noise pollution, compressors and blower units can be decoupled from the main building structure with isolation mounts. The noise of moving air can be reduced by increasing duct volume and reducing blower velocity. Broadband noise leaking in from the outside world can be minimized by replacing the seals around doors and windows and by adding soundproofing at cable entrances and exits. Crew noise within the studio can be reduced by adding absorptive materials in off-camera areas.

These are all minor points, but their effects are cumulative. It is worth it to track down and correct as many problems as you can. A number of electronic fixes are available, but all of them will repeatedly cost you time and money later in the production process. Your goal should be to ensure that all

Figure 1. *Reducing air-conditioner noise can be difficult. Note the difference in noise generated by various types of fan blades.*



Dickey is vice president of design communication, Solid State Logic, Oxford, England.

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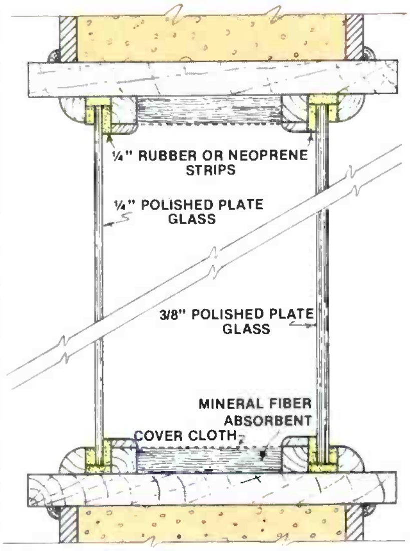

Adapted from Acoustic Techniques for Home and Studio, Tab Books

Figure 2. *Typical control room window construction.*

microphone signals arrive at the console as clean and natural as possible.

Ambiance

A properly constructed stereo mix will convey not only a sense of left-to-right panorama, but a front-to-back depth and even a sense of height. There has been a resurgence of interest in stereo microphones because of their capability to capture this. For elements such as crowd and audience sounds, certain music applications and some ENG applications, stereo microphones are a valuable tool. One especially useful stereo micing technique is called the mid-side (M-S) recording process. It is described in the related article, "M-S: A Special Case."

Unfortunately, the technique of effective stereo microphony is extremely dependent on the positioning of the mics in *exactly* the right place. Even in the world's great concert halls, finding this place can take hours. In many TV studios, it doesn't even exist—or if it does, its location gives the lighting director insurmountable problems. For practical as well as aesthetic reasons then, multiple mono pickups will continue to be the norm for stereo production. The stereo *image* will be created at the console through the use of panning and special effects devices.

The greatest potential problem with multiple microphones is that of phase cancellation due to off-axis leakage between mics. This can result not only in an unnatural sound quality, but in the complete disappearance of certain audio frequencies to the monaural listener. Proper studio acoustics will greatly minimize the likelihood of this occurring, and increase your working flexibility.

Control room acoustics

The audio control room must provide a reference listening environment that allows the recording engineer and other production staff members to make accurate judgments about a program's audio content. One requirement imposed by stereo is the need for control room symmetry. Surfaces with dissimilar

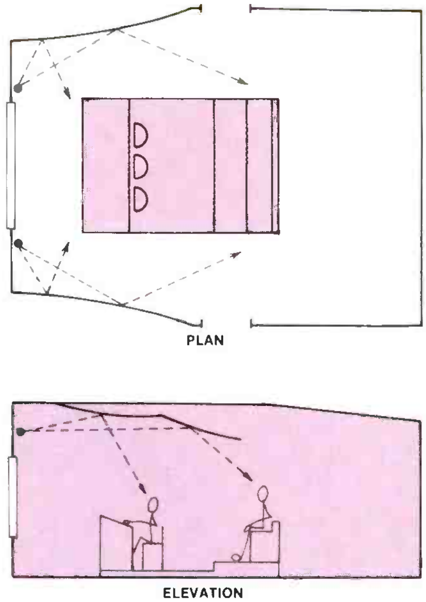

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Figure 3. *The control room must provide a stable stereo image, free from frequency response and reverberation aberrations.*

Continued on page 42

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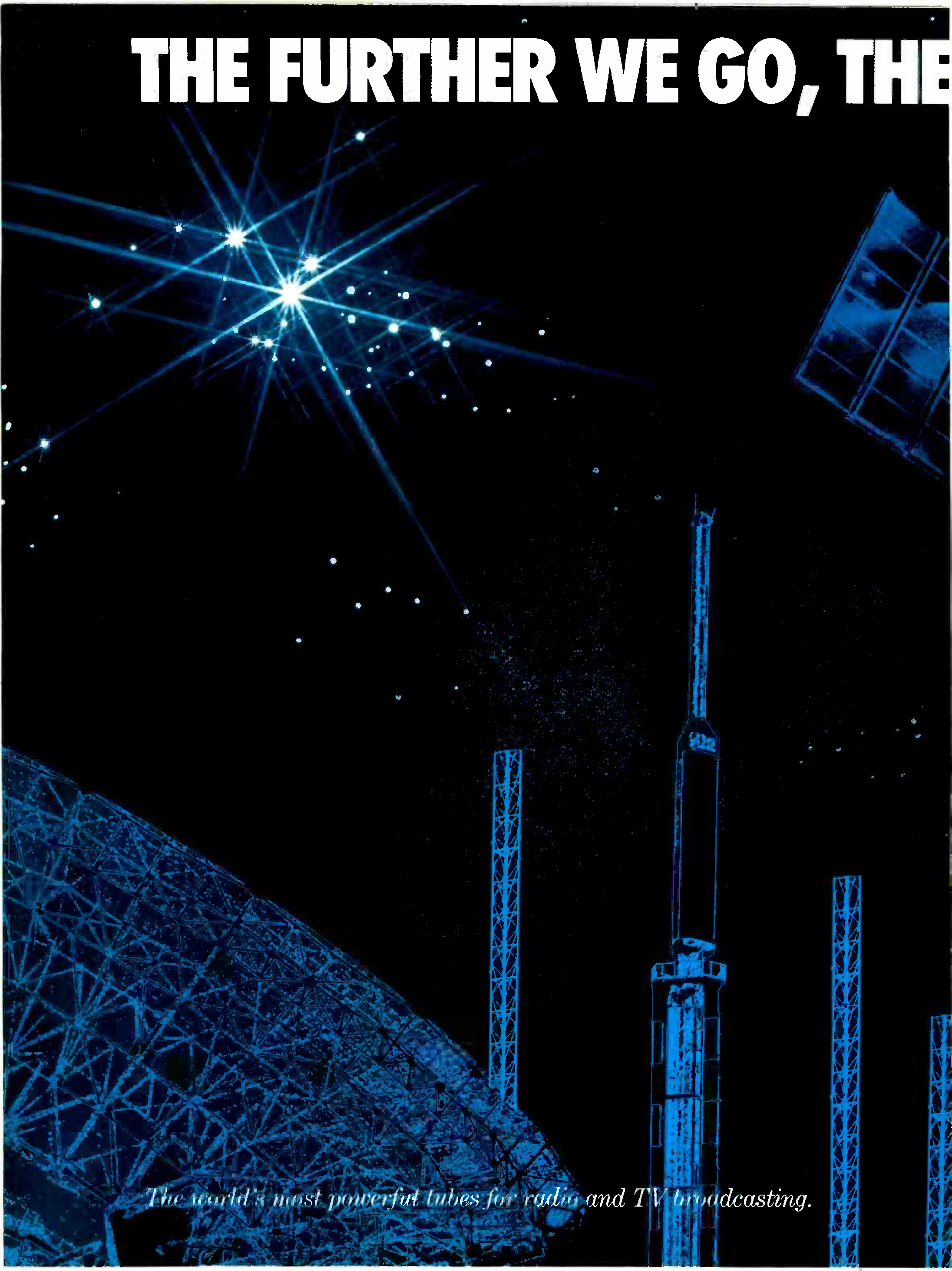
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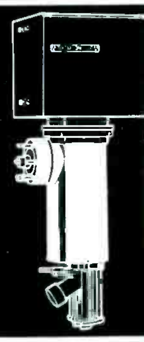

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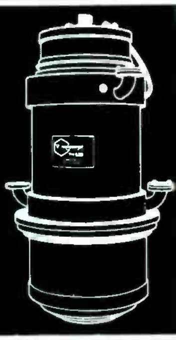

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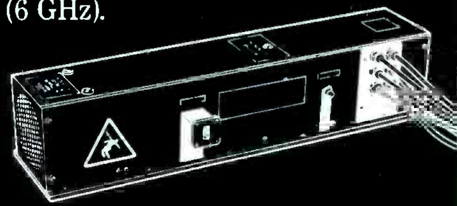

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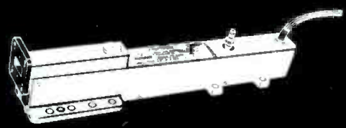

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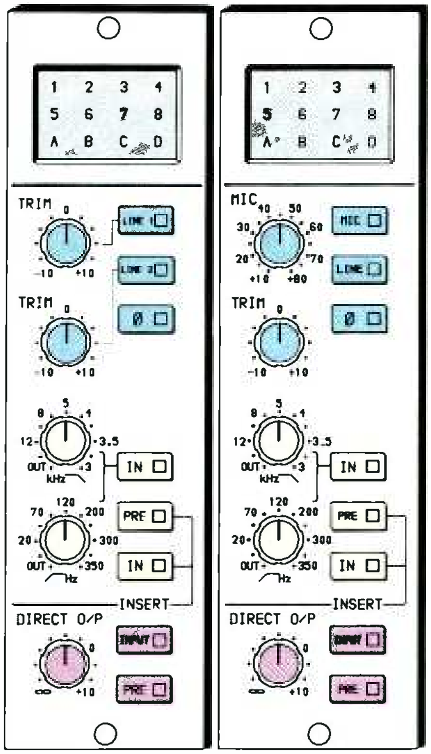


Figure 4. Typical input modules provide a selection of several inputs, phase reversal and gain trim controls. The I/O module on the left provides two line-level inputs. The one on the right provides both line and mic inputs.

Continued from page 38

properties on either side of the recording engineer can cause errors in judgment. Control room acoustics should provide a *stable* stereo image across as wide an area as possible.

Equal attention should be given to attaining smooth frequency response and uniform decay times across the operator's position. If production staff members involved in the creative audio judgments will be sitting behind the recording engineer, you should ensure that the sound they hear is as similar as possible to that at the mixer's position.

One frequently overlooked element is the effect the console itself can have on the control room acoustics. In fact, all control surfaces and equipment racks can affect the room's frequency response as well as the decay time as measured at the listening position. A balance must be struck between the operator's needs, the technical facility requirements and the acoustic implications of these decisions. Each of these aspects should be considered in control room layout.

Control room monitors

In addition to the primary control room monitors, it's extremely useful to have one or two alternate speaker sets and the capability to easily switch between them. This technique allows the recording engineer to compare the spectral balance of the mix on different speakers. It also allows the mix to be judged on speakers located at different distances from the listening position.

By mentally averaging the perceived differences, the engineer can arrive at an optimum balance—one that will sound just fine to the audience. The majority of TV viewers will be listening in mono for at least the next few years, so it also must be easy for the engineer to switch between stereo and mono listening.

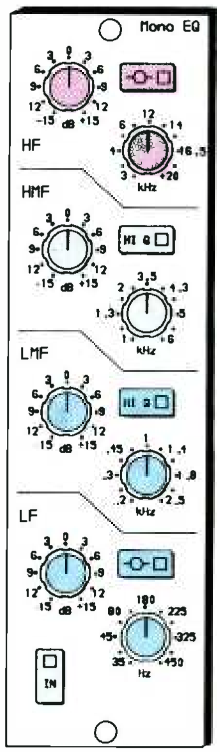
It is worthwhile to connect a phase scope or phase meter across the main stereo program outputs. The scope display or meter provides a visual indication of the signal's phase. This is especially important if you are monitoring in stereo, which makes it easy to misjudge the phase compatibility of the mono mix. The phase meter or scope will help prevent the broadcast of a phase-reversed signal that can't be heard by the majority of your audience.

If you plan on using the second audio program (SAP) channel, some additional monitoring provisions usually are required. If, however, the SAP is always created in post-production, additional monitors may not be needed. You may want to be able to insert a filter in the monitor chain to simulate the SAP's reduced bandwidth. This option allows you to equalize the mix to compensate for the SAP's frequency limitations.

Console selection

Assuming that all the practical steps mentioned have been taken to provide clean audio sources and accurate audio

Figure 5. Today's consoles often provide individual channel equalizers like the one shown below left.



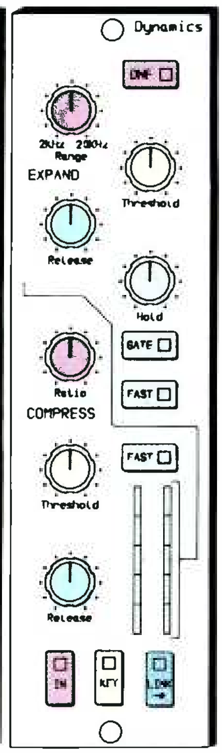


Figure 6. When live music or voice production is required, compressors, limiters and noise gates are useful devices to have built into your console. A typical compressor/expander is shown above right.

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monitoring, the next step is to use suitable technology for stereo audio mixing. The production equipment must be evaluated, not only in terms of capacity and creative flexibility, but also in terms of operational speed. Although the mixing console is the single most important element, the twin goals of quality and efficiency dictate a close look at the ways various audio control room elements work together. Machine control, effects processing and mixing automation may all be part of your total system.

Consider that the audio console must handle greater numbers of both mono and stereo sources than ever before. These sources must be combined into mixes that convincingly match the picture perspective in both stereo and mono. To accommodate the SAP, the sources also must be divisible into splits such as dialogue, music and effects, and these must also be available in both stereo and mono. In addition to various mix-minuses to feed the talent and production foldback lines, auxiliary sends must be provided to the various effects devices, which will be used to reinforce the illusions of space and perspective.

Input controls

For mono input channels, the minimum controls should include a mic/line switch, a line-trim control, a mic pre-amplifier gain control and a phase-reversal switch. For maximum efficiency, stereo inputs require additional controls. An input balance control for trimming the left and right channels should be provided, along with phase-reversal switches for both left and right inputs. The console should also be able to direct either the left or right signal to both sides of the mix bus or to feed the L+R signals to both sides of the bus. For stereo microphone sources, provision for converting the mid-side (M-S) encoded inputs to standard left and right signals is also a desirable feature.

Signal processing

Following these input controls, both the mono and stereo channels should be equipped with some signal-processing capability. This should at least include high- and low-pass filters for cleaning up rumble and hiss. Flexible equalization is also required to fine-tune each source in relationship to the others. Many console manufacturers now provide 4-band equalizers on their broadcast consoles. Although this may seem to be overkill, it has the advantage of allowing two overlapping bands in the mid-range areas, which are critical to speech intelligibility. This feature is well worth the price in complex mixes.

A switchable patch point that allows outboard gear to be inserted into each channel path is another useful feature. Some manufacturers have taken this approach a step further by including a switchable compressor/limiter on each

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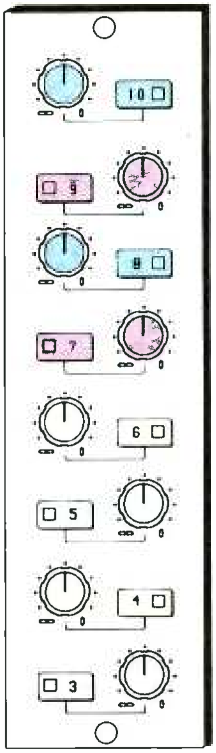

Figure 7. Auxiliary send channels provide an extra measure of flexibility in live-mixing situations.

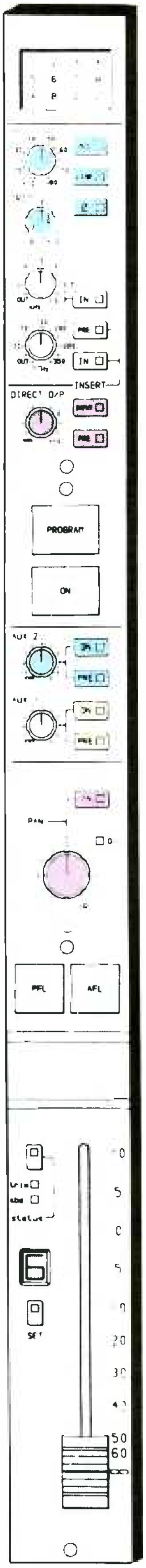

Figure 8. Typical console module assembly.

channel. This approach has the advantage of allowing rapid and precise control over the dynamics of each channel. Some consoles also include noise gates, which can be used to automatically close an input channel in the absence of a signal. This automatic switch contributes to a cleaner mix.

Auxiliary sends

Auxiliary sends are used not only to provide foldback to the talent and the production crews, but also to feed special effects devices. Each local send control should provide on/off switching, level control and the capability to select its source either pre- or post-fader. The number of required mono and stereo sends varies between applications. Usually, a minimum of four mono sends is required. Some productions need as many as eight or 10 mono and stereo sends.

Group outputs

In addition to auxiliary sends, a number of group outputs should be provided. For the sake of manageability, it is often useful to combine numbers of microphones into common audio subgroups. For example, the individual levels of several audience mics may have their outputs routed to a common audio group. This group's fader is then used to adjust the overall level of the audience microphones.

Group outputs may also be used to route individual elements to one or more channels of a multitrack tape machine. This allows you to create a multitrack backup tape of a live event, or to build a multitrack master in post-production. This master tape can then be used to develop the final mix. As a general rule, a minimum of four or eight audio subgroups should be provided. If extensive multitrack work is anticipated, 24 or 32 group outputs may be required.

Control groups

Several manufacturers offer control groups, also known as *VCA* (voltage-controlled amplifier) groups. This feature allows common level control over a number of channels while maintaining their independent audio paths. For example, you might want to individually route the various orchestra microphones to separate multitrack channels and to different split feeds. At the same time, it might be necessary or desirable to control the overall orchestra level with a single fader. This type of control makes live mixes more manageable.

This feature can't be accomplished by audio subgrouping, because that requires all sources to be grouped to a common bus. Control groups, on the other hand, simply place the control voltages for each element's fader under the control of a master control group fader. If you anticipate productions involving 20 or more channels, some sort of control group scheme will prove to be worth its weight in gold.

Splits and submixes

In some post-production applications, the stereo TV industry is borrowing the film technique of creating separate music, dialogue, effects and ambiance

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mixes. By dividing the total mix into separate submixes, it becomes much less expensive to subsequently create specialized mixes. For example, a Spanish language version of a program could be easily developed by simply replacing the English dialogue with Spanish. Only the dialogue would need to be remixed and then combined with the existing music and effects mixes.

Unlike film, television often has to meet these complex production requirements in real time. Live broadcasts and live-taped productions are examples of complex feeds. Separating the audio into individual feeds or splits is often the only feasible way to control all of the audio elements.

Typical console mixes

One manufacturer's console allows each channel and audio subgroup to be routed to three stereo mix buses designated A, B and C. On mono channels, stereo panning is provided between the left and right channels of the selected bus. On stereo channels, image width controls allow the engineer to correct the perspective of prerecorded materials to better match the picture.

Each of these three stereo buses then feeds two tracks of a multitrack machine. A mono L+R feed is also derived from each stereo bus. The A, B and C stereo buses then may be combined onto the stereo program bus to create the final stereo mix. Stereo level controls adjust the overall contribution of each bus to the final mix. To compensate for the mono phenomenon of center-channel buildup, a separate set of mono trim controls is provided. These controls combine the L+R feeds from the A, B and C buses into the composite mono output.

Computers

As you can see, the TV studio engineer has a great deal to keep track of these days. Fortunately, powerful assistance is available in the form of audio production computers. The first computer applications centered on automated mixing for post-production. The early systems recorded the engineer's fader adjustments and could later play them back for modification. These systems were primitive compared to the systems now available.

Today's sophisticated dynamic mixing automation allows mix data to be manipulated and edited with uncanny ease and speed. In addition to automated level control, these systems provide dynamic panning and even dynamic equalization. These features are useful in dialogue-matching and effects.

Some advanced computer-driven consoles allow complex transitions between console presets in live situations. The transition can be accomplished with a single fader or switch providing instant reset of the console's entire switching

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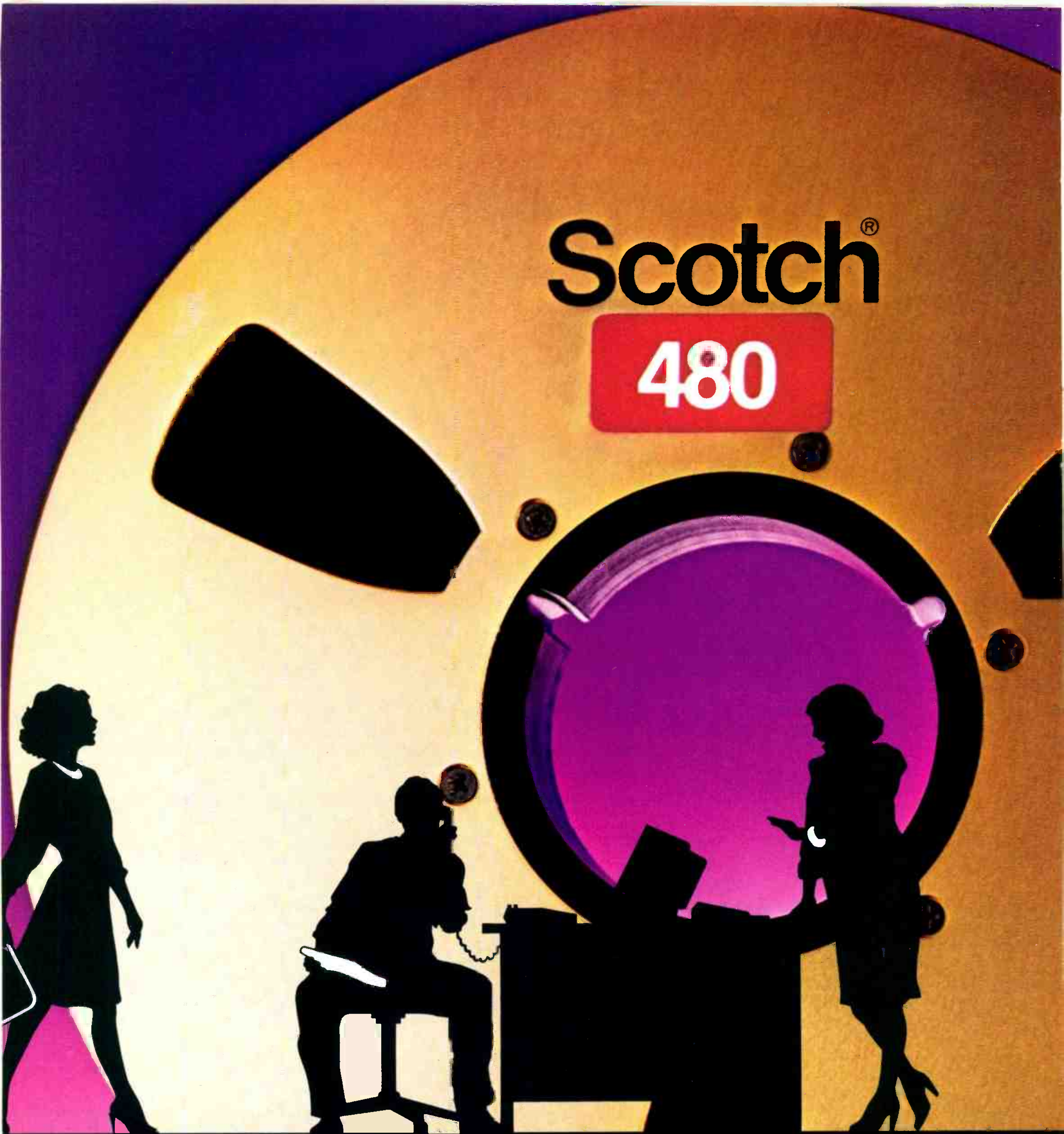
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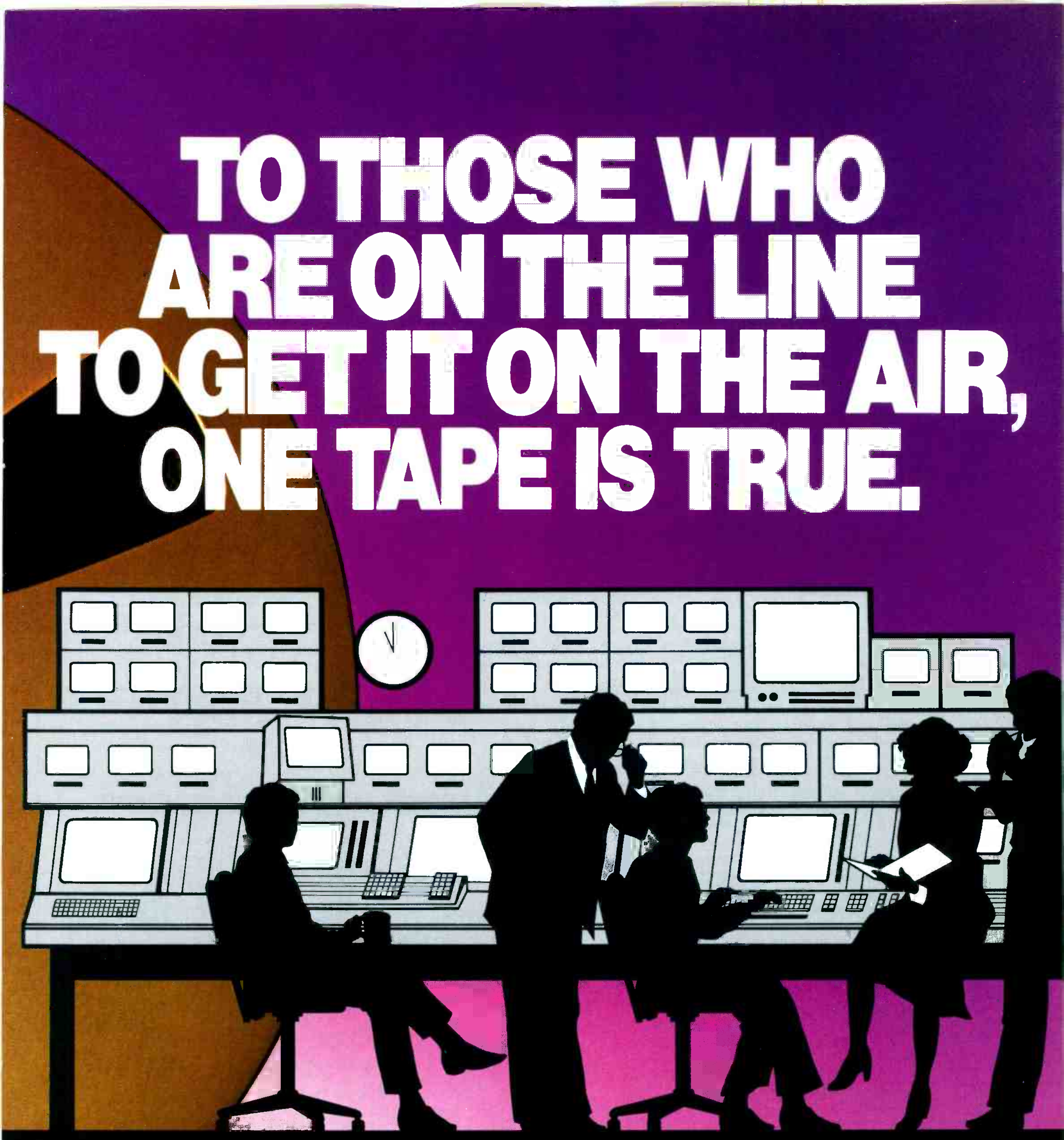
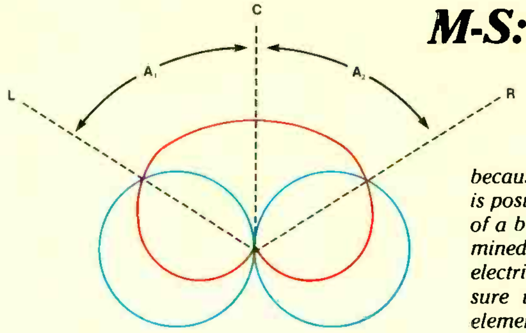

TO THOSE WHO
ARE ON THE LINE
TO GET IT ON THE AIR,
ONE TAPE IS TRUE.

M-S: A special case



M-S pattern overlay. Angles A_1 and A_2 are always equal and will vary depending on the relative gain of the M vs. S microphones.

The M-S (mid-side) method of microphone placement is a special technique, developed by Lauridsen in Germany, that is well suited to stereo pickup. Similar to the coincident and near-coincident X-Y techniques more common to broadcasters, M-S stereo uses two microphones in close proximity, or two independent microphone elements within the same housing. This technique provides phase coherence of the summed L+R audio for good mono compatibility.

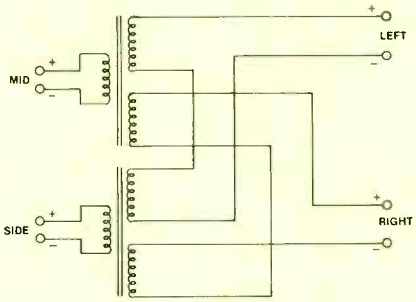
The mid microphone can be omnidirectional, but typically is a cardioid aimed directly at the primary sound source. This microphone, when properly placed, will pick up all of the primary sound, just as if it were being used monaurally. The omni pattern tends to emphasize the ambient (reverberant, or hall) sound, while the cardioid tends to emphasize the primary sound.

The M-S side microphone is always a bidirectional (figure eight) microphone with the pattern rotated 90°. The front of the microphone faces toward the left, and the back of the microphone faces toward the right. In this way, one of the pattern nulls lines up directly with the cardioid M microphone axis. This bidirectional pattern null is quite deep—on the order of 25dB or more. The S microphone picks up virtually no central sound but, rather, sounds to the left and to the right. Obviously, this combination of microphones will produce stereo sound with directional cues, but how this technique is accomplished is what makes it unique.

Directional cues to the left of center are achieved by summing the M and S microphones together in phase, because the front of the S microphone is positioned to the left. (The front lobe of a bidirectional microphone is determined by the generation of a positive electrical signal when a positive pressure wave contacts the microphone element.) A sound source on axis with the M microphone is fed in phase to both channels, appearing centered in the stereo spread.

Directional cues to the right of center are also achieved by summing the M and S microphones. However, because the right side of the S microphone is the back lobe, sound entering this lobe will be out of phase when mixed with the M microphone. The S microphone must have its phase reversed before summing with the M microphone to produce a right channel output.

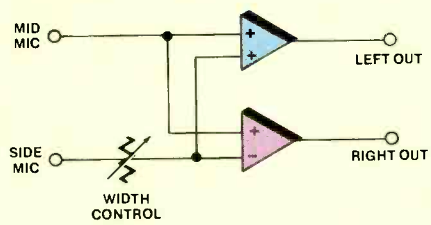
Simple passive matrix to convert the mid and side signals to left and right outputs.



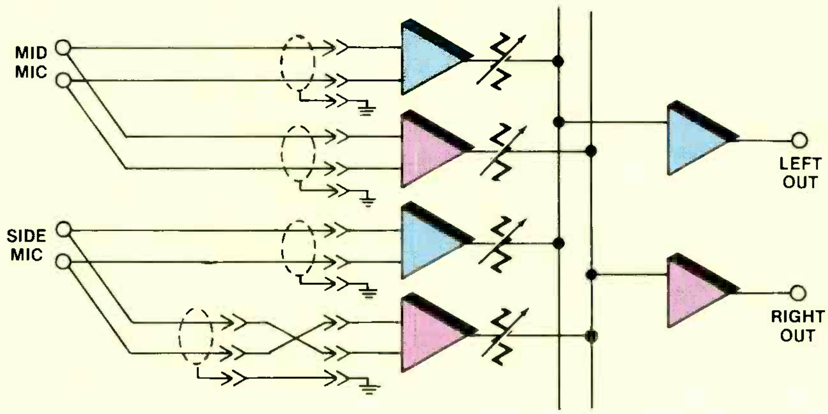
At that point, the final product is essentially the same as an X–Y pair. The real advantage to M-S is the ability to alter the stereo spread (width) from mono to exaggerated stereo simply by adjusting the comparative gains of the M and S microphones prior to the matrix. This can be quite advantageous in video production because you can adjust the audio width to match the camera shot. In fact, the M and S microphones can be recorded directly onto separate tracks on-location, then matrixed during post-production to achieve the precise width desired.

Finally, an M-S matrix can be developed using four inputs on any stereo console. Although more operationally cumbersome than a dedicated matrix, it can be duplicated anywhere with just a few commonly available accessories.

Simplified block diagram of an electronic M-S matrix. Note the inclusion of a width control. See the text for further details.



An M-S matrix using four inputs on a typical stereo console. Two *Y* adapters and one phase-reverse adapter are required to implement this technique.



Continued from page 49
network and fader levels.

Unquestionably, the studio computer will play a steadily increasing role in improving the efficiency and creative flexibility of stereo TV production. A detailed investigation of the present hardware and software capabilities and future plans of the major console manufacturers should be a part of your evaluation in planning any MTS production facility.

A complex process

Unlike transmitter conversion, which takes place in one shot, the conversion to multichannel sound can take place over a prolonged time period. The starting point is to clean up your existing facility, both acoustically and electronically. A proof of performance should be run on the entire audio chain and any weak links should be replaced.

The next step involves equipment upgrades and replacements. Start with your audio monitors. You need a dependable reference point against which to gauge all other changes. Take time and experiment. You can learn a lot before you spend any money. Effective multichannel sound is a function of art as well as science, and of technique as well as technology.

Finally, beware of bargains. The capital costs involved in a new console and its associated support equipment are considerable. The measurement of success is the return on your investment. This return must be calculated in terms of overall high quality, which your audience increasingly expects, and production efficiency, which your operation demands.

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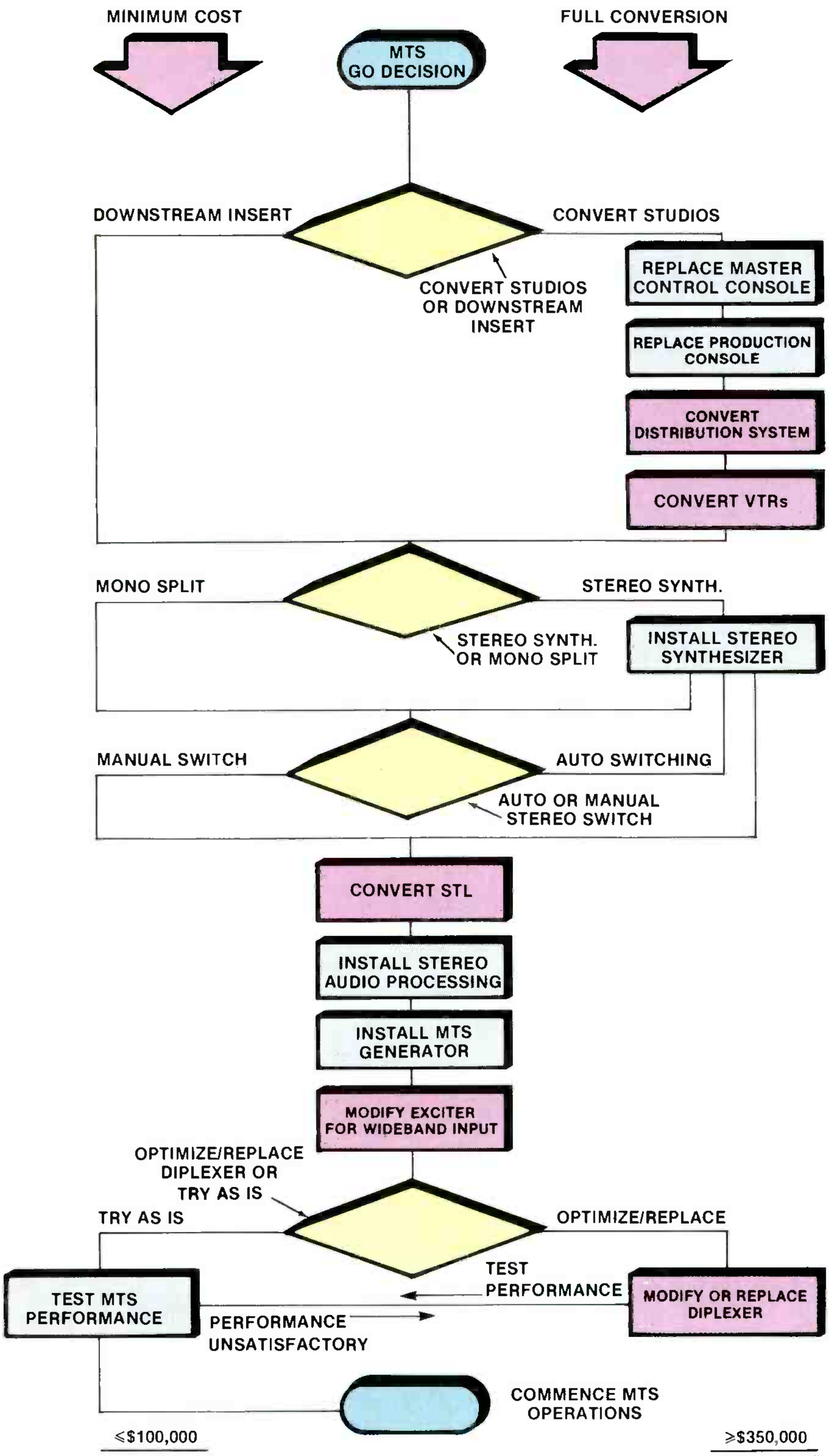
The real world of stereo TV

By Dennis Ciapura



Both business and technical factors enter into the decision to begin stereo TV broadcasting.

No matter how elegant the system, or how thorough the planning, the real world performance of any broadcast technical enhancement is gauged by audience response.

This is especially true for stereo television. In many ways, the technical conversion process is the least taxing part of the MTS (multichannel TV sound) challenge. Understanding viewer reaction to the various technical aspects of MTS is far more relevant from a business perspective, and often more challenging.

Properly implemented and aggressively promoted, stereo sound could be the most significant technical attraction since color. However, broadcasters converting to the new technology face many of the same hurdles that early color converts did. Television is a tough, competitive business and few companies have unlimited resources for technical improvements. Programming and promotional projects compete with MTS for fiscal and human resources. And, regardless of how quickly stereo receiver penetration grows, it almost always starts from zero.

Every reasonable business decision is based upon a risk-vs.-opportunity analysis. The risk side of the MTS equation contains a lot of certainties, including the installation cost and zero, or near-zero, stereo penetration. On the other hand, the opportunities are less certain at this point, because there is so little industry experience. If receiver penetration grows rapidly, the stereo pioneers will reap the benefits that accrue to the first in the game. These benefits will be both direct and indirect.

As viewers purchase stereo televisions

Figure 1. *Critical path analysis of MTS conversion process with minimum cost and full-conversion options.*

Ciapura, BE's consultant on radio technology, is president of Teknimax, a San Diego-based telecommunications management consulting firm.

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and adapters, they are likely to tune in some programs that they might not otherwise view, to give the stereo a try. A certain percentage will like the programs and stay with them for the long term, even after the novelty of the stereo wanes. That's a *direct* benefit. The improved station's image as a technical leader in the market is an *indirect* benefit of conversion.

The key to effectively optimizing the risk-vs.-opportunity equation lies in knowing how to get the best bang for the buck on the risk side, while making the most of the opportunities once the *go* decision has been made. Over the past few months **BE** has featured several articles dealing with transmission system optimization, stereo audio proofs, equivalent mode tests and programming configuration for stereo television. This article will provide an overview of the technical factors from a *business perspective* with the objective of charting the least costly and most effective path to successful MTS deployment. This approach should be of value to broadcasters planning stereo conversion. The overview also should be of interest to broadcasters already converted to MTS who may be confused by some of the system's many anomalies or by the initial audience response.

How much stereo?

The first tough point of decision is reached before the conversion cost estimate can even get under way. Should the entire audio chain be converted, or should network stereo programs be inserted downstream? Engineering purity suggests that an immediate stereo conversion of the whole system is the right way to go. Unfortunately, the financial consequences of this would be enormous. As a matter of fact, the routing and mixing revamping project would be far more time-consuming and costly than the transmission system conversion.

Adding the MTS generator, monitor, stereo audio processing and STL modification generally costs less than $100,000. A new console and routing system at the studio can quickly total an additional $250,000. The downstream insertion option, therefore, has significant expense advantages, and a reduced initial capital investment means less risk if receiver penetration is slow to build.

One simple method of achieving a downstream insertion is to switch to the network audio feed at the input of the stereo audio processing when the net is feeding stereo. Although a manual switch from mono to stereo is preferred, the left channel is normally used for mono programming. Therefore, the switch may be triggered by the presence of right-channel audio, which would occur only during a stereo feed. When stereo is not available, the stereo audio processor is fed from either the regular mono signal split to both stereo inputs, or from the output of a stereo synthesizer. Some stereo synthesizers provide this feature internally and need only to be installed in the output of the router to the STL in order to accomplish automatic stereo switching.

As with any new technology, practical experience often dictates a somewhat different approach than what seems obvious at the start. Gaining some operational experience with a simple system to begin with, then converting the studio(s) on a gradual basis when all of the requirements and quirks are more fully identified, can result in a much more efficient and flexible system. As few as three or four months can be invaluable for monitoring stereo programs and getting a feel for what technical parameters have the greatest practical significance. If an immediate full conversion is preferred, discussions with engineering staff members at other stations and with consultants who are experienced in MTS can be helpful in avoiding costly errors.

The great synthesis debate

Stereo synthesis for television is one of those areas in which things are not really what they at first appear to be, resulting in some unexpected viewer reaction. As in the early days of FM stereo, when stereo program material was less than abundant, it is attractive to offer a synthesized *stereo* derived from a mono feed so that the stereo pilot may be left on full time. This maximizes the product differentiation that was probably an important factor in your decision to convert to stereo. Unfortunately, like most wonderfully simple solutions, this approach is not without its problems.

Astute viewers will soon realize that the synthesized signal is not real stereo and may conclude that stereo television is deficient compared to the real stereo they get from their VCRs and laserdiscs. Then there are the mono and stereo compatibility problems generated by the synthesizers. There are two different synthesis schemes in wide use today, and each has its own peculiarities.

The band-splitting variety shunts discrete frequency bands to the left and right channels. This approach is based on the theory that most sound covers a relatively narrow frequency band and, therefore, will flow to the channel optimized for its range. In theory, all of the bands from the left and right add up to the original mono signal in an L+R or mono receiver. However, some broadcasters are finding that the process isn't quite perfect and their mono sound on the air simply doesn't sound like the mono program feed. This can be a problem because it means sacrificing the majority of viewers' *mono sound* to achieve the stereo product differentiation. This is a trade-off that many broadcasters are loathe to make.

The other type of synthesizer generates time-delay effects to produce a stereolike sound. The inexpensive versions use bucket-brigade technology, while the premium units employ digital-delay lines. Either way, the result is the generation of an L−R component without affecting the L+R, so the mono signal remains intact. However, this system also has its problems.

An increasing number of viewers are installing surround-sound decoders to retrieve the sound effects that remain encoded on the stereo audio tracks of many videocassette and laserdisc movies. Unfortunately, the L−R component generated by the time-delay synthesizers leaks into the surround channel, producing an irritating echo effect. Also, because the surround speakers in such a system are usually inferior to the left and right front speakers in such a system (they normally only reproduce sound effects), the overall broadcast audio quality is reduced.

Poor phasing integrity on stereo feeds will cause similar effects. In either case, the only solution is for the viewer to turn off the surround sound when stereo television is being received. This is something the viewer does not have to do when watching mono or stereo tapes or discs.

The truth about companded L−R

Although the companded L−R that is a part of the BTSC configuration is an excellent system and can yield greatly improved overall signal-to-noise ratios, it also embodies several traps. First of all, simply measuring the noise floor at the stereo modulation monitor audio output or at a receiver after the audio signal is removed does not give a valid representation of *audible* noise performance. High levels of incidental carrier phase modulation (ICPM) will generate a buzz behind the audio that will be quite audible when speech is present, but will virtually disappear when audio modulation is removed. As a result, although conventional S/N tests will look quite good, stereo-equipped viewers will get a buzz burst with every syllable.

The better the viewer's audio system, the more noticeable the problem. This is because the extended low-frequency response at the receiver exacerbates the modulation noise problem. The real intent of the companding is to improve the broadband noise performance of the L−R channel and to minimize the audibility of Nyquist slope ICPM in intercarrier detection receivers. Broadcasters should not use companding as a cover-up for transmitter ICPM.

Many stations will find it economically attractive to begin MTS transmission with their existing filterplexers and diplexers. This will allow them to see how they work before investing in a major RF plumbing project. That's fine in terms of reducing the capital risk, but it may be tough to keep the ICPM below 3% or 4%.

Fortunately, there is a way to minimize the audible effect of the modulation noise at the viewer's receiver. If the 15.734kHz pilot phase is shifted so that

Answering viewer inquiries

As you might expect, early response from viewers regarding stereo audio includes some surprising comments and unanticipated questions. The following is a summary of the most common ones and suggestions for the station's responses:

•How can I receive the stereo sound that you are advertising?

If the viewer's TV is less than two years old, recommend checking with the dealer or manufacturer to see if a stereo adapter is available. Do not recommend trying adapters not specifically designed for the viewer's receiver. Because of potential level-matching problems with the companded L−R signal, outboard adapters are not as successful as were the old FM stereo adapters. If a dedicated adapter is not available and the viewer is not interested in purchasing a new stereo television, recommend a stereo TV audio receiver. The Radio Shack TV-100 drives line inputs or external speakers directly, tunes all VHF and UHF channels and seems to be well received. As a matter of fact, many TV stations are using them for air monitors.

•I have a stereo VCR and yet I don't get stereo from your station when I feed the tuner output into my stereo system.

Unfortunately, many VCRs, which are equipped for stereo audio record and playback, are not equipped with MTS receivers. Viewers should be instructed to check their operator's manual to see if MTS is mentioned. If not, the VCR almost certainly does not possess a stereo TV tuner.

•There is a hum sometimes when people talk or sing. I only get this on your station. I have a new stereo television that has outputs that drive my stereo system with a speaker on either side of the television.

At this point it is nice to know that the station's ICPM is either low or phase-shifted to null in a quadrature detector. The viewer can then be told that the receiver or cable system is the problem. Viewers who use external

How to keep your mixing board from holding you back.

Today's technological revolution is a battle fought on two fronts: quality and cost. Recent advances in recording equipment let you do more than you ever could before – And for less money. But what about your mixing console? Can it keep pace with recent giant steps such as the significant advances in the quality of analog and digital recording equipment? Without sacrificing your budget?

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speakers from their stereo systems will be the ones to first notice the buzz because of the extended low-frequency response, especially if the loudness contour is turned on.

•When a talk show is on in stereo the announcer's voice tone seems to change periodically.

Some stereo synthesizers switch automatically from stereo pass-through to synthesize when they sense equal left and right, which would be the case with a mono signal. Unfortunately, an announcer speaking alone and mixed to center produces the same signal. The synthesizer thinks it's a mono program and switches on. The solution is to disable the mono-sensing feature in the synthesizer so that it senses mono only when a left-only signal is present. It is not often that a left-only mix shows up during a stereocast, but it can happen. An interview is one case in which this can occur. Ideally, the mono-to-stereo switch should be done manually.

•After I hooked up my stereo to my stereo TV receiver the picture got worse.

Ask if the viewer used a signal splitter to obtain an antenna signal for the stereo receiver. The additional loss may be just enough to drop the television below its noise-free threshold. This can be a problem if several sets in the house are driven by the same antenna or cable. Also suggest that the viewer check all antenna leads. In just hooking up an external speaker, an unwary viewer can sometimes pull the shield away from an F connector.

the buzz is nulled out in a quadrature detector, the effects of the high ICPM on the viewer's audio will be greatly reduced. The pilot phase adjustment on the stereo generator can be used for this. An adjustable delay in the video input at the exciter should have the same result.

Another trap lies in the critical nature of the level-matching requirements in the BTSC mode. Because the L−R channel is companded, stereo television is *not* like stereo FM. Stereo TV receiver decoders are calibrated to precisely track the 25kHz L+R and 50kHz L−R deviation references. The station must meet these standards precisely or stereo separation will rapidly deteriorate. This is why it has been suggested that fine-tuning of the transmission system should be done in the equivalent mode (uncompanded L−R for testing). (See "Understanding MTS Equivalent Mode," page 52 in the September 1985 issue of **Broadcast Engineering.**) Otherwise, the effects of transmission system nonlinearities are hard to detect in the presence of compander tracking and matching induced separation losses.

The best approach is to check out the transmission system first by making separation measurements in the equivalent mode, then follow up with separation measurements in the BTSC mode to check compander tracking against the standard in the demodulator.

The companded tests should be made at several levels to assure acceptable tracking. Equivalent mode separation figures of about 40dB and BTSC figures of about 30dB should be easily attainable. Level and frequency response errors *inside* a companded loop are multiplied by the amount of the companding ratio, which is 2:1 at low frequencies and 3:1 at high frequencies. This means that the stereo performance of MTS is two to three times more sensitive to differential (L+R vs. L−R) gain errors as stereo FM.

Fortunately, the stereo generator at the station is not likely to require much maintenance. However, it is essential that good BTSC separation figures be verified when the conversion is first made, because it is inevitable that there will be viewer complaints about stereo reception. It is imperative that the station knows for sure that its stereo signal is properly operating. This is especially true where there are intervening cable systems. The trap lies in taking the companding for granted. If you do, you'll forever wonder if the viewer problems with stereo are somehow related to diplexer bandwidth.

Promotional considerations

After the stereocast commitment has been made, it's important for the station to take the lead in helping receiver penetration grow as rapidly as possible. This may be critical if there is to be a reasonable return on the conversion investment through increased ratings. The public can be induced to buy stereo TV equipment only if they know about the stereo and good stereo programs are available to enjoy. Although "Miami Vice" in stereo on NBC may be a super draw, local production opportunities should not be dismissed.

Los Angeles independent, KTLA-TV, broadcasts the Rose Bowl Parade in stereo, and what a viewing experience that is! Chief engineer Ira Goldstone is an MTS pioneer, having made the conversion in 1984. KTLA also produces baseball and basketball games in stereo to supplement syndicated features, such as "Fame," that are available in stereo. Many films also are available in stereo, and despite some of the concerns expressed at last year's SMPTE/USC stereo conference regarding the suitability of stereo film mixes for television, the author has auditioned dozens of laserdisc stereo releases and found them all to be acceptable, and most of them great. These same audio mixes are available for TV broadcast.

On-air promotion of the stereo capability should include a brief message about how to receive the stereo. It's best to recommend only a stereo television or stereo audio receiver in the promo. Recommending stereo VCRs or adapters could come back to haunt your station.

Getting stereo program notations in local newspaper TV guides should not be too difficult. However, as yet, the national TV listings have been slow to respond. This probably means that the country's stereo TV broadcasters have not been assertive enough in exploiting the opportunity to differentiate their air product.

MTS makes sense

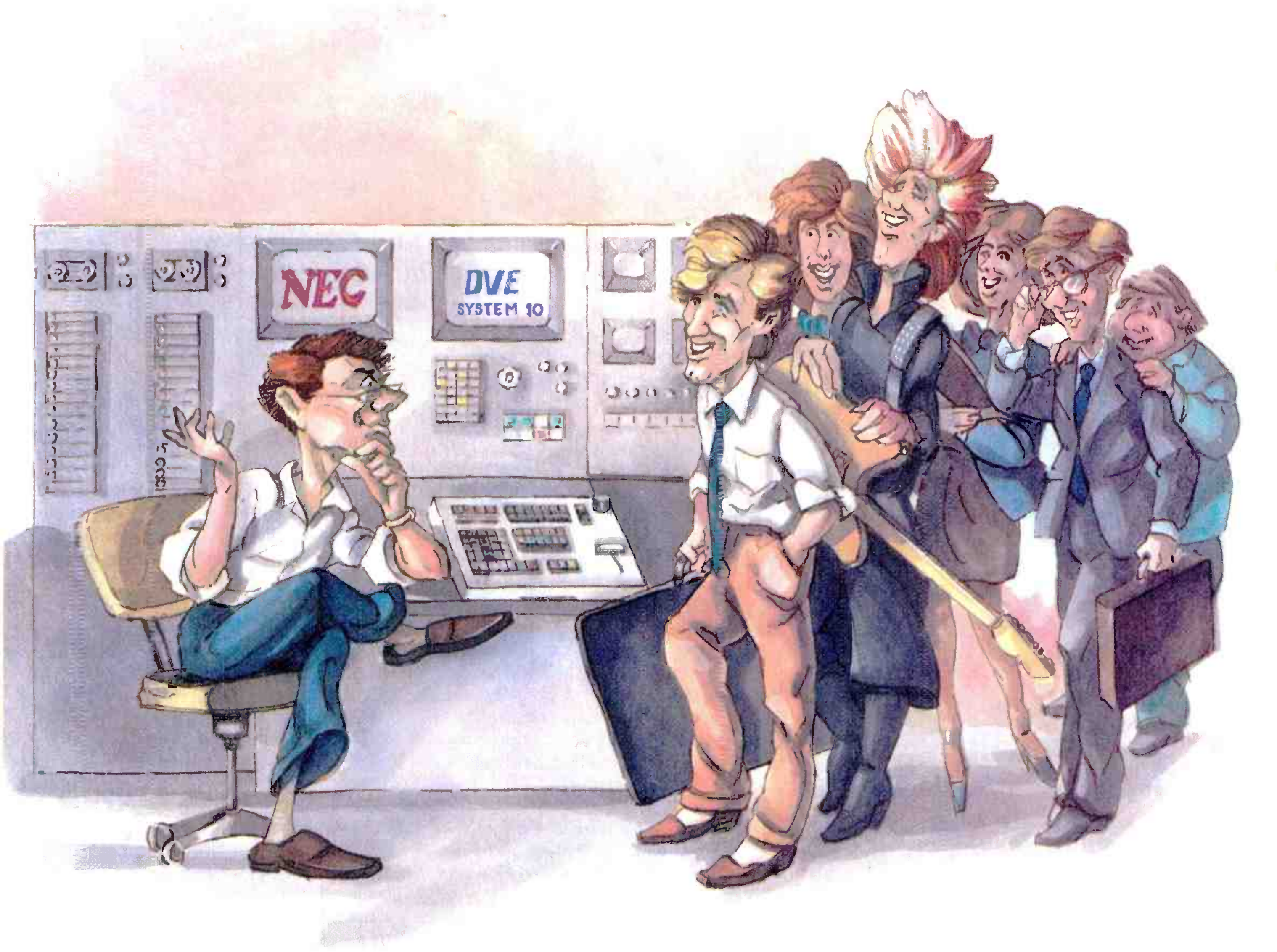
The MTS environment today is, in many ways, reminiscent of the early days of FM stereo. There are few stereo receivers, most programming is still mono and the audience, for the most part, doesn't understand or care about the technology. There's just one big difference. You are talking to a different consumer these days, one who will buy, watch, listen, smell and feel anything that is promoted as being new and good to have. Stereo already has become a part of everything from VCRs to miniature radios and cassette players for joggers. Stereo television is here to stay, and it makes good business sense to get in early and learn the craft of broadcasting it.

The best part about stereo television is that it's really easy and inexpensive to convert. Although some diplexers may not be ideal for MTS, most *will* work. Many older exciters can be converted easily to accept a wideband audio input with a simple card or module change. And, downstream audio insertion allows quick and inexpensive participation.

Network affiliates can look forward to ever-increasing releases of satellite-delivered stereo programming. In addition, almost every movie produced in the past few years has been recorded in Dolby stereo. All this means that the stereo programming is available and that even more programs will become available in the future.

The successful stations are going to be those who take advantage of the MTS system now. They stand to reap the benefits (and profits) of early conversion. Over the past 12 months, the number of stations broadcasting in MTS has increased tenfold. These stations are broadcasting not only network stereo programming, but also locally originated stereo programming. In most cases, the stations convert to stereo as a means to attract a larger local audience.

It appears as though stereo broadcasting will soon become a way of life for TV stations. If your station has not yet converted, it is time to give the matter careful thought.



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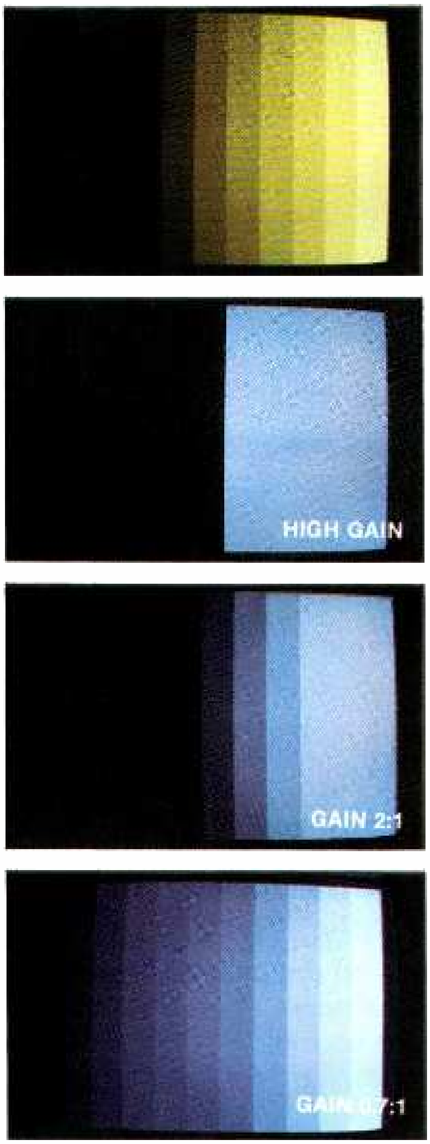
Linear keying in video production

By Tom Goldberg

By using linear keying to soften, highlight and blend images, you can create design effects that give you the edge in video production.



The repertoire of special effects that are made possible by the keying facilities in modern video production switchers is increasingly diverse and sophisticated. It wasn't that long ago that soft-edged keys and glows around images—the results of precise control of key levels and object edge definitions—were impossible to achieve. These fall into the category of effects called *linear keying.*

Goldberg is product manager for switcher products, Ampex Corporation, Wheatridge, CO.

The value of keying

Few TV productions rely strictly upon simple title keying. In most cases, a full-capability keyer provides the numerous key applications used in the video. Matting, seamless inserts and special effects with glowing and soft edges are requirements of many producers and commercial clients.

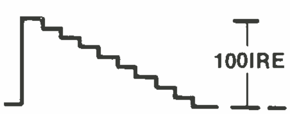
Achieving such effects hinges on advancements in keying technology and the development of high-gain, fine-discrimination and low-gain, natural-edged keys. Typically part of the production switcher, effects keying should play a role in a new switcher.

Key issues

Linear keying describes the new generation of switcher effects. However, a number of questions have been raised in regard to the technique. They include:

- Exactly what is linear keying and what are its advantages?
- How important are high-gain keys where linearity is not critical?
- Are linear low-gain keys possible when control originates from an external source?
- How does the degree of linearity appear in the final key? and
- How important are exact minimum gains in different keying applications?

Answers to these questions and an understanding of basic keying concepts explain how different key effects are accomplished.



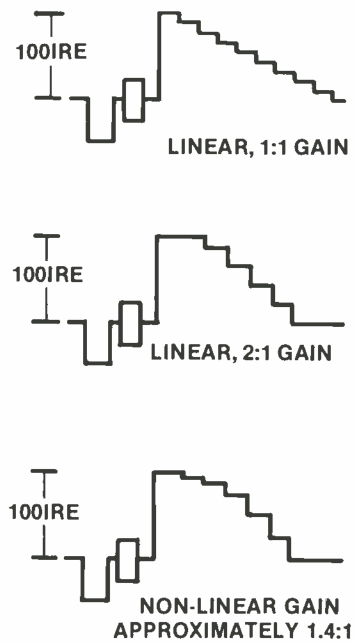


***Figure 1.** The result of a 10-step key signal used with three different gain values of linear and non-linear keyers.*

Reviewing techniques

What is thought of as keying today bears little resemblance to the original concept of keying. When commercial television first began, keying usually involved a non-additive mix between the background and key video signals. The result was more of a superimposition than a key with the brighter of the two images being dominant. The technique worked fine if the background was no brighter than the key. Otherwise, portions of the keyed information were lost in the surrounding image.

In searching for a better method, designers sought to emulate the film technique of creating a matte, that is, cutting a hole in the background and substituting other video where the background had been cut away. The first keyers accomplished this goal electronically. Although early keyers made titling, bordering and other simple matting tasks possible, the film-quality appearance was not achieved. Edges often displayed peculiarities of high-speed switching between the video sources.

A gain control, usually labeled *edge* or *soft,* brought an initial solution for better

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More than a name

Linear key systems are available in most modern, high-quality switchers. When the unit includes gain control through a softness or key edge adjustment, the keyer could be considered linear. In most traditional keys, as with many character generators, whether or not the key is linear is a moot point. Rise times of the video are fast and the levels are either black or white. The result is a key that is either fully in or fully out at any instant in time, regardless of where the gain or clip level is set.

Linear keying becomes more important, however, when the key signal rise times have significant slope or when they contain differing video levels and when the desired result contains areas of mixed key and background video. Consider, for example, a fuzzy appearance or glow around an object or title. The source image is from a monochrome camera. When the camera is defocused, images no longer have sharp rise times because, in the blurred area, the image creating the key may vary from black through gray to white.

A truly linear keyer enables the creation of a mix between background and insert video within this blurred region. The *clip level* determines the point on the control signal slope where the nominal mix occurs. The *gain control* determines the width of the resulting mixing region. From a different point of view, the gain control adjusts how much of a change in key video is necessary to mix the key from fully in to fully out.

With high-gain keys, a slight change causes the key either to replace the background entirely or to not be visible at all. As gain is reduced, a greater change in key video is required to cause a complete swing in the effect video. Between the extremes, insert and background video signals mix in proportion to intermediate values of key video.

Low-gain keying first appeared in the *RGB chroma-key*. Until recently, most chroma-key effects were obvious, showing peculiar sizzling or sparkling edges. By lowering the gain during keying, such undesirable edge effect can be minimized. Even a sharply focused camera image has significant rise times around chroma-key subjects. Therefore, slight gain reduction allows the keyer to mix in the subject during those rise times.

The need for high gain

Reduced gain is not solely responsible for the clarity of high-quality keying or

Hole cutters and fillers

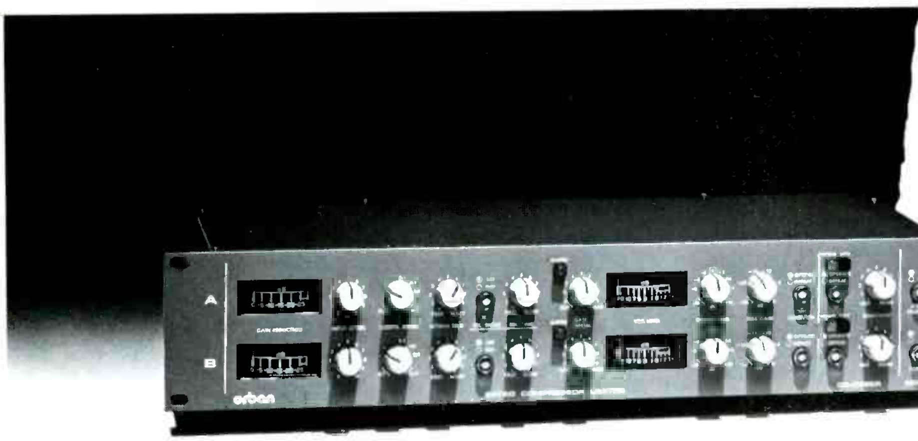
Linear keying hinges on the real differences between the key signal and the key insert. The key signal controls when the key is in, out or in between. It is often referred to as the hole cutter.

The key insert or fill signal is video that appears in the hole in the output. In self-filled luminance keys, the key and the insert are from the same source. Examples of effective self-filled keys are simple character generators or monochrome cameras.

Greater sophistication involves key signals and inserts from different sources. Most high-quality character generators and digital effects devices provide key outputs that are separate from the key video.

The RGB chroma-key was the first commonly used process in which the key was not the same as the insert video. Separate R, G and B video signals, fed to the switcher independent from the camera composite signal, are processed independently to create a shape based on some desired chroma-key hue. The shape cuts the hole for the inserted composite camera video.

Another example of different key and insert signals is the matte-filled key. In this case, the insert is a full field of solid matte color that appears only where determined by the key signal.



compositing. If the key signal rises more slowly than the response time of the keyer circuit, reducing gain will soften the edge of the key and frequently yield a more natural appearance. However, other issues are also involved.

Low gain significantly eliminates a pasted-on look, but when fine differentiations between video levels are necessary, higher-gain systems should be used. For example, consider a logo that is to be keyed over a picture of the automobile dealership's building. The logo contains highlights, reflections and near blacks. Because of the logo variations, any background selected may include areas approximating levels created by features of the logo. You run the risk of punching holes in the logo image. Higher key gains used on the logo improve the chance of discriminating from among the subtle levels of luminance.

The standard video black level (setup) is 7.5IRE units. High gain in keying is important if superblack (between 0IRE and 7.5IRE) is involved. A common production problem arises when an image is transferred to videotape for later keying into a new background. One method would place the image over a solid color on tape, followed by a composite chroma-key. That method seldom looks as good as a luminance key, however. This can be further complicated by the fact that the colors in the image may make it impossible to find a unique solid background color.

Another solution is to place the image over superblack for the recording. Recombining the image uses a luminance key, setting the clip level between the true black and superblack. This may require an exceptional amount of gain, however. The videotape playback contains roughly 1IRE unit of noise at both the true 7.5IRE and 0IRE levels, leaving a 5IRE window in which to differentiate between the subject and the background. In such a situation, the high-gain keyer overcomes the limitation of keyers that can differentiate a 4IRE to 5IRE level change at best.

Keying on components

Video production switcher specification sheets often indicate that chroma-key is available. Some models include a chroma-keyer as standard equipment, while others offer options of encoded and/or RGB systems.

Of the two, the RGB-type keyer should be the simpler because specific levels of red, green and blue signals form the keying pattern. Encoded chroma-keyers must first decode the signal to RGB with the risk of noise entering the decoding process.

Chroma-keying with component signals introduces another challenge. Because of differences in the signals, RGB keyers cannot directly handle Y/I/Q, Y/U/V or Y/R−Y/B−Y signals without some alteration of the key matrix circuits.

Solutions to this dilemma include encoding to composite video, then decoding to RGB. High-quality encoders and decoders make this a viable alternative, but whenever active devices process signals, the possibility of artifacts and noises exists.

Transcoding or intermatrix products allow any component format signal to be translated to any other format. Without introducing reference subcarrier to the rematrixing process, the resulting signals maintain the component video advantages.

A third possibility places format compensation in the keyer as semi-intelligent matrices. From switcher panel controls, adjustments to multiplier circuits in the level-sensing key matrix can be made through software, providing a flexible system that adapts easily to the signals in use.

External keys

So far, this article has discussed simple keying, or the *self key,* in which the key

Continued on page 70

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Switching components

According to some engineers, the most difficult design aspect of a video production switcher is correct timing. The only aspect that might be more difficult is the human interface, that is, the control panel itself.

When a video production switcher is installed, a special effort is needed to allow for and correct signal timing from all sources through video cable lengths, adjustable delay lines or through a system of sync generators that provide for delay compensation. (For more details, see the articles "Sync Processing and Distribution" and "Understanding SC/H Phase" in the July 1986 issue of ***BE****.)*

If you assume all signals are in time at the switcher inputs, then they must remain in time, even though one or more have taken paths through mix-effects amplifiers, multiple re-entries and keyers. An important specification for system design, when considering a new switcher, is the electrical path length, usually given in nanoseconds or in degrees of subcarrier.

Switchers designed to use analog components present additional difficulty. Three paths for each input must remain in time along the entire length of the switcher. Any instability among the three component channels causes a lack of sharpness and color purity in the resulting images.

The stability of electronic devices in modern systems makes possible switcher designs incorporating fixed or variable delays along the length of the electrical path. Fixed-delay designs require the engineer to ensure that all three component signals from each source are in time at their entry point into the switcher. With the alternative, adjustable variable delays, the engineer can compensate for differences between the components more easily.

Some in the broadcast industry have indicated a disappointment in the slow movement toward component production. One of the reasons results from the number of changes made since the first component camera/recorder products were introduced. The lack of component products covering segments of the production process, particularly switchers, video monitors and monitoring systems, has helped to slow the conversion to components. The problems will lessen as complete component systems are introduced.

Designs are expensive without a ready base of customers. On the other hand, without available products, equipment users tend to shy away from concepts that lack a visible manufacturer base. As manufacturers and users become better acquainted with analog or digital component operation, component use will increase.

Continued from page 66

signal and the insert video are the same source. Isolated or *external* keys present a different challenge because separate hole cutters and insert video are provided. Although linear keyers perform the self key well, not all are capable of doing a low-gain key based upon external key signals. In order to take advantage of today's repertoire of production tools, graphic art paint systems, digital effects units and anti-aliased character generators, the keyer must work with a signal that is separate from the insert video.

In the case of a digital effects unit, under normal circumstances the external key shape comes into the switcher from the effects system to cut a hole precisely the size and shape of the reduced raster coming from that unit's composite video output. Keyer gain is not necessarily critical, because the rise times are fast. However, if an effects system key-softness feature is used, the hole-cutting signal will have sloped edges.

Suppose the desired effect is for the keyer to mix between the background

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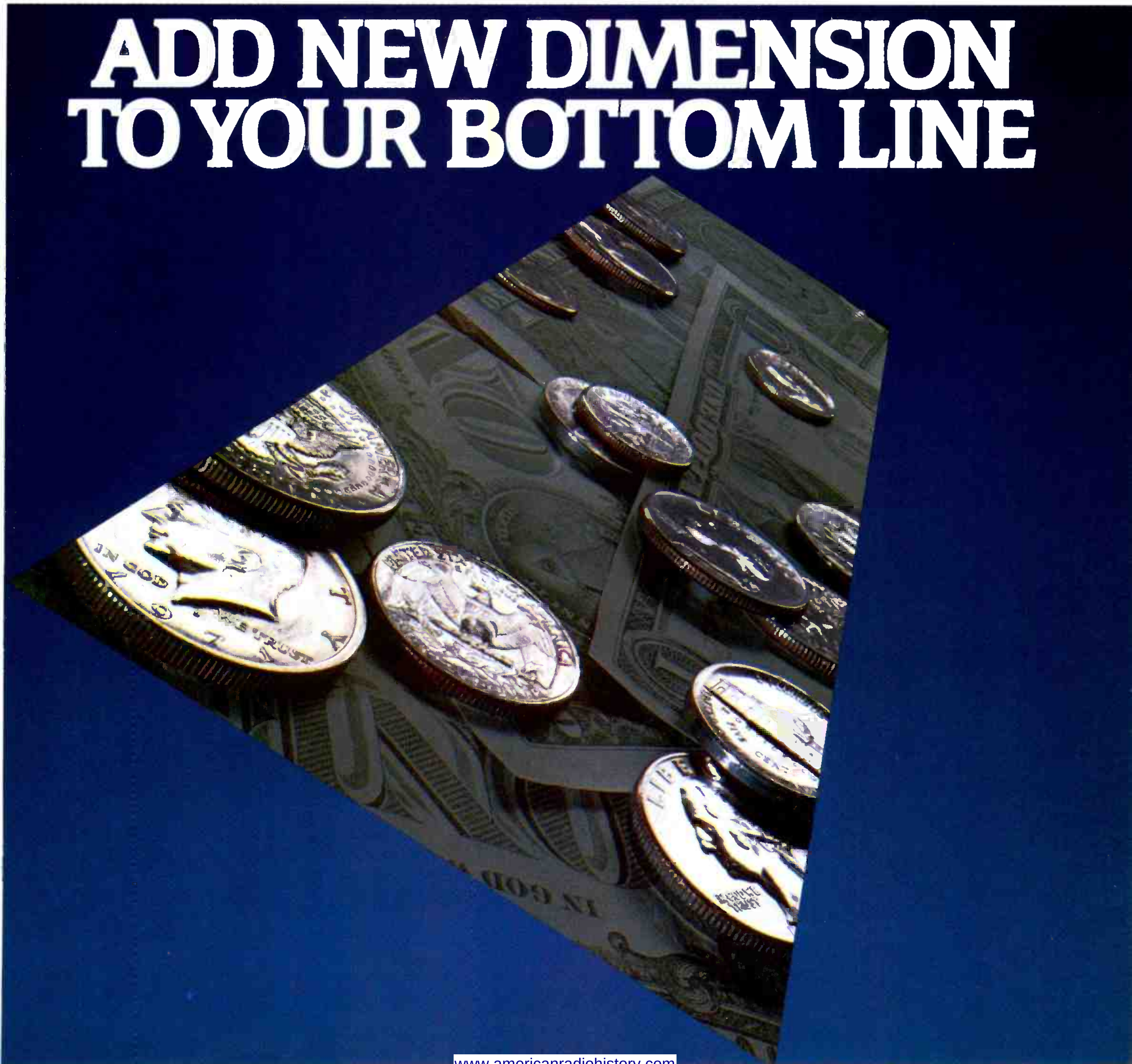
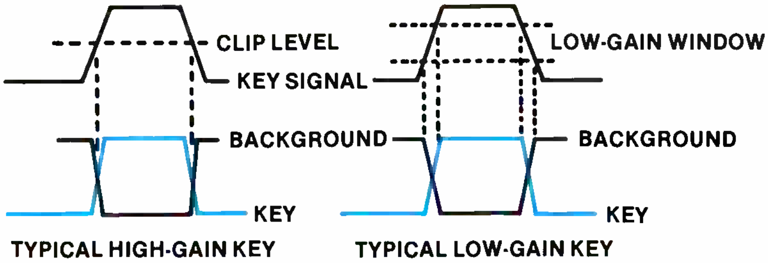




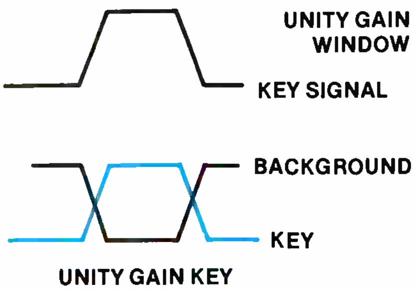


Figure 2. A view of the key input and background signals shows their interaction in different keyers. In the low-gain key, the window moves and changes size with clip setting.

and effects video during the sloping region of the key signal. The effect is possible only if the keyer can apply variable gain to the isolated hole-cutting signal. To circumvent this necessity requires patching of video and tying up additional capabilities of the switcher.

A favorite effect in today's production market involves flying a key signal and its associated video around the screen. If the key signal has any softness, then the flying image can be combined with soft edges blending into the background. To accomplish this, a hole-cutting signal applied to the digital key channel of the digital effects unit produces an output for rekeying into an image. With external linear keying capability, the rise times of the key signal maintained in the effects equipment make the flown image look more natural.

Another application requiring linear keying from an external key source involves an independent key hole from the graphic art paint system. The artist creates a soft-edged shape with the graphic airbrush to produce a highlighting glow around an advertised product. The shape signal is then fed into an isolated key input of a linear keyer.

Degrees of linearity

As long as keyers have high gain for level discrimination and low gain for any type of key, most production requirements can be met. Because image quality is the goal, however, other factors should also be considered.

For a keyer labeled as linear, the question arises as to how linear, and how low a gain is available. Accurate linearity is important when the production calls for precise control over the smoothness of transitions between insert and background videos. Often the difference between true and approximate linearity is visible only through close scrutiny, but production clients have a way of seeing the smallest discrepancy.

The degree of linearity determines if a certain percentage of change in key video yields the same relative percentage variation in the key and background mix at high- and low-luminance levels. To measure this, you can key a monochrome stairstep over black with low gain and a white matte fill. Then, determine how much variation exists in the number of IRE units between each step with a given clip and gain setting.

The measurement of keyer linearity requires that the key be white-filled over black (or vice versa), so the key signal determines how much white is mixed with the black. If the key were self-filled, each step of key signal would control how much of that same luminance mixed with the background. This would yield the product of the video times itself, a squared relationship and a resulting key that is far from linear.

Minimum gain factors

Just how low is minimum gain? For most practical low-keying work, a gain of two will do. For a 10IRE change in key signal, the result is a 20IRE change with an appropriate clip setting (as in the white-insert-over-black example). Gains of approximately two allow easy control of soft-key transitions.

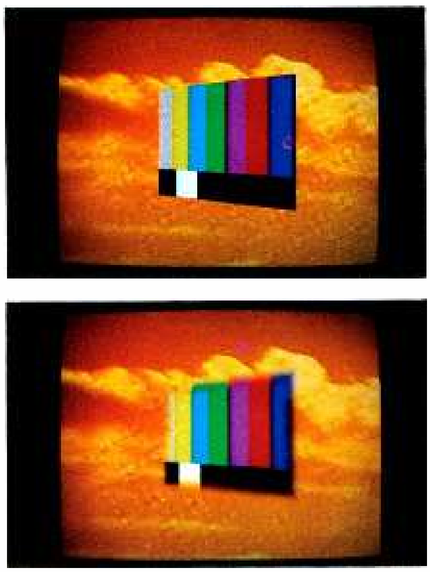
Some facilities require a gain of one. For each increment of 10IRE in key signal, the result is exactly 10IRE of change. That is, the key signal is directly proportional to the mix value in a one-to-one correspondence. If a monochrome ramp key signal is filled with white over black, the net result is the same image as the keying ramp. With a gain of two, only half the ramp would be visible.

In reality, the requirement is that the exact gain is known and is suitably low that subtle mix variations can be controlled. Not every keying system with this capability allows control over this type of key to come from the switcher. Adjustments are made by changing the key video rather than adjusting keyer controls. All in all, the best keyer will have low-gain adjustment and yet allow adequate control of clipping, regardless of what gain level has been used.

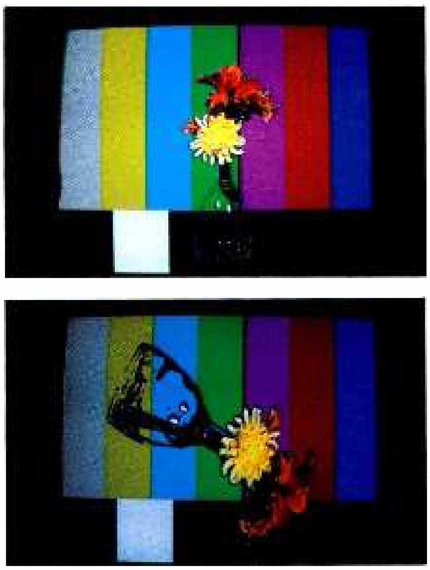
Key decisions

Analyzing production requirements allows you to determine how important the keying factors are to your applications. Beyond simple titling, most users could benefit from a linear keyer. High-gain, fine-discrimination keys; natural-edged keys; exactly linear mixed key levels and exactly controlled proportions of the key mix would allow you to perform a variety of keying applications.

All the criteria should be examined in the evaluation of any piece of equipment. Your major concern, particularly in purchasing a new switcher, is deciding on the capabilities you require today and planning for what you'll need tomorrow. At issue is that future equipment and production techniques may make even heavier demands upon any keyer's flexibility and accuracy.



A special effects system inserts color bars into the cloud background. With key softness added, sharp edges are removed.



A low-gain RGB chroma nulled key places the flowers and vase over bars. With high gain, the flowers remain realistic, while the vase takes on a surrealistic aspect.

Wiring an audio-video production facility

By Edgar Lee Howard

Properly wiring an audio-video facility requires more than a reel of cable. If you don't know what you're doing, there are pitfalls at every connection.

It should come as no surprise to most of you that the systems in the broadcast business are not all fused together into one giant black box. Rather, broadcast facilities consist of a myriad of small black boxes, interconnected with each other and with the outside world. These days, more time is devoted not to designing and building these black boxes, but to mounting them in racks and connecting them into systems.

There have been many technical changes over the years. Gone is the cotton-covered wire. Gone is the big, fat RG/11, with its solder-on, screw-on connectors. Gone is the enigma of all audio interconnects, the Christmas tree—and with it, the melted insulation and burned fingers. On the way to well-deserved extinction are most solder-type connectors. They are being replaced with neat crimp-on units that are not only faster, but more reliable.

Interconnection theory

In a typical broadcast system, several common elements exist. For one thing, the total system is composed of a large number of individual components. Many of these components, such as tape machines, audio consoles and cameras, can operate as stand-alone devices. However, they are of little use when operating alone. For broadcast equipment to be useful, it has to be interconnected with other devices. Unfortunately, the interconnection process is complex and fraught with pitfalls.

To connect the broadcast equipment to other devices, cable or wire is used. Paired and shielded wire typically is used for audio, and coaxial cable is used for video. In each case, the specific wiring requirements are different. However, the basic task is the same: to deliver signal or power to other broadcast equipment.

Whenever two devices are connected together, there is the chance that problems will be created. Interconnecting equipment can produce noise, distortion and even dangerous conditions. If you are to avoid these potential problems in your installation, you must understand the theory behind proper interconnection techniques.

Figure 1 shows a simple current loop, with the same instantaneous current circulating in every part. All the voltage generated appears up across the load.

Figure 2 shows a more realistic situation. Wires have resistance and, therefore, some loss. Generators are not perfect, and they too have losses. This internal loss is shown as a series source resistance in Figure 2. Most active devices are single-ended. Their inputs

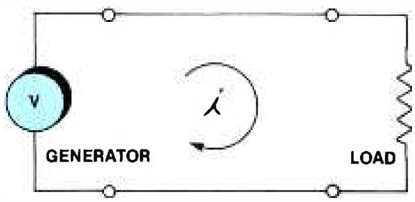


Figure 1. *A simple current loop consisting of a generator and load.*

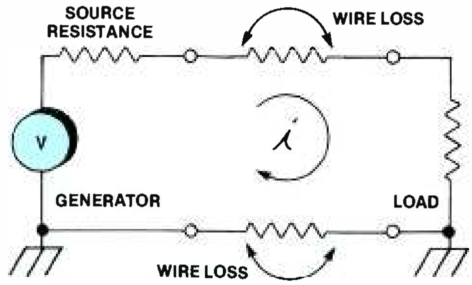


Figure 2. *This circuit shows the addition of a source resistance and wire loss, which causes a voltage drop.*

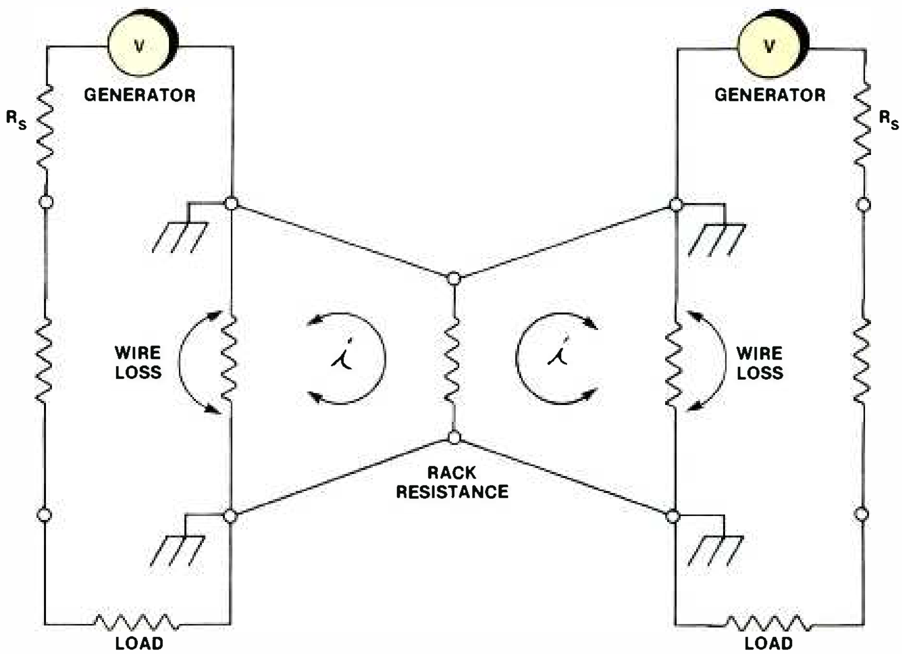


Figure 3. *Mounting two sets of generators and loads in the same equipment rack can cause circulating currents to be exchanged between the devices.*

Howard is supervisor of maintenance and systems development for WOSU-TV, Columbus, OH.

and outputs usually are referenced to the same common point. Therefore, you can assume the lower end of the generator and the load are connected to the local chassis ground.

What happens now? Well, for the dc and low-frequency ac cases, there is still a simple current loop, so some of the signal from the generator develops voltages across the two wire resistances. This reduces the signal developed across the load resistor, which is called *wire loss*. Notice that there is a signal (voltage) drop across the lower conductor because of the wire loss. Each end of the lower conductor is connected to each chassis ground. The two chassis (generator and load) are now at different potentials.

If the generator and the load both are installed into the same equipment rack, the resistance of the rack frame will appear as a parallel current path to the lower conductor. At first, this might seem to be an advantage, in that the rack-frame path somewhat decreases the losses in the lower conductor. However, consider what happens if there are two pairs of equipment chassis mounted in the same rack. (See Figure 3.)

Notice that each pair of chassis generates a voltage drop across the rack resistance. However, each pair sees the voltage drop of the other pair as a part of its own current loop. If you turned off one of the generators, you'd hope that its companion load would see no signal.

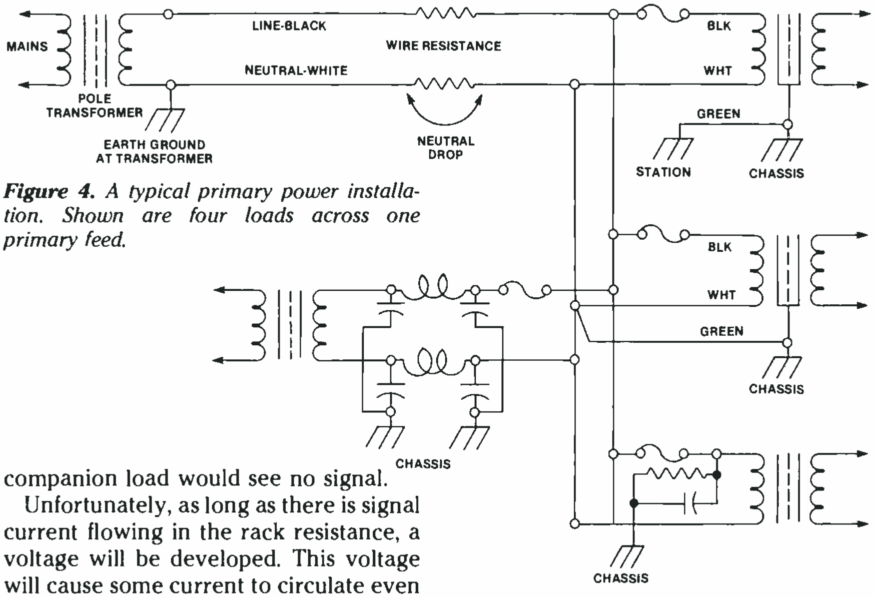


Figure 4. A typical primary power installation. Shown are four loads across one primary feed.

Unfortunately, as long as there is signal current flowing in the rack resistance, a voltage will be developed. This voltage will cause some current to circulate even in the circuit whose generator has been de-energized. You have just created crosstalk. Although the signal levels may be small, they still exist and can become a real problem, as you'll see later.

Primary wiring

Even worse signal contamination can result from improperly installed power systems. Figure 4 illustrates a typical primary distribution system. For most installations, there is a pole- or pad-mounted transformer that develops the 120V, 240V or 3-phase 208V service your facility uses. For reasons probably more historical than sensible, one leg of the load side of this transformer is grounded. For single-phase service, this means that there is one *hot* wire and one *neutral* wire. The hot wire is usually black and the neutral wire is usually white. The neutral wire is close to ground potential. For safety reasons, fuses or circuit breakers are installed in the hot or *line* path to each major equipment load.

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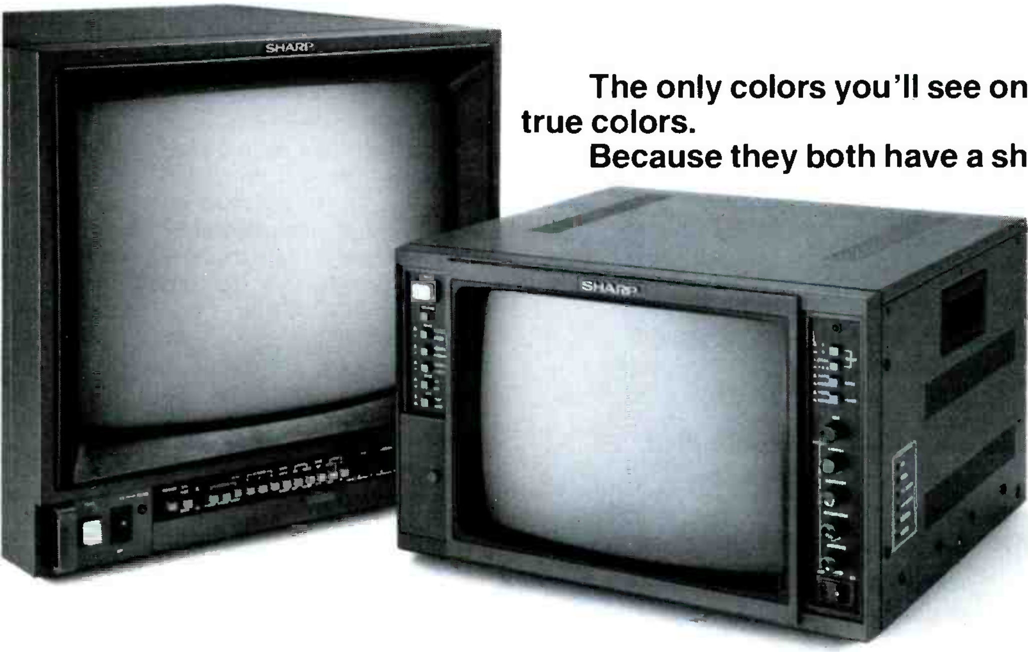

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If a load such as an equipment power transformer is attached, current will flow in the loop and both transformers. As might be expected, IR *drops* will occur in both the line and neutral conductors. Because this is primary power, and not video or audio signals, there are amperes of current flowing in these wires. This current can produce several volts of drop as a result. Zero gauge wire has a resistance of approximately 0.1Ω per 1,000 feet. A 500-foot feeder would have 1,000 total feet of wire. If 100A is flowing in the circuit, a voltage drop of approximately 10V, 5V each way, is produced. You can see that IR drop in primary feeders can be significant.

If the power transformer primaries were the only elements connected to the power distribution point, you'd have few problems. However, that is not usually the case.

Most equipment chassis are connected to the station ground system. This ground should be an earth ground. Remember that one side of the primary power transformer also is connected to earth ground. The neutral wire, which connects the two transformers as shown in Figure 4, develops several volts of drop because of the resistance in the wire. A third wire now comes into play.

This third wire, called the *safety ground*, is not connected to the neutral. Generally, the safety ground (which is usually a green wire) is connected to the station ground through the grounded equipment chassis.

Consider what can happen if the safety ground is connected to the neutral at the power panel. Suppose there is a drop of 5V in the neutral between the pole transformer earth ground and the power-panel neutral. Remember that the green-wire safety ground has just been connected to this same power-panel neutral. The safety ground is also connected to the equipment chassis, which is connected to the station ground and in turn to earth ground. An ac circulating current has now been developed through the station ground, in parallel with all of those interconnects discussed previously. This combination of signals adds to the total noise problem in the facility. Connecting the safety ground to the power-panel neutral is a common mistake.

The safety ground is by far the worst culprit when it comes to generating noise. However, it is not the only one. Anything that permits current to flow from the primary circuit of the power transformers into the chassis ground can cause noise. Some equipment is supplied with resistor-capacitor bypass networks connected between the line side of the ac input and the chassis ground. This bypass network simply couples ac noise directly into the equipment chassis.

Another noise source is a *noise suppression filter* that decouples both sides of the ac line to the chassis. To a lesser extent, the winding capacitance between the power transformer primary and the transformer core or electrostatic shield also can couple ac energy into the station ground system.

Solutions

How can you get rid of these noise sources? Check within each piece of equipment to be sure nothing but inductance in the power transformer couples energy out of the primary circuit. Remove all of those little RC bypass networks whenever you find them. Ensure that RF filters bypass from line to neutral and never to the chassis.

Check the capacitance of each power transformer primary to the electrostatic shield. Be sure the end with the most capacitance is connected to the neutral. More capacitance but much less voltage means that less energy is coupled into the chassis. Above all else, never connect the safety ground wire to anything but the station ground.

If you can get away with it, eliminate the safety ground wire altogether and wire all of the ac distribution with two conductor cables. Equipment mounted in metal racks and bonded to a technical ground is unlikely to elevate itself dangerously above ground, so no safety hazard exists.

If you have to meet local code re-

Continued on page 82

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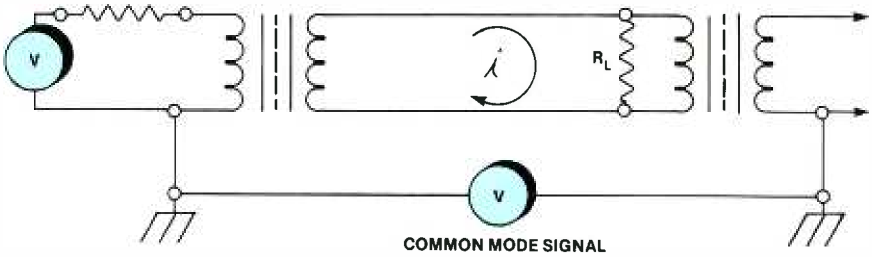

Figure 5. *Using transformers can isolate circulating currents, preventing noise. Here, the common-mode signal is never coupled to the audio signal.*

Continued from page 78
quirements, use the electrical scheme that is used in hospitals. These areas meet special safety requirements and use a separate technical ground that has no connection to the electrical power distribution system Sometimes called *orange ground* systems, they are more expensive to implement than the *green ground* systems, but meet safety code requirements while preventing circulating currents in the equipment grounds.

Signal distribution

Now that you have a better idea of the problems associated with power distribution, look at signal distribution. Recall from Figure 2 that the grounding problems began when the chassis grounds were interconnected on the generator and the load. If nothing is connected to the equipment chassis, circulating currents in the grounds are not a problem. Or, if the ground to the signal path is eliminated, circulating currents cannot flow. This will prevent noise problems. For audio-range signals, this ground path is eliminated easily. Simply use transformers to interconnect the equipment, as shown in Figure 5.

The current loop in the interconnecting wires remains, but the current is entirely isolated from the grounds and from any common-mode voltages and currents. Also note that two transformers aren't necessary. Figure 6 achieves the same current loop independence with only one transformer. Having the loop grounded at one point does not couple noise into the loop, because only one connection is made. This is fortunate, because transformers tend to become large and expensive when they are required to pass full-bandwidth audio signals at high power levels. Transformers, if they are used at all, belong in the low-power input stages.

High-frequency noise

These techniques are fine for low frequencies. At higher frequencies, however, stray capacitances begin to manifest themselves. Figure 7 shows that, with high frequencies, capacitive leakage paths are possible. For instance, a path from the high side of the loop to the chassis ground provides a complete

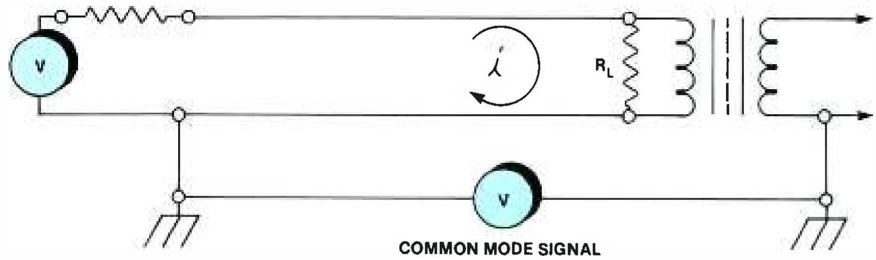

Figure 6. *A single transformer can prevent circulating noise currents as shown here.*

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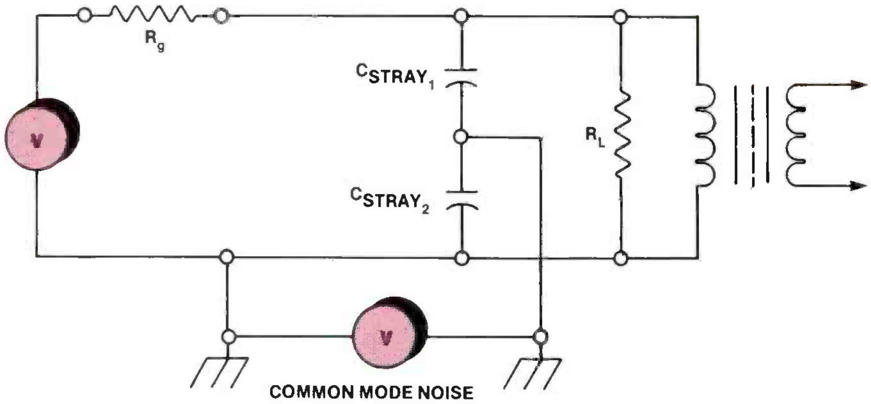

Figure 7. Capacitive leakage paths develop when high frequencies are present. These paths are represented by $C_{stray\ 1\ and\ 2}$.

circuit for ground signals to flow. Some of these high frequencies also flow through the input transformer primary and, therefore, can add noise to the desired signal. The higher the frequency, the lower the effective impedance and the greater the signal contamination.

What can you do about it? You could electrostatically shield the interconnecting wires and tie the shield to only the sending end's chassis ground, as shown in Figure 8. With this scheme, both ends of the stray capacitors are now at the same potential, so no ground signal currents flow. Notice, however, that if the shield is grounded at only the *receiving* end, as in Figure 9, you have just about the worst possible case of capacitive ground currents.

The sending end of the shield and the chassis are now at the same potential, and can't couple noise. The receiving end, however, is still able to couple stray energy as before, so the improvement is limited to approximately 6dB. This theory indicates that when shields are used, they should be grounded at the sending end only.

Balanced circuits

Look again at the noise problem. Recall that signal contamination noise comes from currents flowing through the load due to capacitive coupling between the *hot wire* and the *local ground*. Consider how you can use a *balanced output* to your advantage.

Figure 10 shows a symmetrical or balanced output stage with identical

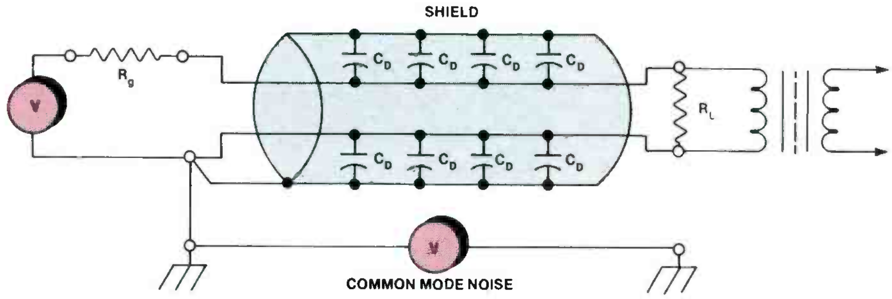

Figure 8. Grounding the cable shield at the sending end proves to be an effective method of reducing the effects of stray capacitance.

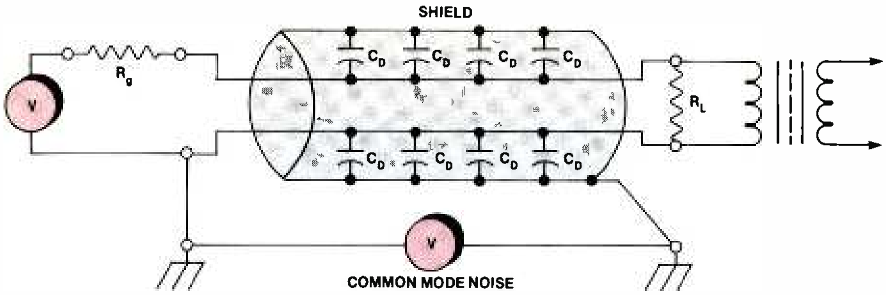

Figure 9. *Grounding the cable shield at the receiving end can still couple ground noise into the system.*

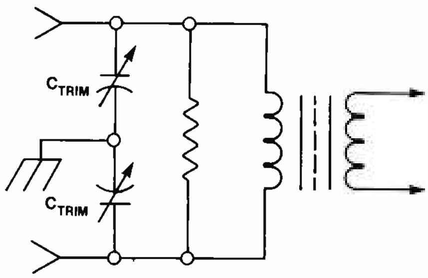

Figure 12. *Small trimmer capacitors can be used to balance out any stray capacitance.*

generator or source impedances, R_g, in each output line. These generators produce out-of-phase identical signals on each output with respect to the local chassis ground. The interconnecting wire is terminated as before, and symbolic stray capacitances are shown connected to the terminating chassis. Again, this is a worst-case example.

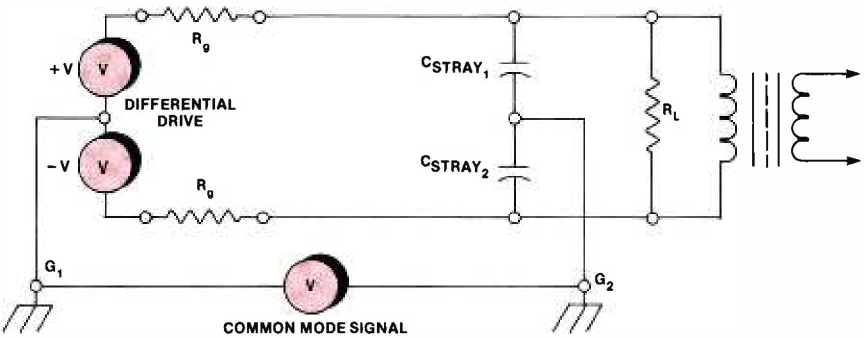

Figure 10. *The balanced source and load configuration shown here can still suffer from stray capacitance problems.*

Figure 10 has been redrawn to give a better idea of what is happening. The new schematic, shown in Figure 11, treats the generators, stray capacitances, and ground-noise sources as a bridge configuration. If the R_g values are equal and the C_{STRAY} values are equal, then you have a balanced bridge. This means that points A and B are at the same potential with respect to the ground noise.

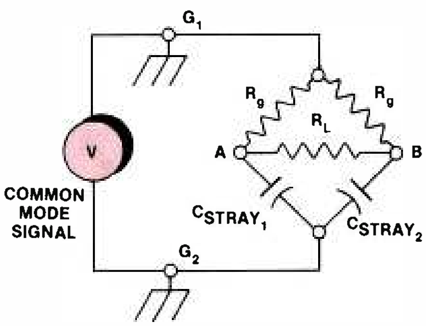

Figure 11. *Balanced source and load redrawn in a bridge configuration.*

Therefore, no ground noise-induced currents can flow through the load.

Assume that the source resistances are the same and the stray capacitances are the same. If they aren't, suitable variable capacitors (see Figure 12) could be installed from each side of the input to local ground, and one or the other could be adjusted to *balance* the stray capacitance or the magnitude of the source resistance. This is sometimes necessary to deal with adverse sources, such as telephone lines.

Other noise sources

If you change the label of the ground-noise generator and think of it as just some other signal, then you can use this same model to consider the effects of capacitive coupling other signals into the circuit. The model and the results are the same. If the source resistances are equal in the circuit, and the stray capacitances are the same between the other signal and each of the conductors, then no interference-signal energy can exist across the load. Therefore, there will be no crosstalk.

The key is having equal-value stray capacitances from the outside sources to the two conductors. The simplest way to ensure this is by using twisted pairs of wires for the interconnects. Over any reasonable length, the tightly twisted conductors both occupy the same space. The two conductors are both equally close to any adjacent noise source, so they have identical stray capacitance values. When driven and terminated in a balanced manner, twisted pairs, even unshielded pairs, are virtually immune to capacitive crosstalk. In a similar manner, balanced-driven twisted pairs produce little coupling into other conductors. Again, the two equal capacitive components of coupling are out of phase and, therefore, cancel each other.

Inductive coupling

Although this article has focused on the effects of capacitive coupling, inductive coupling effects also are present. The current loop discussed previously can be thought of as a single-turn winding of a transformer. Therefore, any magnetic flux passing through this loop will induce a current in the wire and create unwanted signals into the load. Shielding, whether woven mesh or foil, is not composed from magnetic materials, which makes it of little use against magnetic flux.

Fortunately, the twisted pair is the answer again. In a tightly twisted pair there is little space between the conductors, so the *area* of the one turn loop is small, and little flux can pass through it. Also, because the wires are twisted, the direction in which current is induced by the applied magnetic field reverses for each half-twist of the wires. Over a large number of twists, the net-induced current is quite small because each half-twist cancels out the one before it.

Twisted pairs are also virtually immune to inductive crosstalk. Twisted pairs generate little *net* magnetic flux because the contributions from successive half-twists are out of phase and cancel out.

The major points that have been discussed are that:

• Twisted pairs should be used to eliminate inductive crosstalk.

• Twisted pairs, shielded or not, should be used to eliminate capacitive crosstalk. The circuit must be driven balanced with equal source resistances and terminated in a true balanced input.

• Electrostatic shielding, if present, must be grounded only at the sending end.

Proper operation is contingent upon terminating the twisted pair with a balanced input. So far, this article has discussed using transformers to balance the circuits. Even though the transformer has a number of inherent problems, such as poor frequency response and high distortion, the floating-primary input transformer is virtually insensitive to the ground-referenced inputs (ground noise and crosstalk). This insensitivity is possible because there is no current path from the primary to ground. Only an imbalance in primary winding capacitances to ground from the windings can upset

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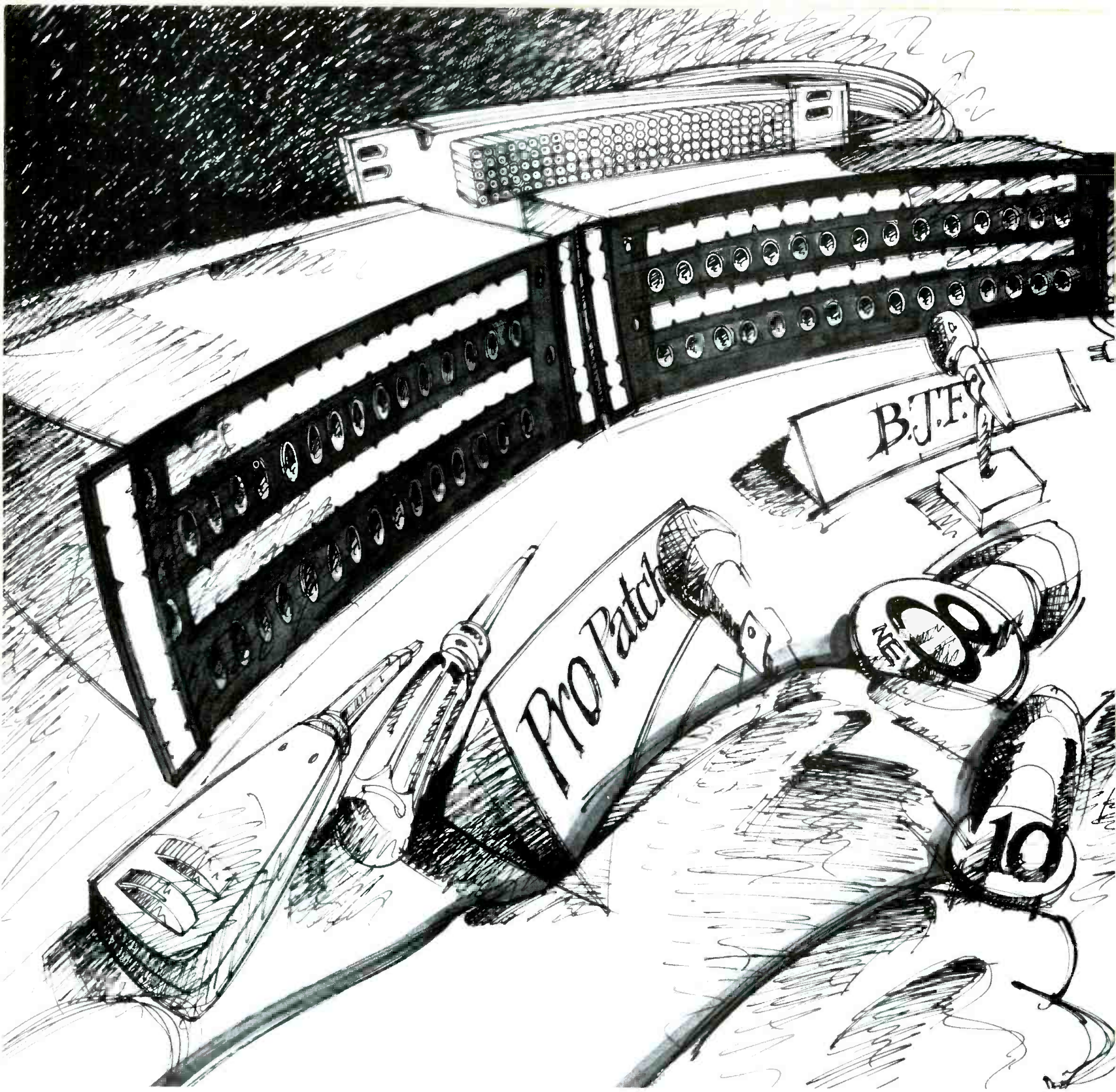

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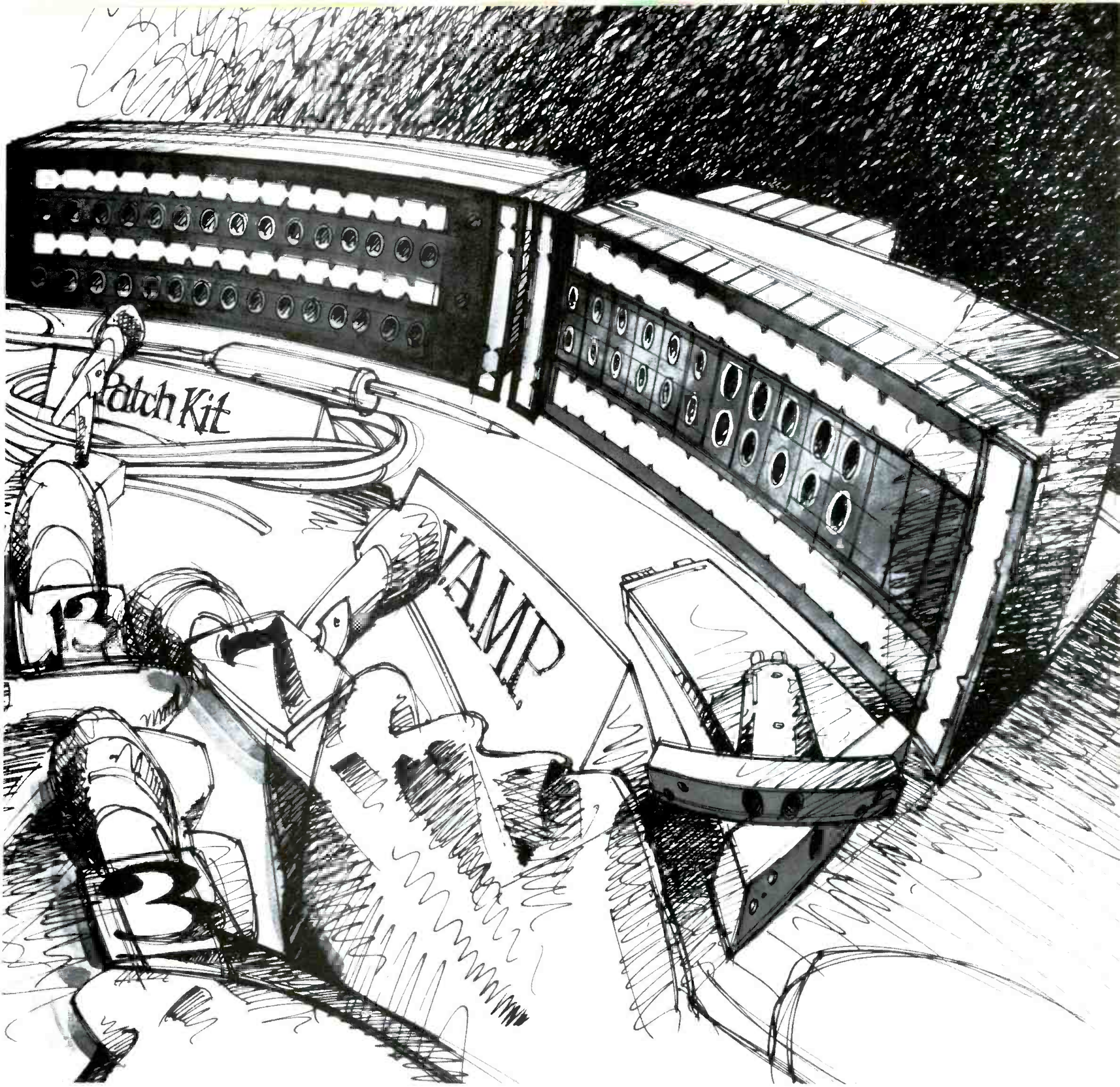

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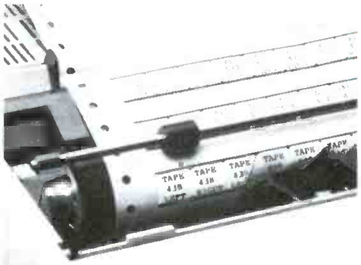

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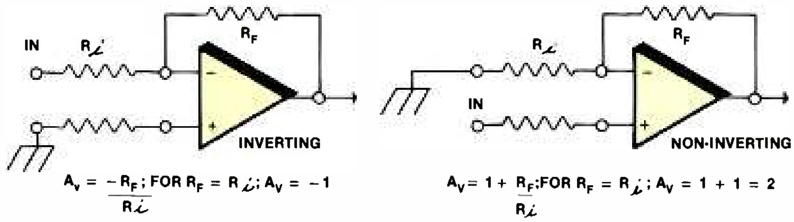


Figure 13. *Inverting and non-inverting operational amplifiers.*

Continued from page 86

the isolation.

The transformer's center tap should not be connected to anything. If it is grounded, the transformer's rejection of ground-returned signals or noises depends on the precision with which the center tap is placed in the electrical center of the winding.

Active circuits

In many instances, active circuits can be used in place of transformers. If the ground-return signals are common to both input lines and are reasonable in terms of level and frequency, the noise can be suppressed by active circuits.

The operational amplifier (shown in Figure 13) has two operational modes: inverting and non-inverting. The resistor connected to the positive input does not affect the gain and is usually selected to minimize offset in the amplifier.

Figure 14 illustrates a unity gain line receiver with immunity to common-mode signals. This can be demonstrated by taking each input signal through the circuit separately, and then adding the resulting outputs. The top input, consisting of +signal, +noise (+S+N), passes through inverted with unity gain, as −(+S+N).

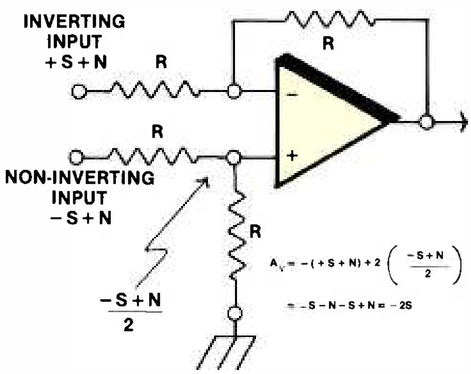


Figure 14. *Balanced, unity gain receivers, such as the one here, can provide isolation from common-mode noise signals.*

The lower input, consisting of −signal, +noise (−S+N), is divided by two to compensate for the circuit's gain of two. This −S+N signal passes through unchanged, as −S+N. The sum is −2S. The differential input terms add and the common-mode terms cancel.

This circuit serves to illustrate that common-mode rejection is possible without the use of transformers. Unlike the transformer, which simply ignores common-mode energy, the active line receiver must amplify and then cancel out common-mode energy. The amplifier also has some maximum signal-handling capability limit. Common-mode signals greater in amplitude than this limit will saturate the amplifier and destroy the desired signal.

Also, no amplifier is completely free from distortion. A small amount of noise will contaminate the signal. The result is that the −2S output is not pure S, but rather, includes a noise residue instead of a perfectly canceled N. In high-noise environments the floating-primary transformer is often still the best answer.

Video

These designs work well for audio signals, but what about video? Balanced video coaxial cables are available, but are usually reserved for long-haul telephone company circuits and other special applications. They are seldom used in station construction. Fiber-optic links are also free from common-mode problems, but are not widely used for simple system interconnects.

Because of the requirements for wide bandwidth and minimal waveform distortion, video cable is typically driven unbalanced and terminated at its characteristic impedance. Typically, the shield is grounded to the chassis at each end of the cable. By now, you can probably guess that this will introduce ground-noise currents into the video circuit loop.

It is not possible to truly balance the coaxial cable. This is because the center and outer conductors' resistances are different and the stray capacitances are not at all symmetrical. Even so, ground-noise currents can be eliminated by terminating the cable with a differential amplifier.

Most of the newer video DAs and similar pieces of equipment have floating video connectors and differential-mode input circuitry to make ground-noise elimination possible. Special care must be taken when passing video cables through patch panels and feedthroughs. If the shield comes into electrical contact with the local ground, ground noise will be introduced inadvertently.

Installation notes

The author has had success distributing audio throughout a facility with foil-shielded cable (Belden 8451). Ground the shield, where practical, at the sending end. Otherwise let it float. Telephone-style punchblocks are used as terminal and interconnect blocks. The punch-on contacts work well even with the stranded 8451 wire. The punch-on blocks are also easy to use.

Mount the punchblocks on the exposed ends of equipment rack rows where they will be neatly covered by the rack end-panels. Plastic wire channels run vertically next to the punchblocks to contain the wiring. First strip off the jacket and cable shield at the base of the rack to save space in the channels. The red and black conductors are then tightly twisted with an electric drill, placed in the plastic channels, then connected to the blocks.

Build plug-in audio patchpanels by mounting each jackfield onto a 1¾-inch bathtub chassis, with two 25-pair ribbon connectors mounted on the back of each chassis. The top and bottom rows of the jacks are wired to the top and bottom 25-pair connectors. Premanufactured or locally made 25-pair pigtails carry the signals to and from the punchblocks. Even though the pairs are not shielded, crosstalk is not a problem.

It should be stressed that punchblocks, 25-pair twisted cables, and these installation techniques are for line-level signals. These techniques should not be used for microphone-level signals. Microphone circuits should have continuous shields and soldered connections all the way from the microphone to the preamplifier. Patching microphone-level circuits also is not recommended.

Swept-video cable should be used in your installations even though it is more expensive than RF cable. The swept cable's solid-copper center conductors and densely woven shields provide much lower resistance than other cables. In addition to the lower resistive losses, swept video cable (such as Belden 8279 or 8281) has been optimized for flat response in the video spectrum. Therefore, this type of cable requires less equalization than RF-type cables.

Plan ahead

Now that you've covered the basics, the first step to any wiring project is the drawing board. You need to carefully plan the installation. Drawing the proposed facility on paper helps to avoid costly wiring mistakes.

As you design the system on paper, look for areas that have the potential for grounding problems. Are there bulkheads where the video cables can be inadvertently grounded? Are any of the audio or video cables being carried in conduit with power cables? Have you routed any audio or video cables near primary power transformers?

Use the planning stage to try out different installation and connection ideas. You need time to think through the project and try to resolve any problems on paper first—before you have to resolve them in the field.

Wiring any facility is a challenge. Carefully planned and executed, however, this kind of project can be highly gratifying.

Microphones, from the inside out

By Tim Schneckloth

The more you know about microphones, the better your station will sound.

Microphones are transducers—nothing more, nothing less. No matter how large or small, elaborate or simple, expensive or economical a microphone might be, it has only one basic function: to convert acoustical energy to electrical energy.

With that established, you might wonder why microphones exist in such a mind-boggling array of sizes, shapes, frequency-response tailorings and element types. The answer is simple. Although the basic function of all microphones is the same, they have to work for many different applications and under various conditions. A transducer element that works well with a CB radio, for instance, might be a noisy horror in a recording studio.

With applications in mind, let's examine some different microphone types, what's inside them and how they work.

Condensers

Condenser microphones have been steadily gaining in popularity over the past decade, and with good reason. They can be designed to be extremely small and lightweight, and they can provide clean, precise, accurate sound reproduction with great clarity. For these reasons, condenser microphones (such as lavalier and surface-mount microphones) are often used for applications in which unobtrusiveness or high-quality sound reproduction (such as in studio recording) is a must.

In the world of microphones, however, there's always a trade-off. To get the advantages of a condenser microphone you have to put up with a few disadvantages. These include the necessity of powering an impedance-converting circuit, a high degree of sensitivity to wind, a dynamic range limited by the impedance converter and the need for shielding against RF and electrostatic interference.

A condenser microphone's transducer element consists of a lightweight metal or metalized plastic diaphragm located near a metal backplate. This forms a capacitor. When sound waves strike the diaphragm, they cause a change in the spacing between the diaphragm and backplate, varying the electrical capacitance above and below a nominal value. When a dc bias voltage is added, the capacitance variations are translated into variations in electrical voltage. The extremely small capacitance value gives condenser microphones a high impedance, making it necessary to add an active circuit that converts the impedance value and makes the signal usable.

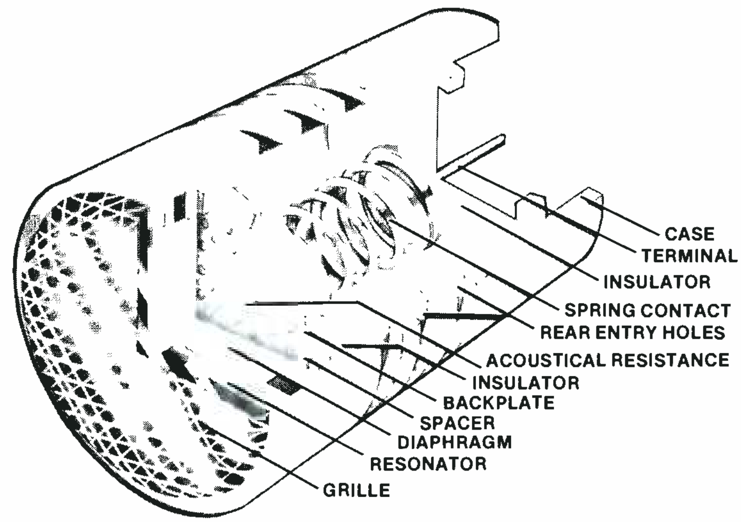
A related technique is used in electret microphones (more accurately called electret-biased condenser microphones). In this case, the condenser's dc bias is supplied by an electret material, rather than by a battery or power supply. The electret material, generally a fluorocarbon polymer, can be a part of the diaphragm or the backplate, and its electrostatic charge lasts indefinitely.

The increasing popularity of condenser microphones is largely a function of the recent improvements in condenser microphone design. A lot of the problems traditionally associated with these microphones, (sensitivity to wind and "explosive" breath, fragility and RF noise) can be alleviated by new condenser designs and improvements in shock mounting and wind/pop filters. As a result, condenser microphones are being used more and more for virtually all broadcast, stage, recording and general sound-reinforcement applications. In all likelihood, this trend will continue.

Dynamics

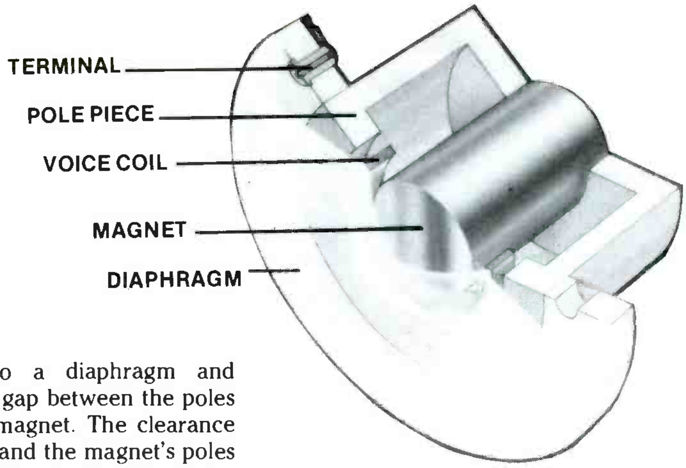
Dynamic (also known as *moving coil*) microphones are the real workhorses of the microphone world. When you consider the pros and cons previously discussed, dynamics fare well. They can be built for extreme ruggedness and reliability, they aren't particularly temperamental and they don't require a powered impedance-conversion circuit or a dc bias charge. Dynamics also have good sound quality, although they can't provide the detail and precision of the finest, most expensive condenser (dynamics can be built fairly inexpensively). All these factors combine to make the dynamic microphone popular in many applications, and to make it the world's most common, best-known microphone type.

A dynamic transducer consists of a lightweight, bobbinless coil (the *voice*



A cutaway illustration of a condenser microphone element used in a unidirectional microphone.

Schneckloth is marketing communications coordinator for Shure Brothers, Evanston, IL.



A basic dynamic microphone element.

coil) attached to a diaphragm and suspended in the gap between the poles of a permanent magnet. The clearance between the coil and the magnet's poles is quite small. When sound waves cause the diaphragm to move, the coil moves as well. By moving within the magnetic gap, the coil induces an output voltage—your signal.

The impedance of dynamic microphones is mostly resistive and, as a result, the output is not substantially affected by electrical loading. These microphones are capable of a wide frequency response and have a large dynamic range with low noise and minimal distortion. Dynamic microphones can be readily designed to be unidirectional or omnidirectional.

Owing to their advantages and versatility, dynamic microphones are commonly used for practically every application. Size is something of a limitation, however. Although they can be made fairly small and lightweight, the performance of dynamic microphones tends to suffer as they decrease in size. After all, an effective voice coil and magnet can be made only so small. For this reason, condenser-type transducers have, for the most part, taken over the lavalier microphone market.

Ribbons

Ribbon microphones are not nearly as common as condensers and dynamics, largely because of their reputation for fragility and their tendency toward large size. They do, however, provide good frequency response (including extended low-frequency response), excellent sound quality and low handling sensitivity. They are used for studio recording, broadcast and stage applications.

Basically, ribbon microphones produce an output signal in the same way that dynamic microphones do: a conductor moves in a magnetic field and induces a voltage. Instead of a voice coil, however, a ribbon microphone has a thin strip (or *ribbon*) of aluminum foil suspended between two poles of a permanent magnet. The ribbon, which may be as thin as 0.0001 of an inch, acts like a 1-turn coil and also serves as the diaphragm.

Piezoelectrics

Piezoelectric (ceramic) transducers have a high output and a fairly broad frequency response, especially at the low-frequency end. They are generally inexpensive and reliable and are used in communication microphones and some sound measurement devices. Their main disadvantages are a high impedance (which makes them susceptible to electrical noise) and a substantial response to mechanical vibration.

Piezoelectric transducers have the equivalent circuit of a capacitor in series with a voltage generator. When mechanically stressed, the element generates a

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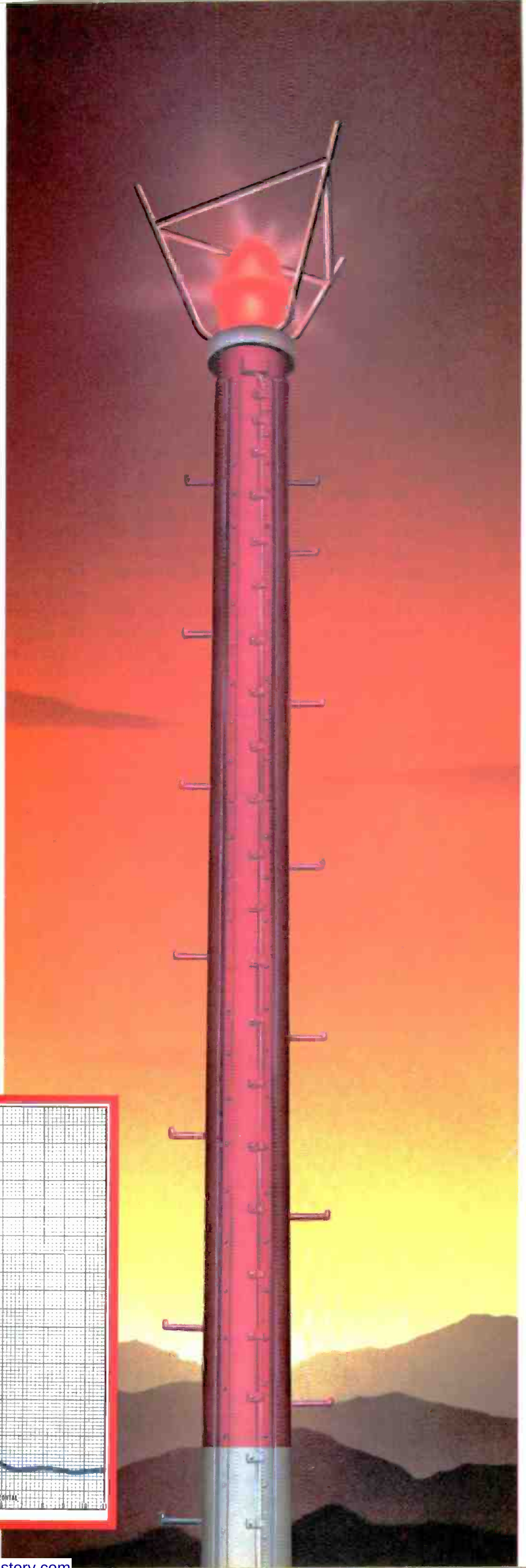

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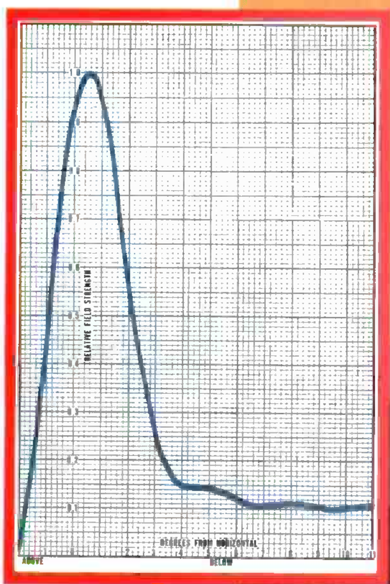

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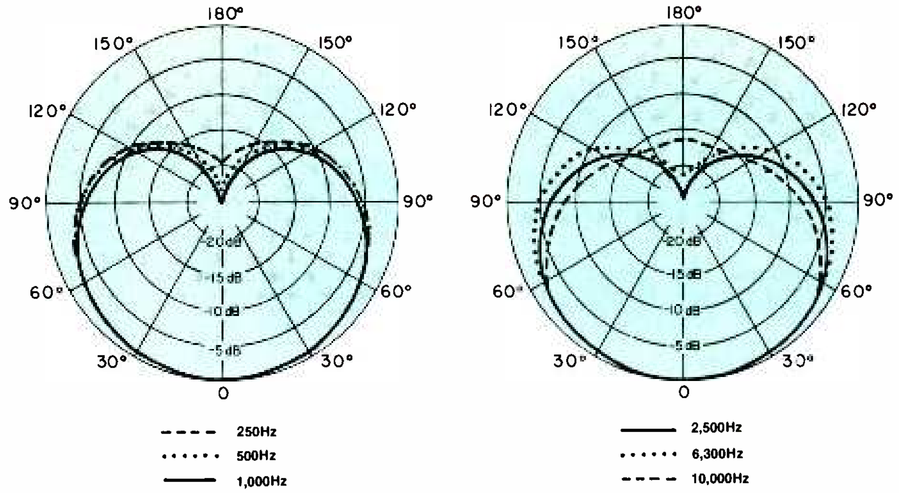

Figure 1. *Typical cardioid polar pattern. The circular graph plots the output in decibels as a function of the microphone's angle relative to the sound source.*

voltage across its opposing surfaces. One end of the piezoelectric element is attached to the center of a diaphragm (usually made of aluminum foil) and the other end of the element is clamped to the microphone frame.

Controlled magnetics

Because controlled magnetic microphones have a narrow frequency range and are highly susceptible to vibration, they are largely unsuitable for broadcast or stage applications. They are, however, often used for communications and paging, because of their fairly high degree of sensitivity, ruggedness and dependability.

Controlled magnetic transducers have also been called magnetic, variable-reluctance, moving-armature and balanced-armature, depending on the manufacturer. They consist of a strip of magnetically permeable material suspended in a coil of wire, with one end placed between the poles of a permanent magnet. The center of the diaphragm is attached at the suspended end of the armature.

Movement of the armature in the magnet's gap induces a voltage in the surrounding coil. The voltage is proportionate to the armature swing and constitutes the output signal. Electrically, the transducer is equivalent to a voltage generator in series with a resistor and an inductor.

Carbons

Carbon microphones are low cost, rugged and reliable, and they have a high output signal. They are used by the millions in telephone handsets. However, their output is inconsistent, distorted and useful only over a limited frequency range.

The carbon microphone consists of a metal diaphragm, a fixed backplate and carbon granules sandwiched in between. When sound waves move the diaphragm, they vary the pressure on the carbon granules. The changes in pressure in turn cause the resistance between diaphragm and backplate to vary. The transducer doesn't actually generate a voltage, but rather, modulates an externally supplied current.

The priorities involved in whatever job a microphone is to perform dictates what type of transducer element is needed. Most broadcast applications require either a dynamic or a condenser element. Once this has been determined, there are other factors to consider.

Directionality

Every microphone has a *directionality* or *polar pattern.* That is, each microphone responds in a specific way to sounds arriving from different directions. The polar pattern simply describes graphically the directionality of a given microphone. Although many different polar patterns are possible, the most common are *omnidirectional, bidirectional* and varieties of unidirectional.

An omnidirectional microphone responds uniformly to the sound arriving from any direction, whereas a unidirectional microphone is most sensitive to sounds arriving at the front of the microphone. It is less sensitive to sounds coming from other directions.

The main disadvantages of an omnidirectional microphone as compared with a unidirectional microphone are a susceptibility to feedback (especially in sound-reinforcement applications) and a lack of rejection of background sounds and noise.

Omnidirectional microphones are, however, widely used in broadcast applications for several reasons. It's difficult to make a unidirectional microphone very small. As a result, most small lavalier microphones are omnidirectional. This doesn't create much of a problem, however, because most broadcast situations in which lavalier microphones are employed can be controlled to minimize background noise and unwanted extraneous sounds.

Also, many of the microphones used by reporters are omnidirectional, because it's often desirable for a broadcast microphone in the field to pick up some ambient sounds and background noises to add to the broadcast's sense of *liveness.* Another plus is the omnidirectional microphone's capability to pick up room ambiance and natural reverberation to alleviate the aural *flatness* a unidirectional mic might provide.

There are many applications, however, in which unidirectionality is a must. The most obvious, of course, are those that have feedback problems. By avoiding the pickup of extraneous sounds, a unidirectional microphone will make more overall system gain available, resulting in less of a tendency to set up a feedback loop. The unidirectional microphone's rejection of off-axis sounds is often a plus in broadcast situations because the results are cleaner and more intelligible, especially under noisy conditions.

The most common form of unidirectional microphone is the basic *cardioid* type, whose polar pattern (see Figure 1) is graphically depicted as heart-shaped. The area at the bottom of the heart corresponds to the on-axis front of the microphone, the area of best receptivity. The notch at the top of the heart cor-

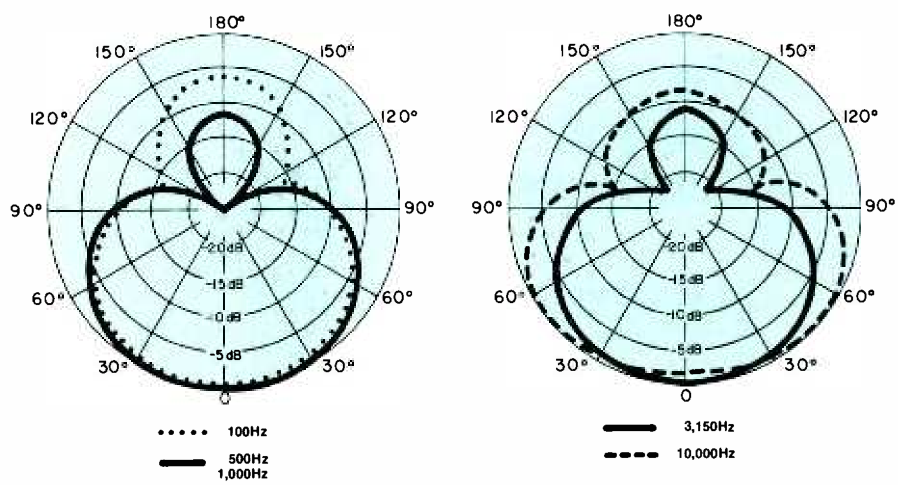

Figure 2. *Typical supercardioid polar pattern. Note the nulls, which appear at the sides of the microphone rather than at the back.*

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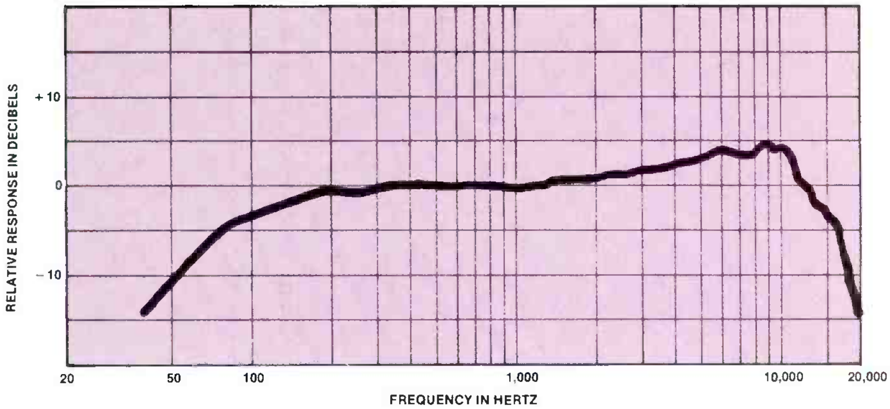


Figure 3. *A typical frequency response for a microphone used in stage and general sound-reinforcement work. Note the high-end presence peak and low-end rolloff.*

responds to the back of the microphone, the area of least receptivity, referred to as the *null*. By contrast, an omnidirectional microphone's polar pattern is ideally depicted as a circle.

Other varieties of unidirectional microphones include the *supercardioid* (in which the nulls are located at the sides of the polar pattern, as shown in Figure 2), the *hypercardioid*, and ultradirectional types such as *shotgun* microphones and *parabolic reflectors*. These types offer progressively better rejection of off-axis sound but sometimes at the expense of frequency response and/or polar pattern smoothness.

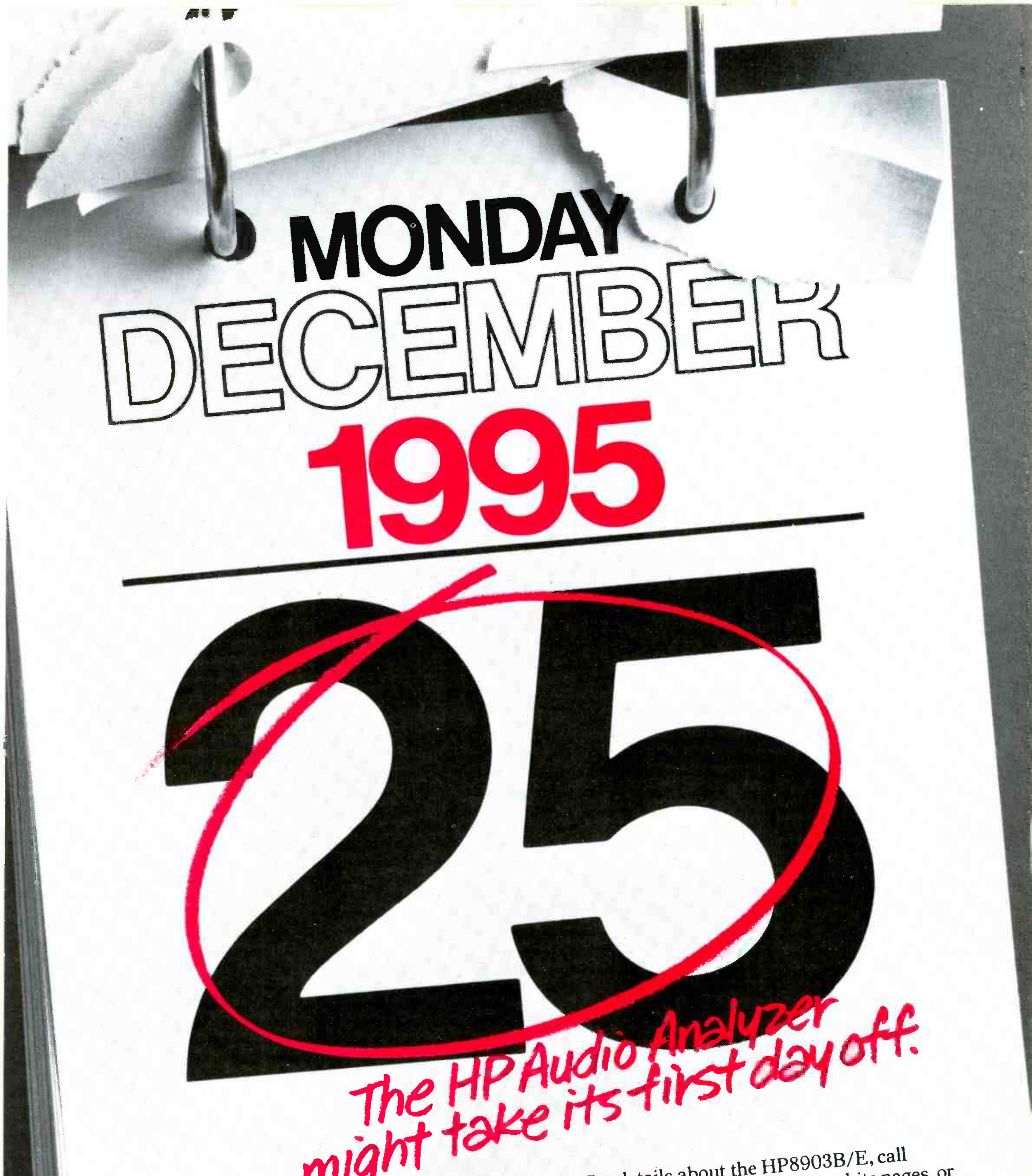
Frequency response

The frequency response of a microphone describes the sensitivity of a microphone as a function of frequency (see Figure 3). The *range* of the response defines the highest and lowest frequencies the microphone can successfully reproduce. The shape of a microphone's response curve indicates how it responds in this range. The specification is usually given in hertz plus or minus some decibel limits. In most cases, a graph showing at least the on-axis response of the microphone accompanies the description.

Frequency response is often affected by the polar pattern of the microphone. That is, the frequency response may vary depending on the direction of the sound source and the distance from the sound source to the microphone. In addition, some microphones have built-in equalization controls that can alter their frequency response.

What kind of frequency response a microphone should have depends on its application and the personal taste of the users. There is no such thing as an ideal frequency response for a particular microphone. For a precise, accurate, lifelike studio recording, a microphone with an extremely flat frequency response might be desirable. For most sound reinforcement and other vocal-oriented applications, however, a presence boost in the upper mid-range and rolloff on the low end adds clarity, brilliance and intelligibility, and helps alleviate *proximity effect* (the tendency of a unidirectional microphone's bass response to increase as the sound source gets closer to the microphone element).

When selecting a microphone for broadcast applications, it's best to closely examine the application and the environment in which the microphone will be used. Will the microphone be used up close? Consider proximity effect. What kind of voice does the user have? A person with a low voice might prefer a high-end presence boost; someone with a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high-pitched voice might prefer a flat response. Will the microphone be worn on the chest? Some microphones' frequency responses are specially tailored to compensate for *chest resonance*. Also, think about the kind of room or enclosure in which the microphone will be used.

There are a lot of variables to consider, but in the final analysis, the best judge of the right microphone is a trained ear.

Other considerations

Other microphone specifications that should be considered when selecting a particular model for a particular job include sensitivity (the voltage or power output level of a microphone as a function of the sound-pressure level applied), impedance rating (which tells the user whether the microphone is compatible with other equipment), polarity and power requirements.

Microphone specifications that may be critical to a broadcast application include hum and RFI pickup, output noise, clipping level, maximum sound-pressure level (SPL) and signal-to-noise (S/N). The *hum pickup* (or hum sensitivity) describes the microphone's susceptibility to stray electromagnetic fields from fluorescent lights, motors, power transformers and other ac sources. The measurement usually is given in equivalent SPL for a specified hum field strength. The *RFI sensitivity* of a microphone, although not usually specified, is a measurement of the susceptibility of the unit to radio frequency interference. In general, condenser microphones are more at risk than dynamics, but any application in an area of strong radio or TV signals requires minimum RFI sensitivity.

The *output noise* of a dynamic microphone is a function of its actual impedance, because a dynamic microphone is a passive (non-powered) device. In practice, the noise figure for a dynamic microphone is never quoted. For condenser microphones, however, the output noise is an important and measurable quantity. Because the condenser microphone is an active device, its internal circuitry produces a finite amount of electrical noise. This measurement usually is given in equivalent SPL with a specified weighting curve that relates the noise to its perceived loudness by the human ear. The lower the noise figure, the better.

The output *clipping level* of a microphone is its maximum electrical output (in volts or decibels) before significant distortion is produced. It is usually given at some specified load impedance(s) together with the minimum recommended load impedance. Again, this figure is quoted only for condenser microphones, because it is a function of the active circuitry in the device. The maximum output level of a microphone is affected by the input impedance of the associated equipment.

Maximum SPL (given in decibels at one or more load impedances) refers to the loudest sound the microphone can take before distortion occurs. Once again, this is always specified for condenser microphones and almost never for dynamics. The limitations in the condenser microphones are the internal circuits and, in some cases, the condenser element itself. Dynamic microphones have no active internal circuitry to overload, and dynamic elements are generally capable of withstanding much higher sound-pressure levels without damage or distortion.

The microphone's S/N is the difference (in decibels) between the residual output noise of the microphone and the output level of the microphone at some specified input SPL (usually 94dB). This specification applies only to condenser microphones because of their inherent output noise and maximum output level limitations.

It's obvious that a lot of variables are involved in the microphone's task of changing acoustical energy to electrical energy. Fortunately, the variety of microphones available is so vast that you can find a suitable one for just about any application.

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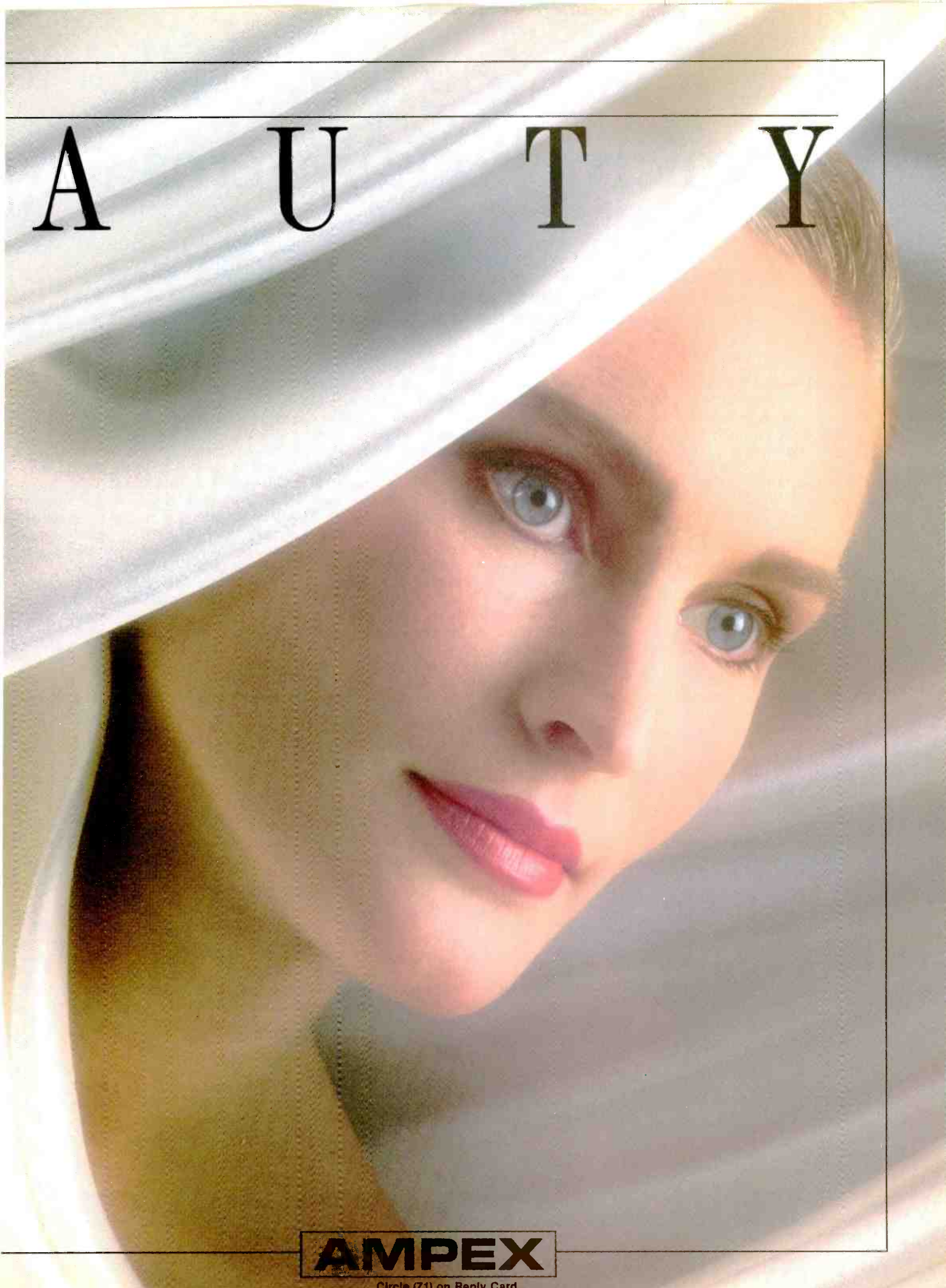

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Planning wireless microphone systems

By H.Y. Miyahira
and Donald A. Kutz

Wireless microphones are useful devices, but you have to do a lot of planning in order to avoid trouble.

Technological advances of the late 1960s have tremendously affected both the size and performance of wireless mics. Until the mid-60s, wireless mics were large and used miniature vacuum tubes, offering limited dynamic range and poor audio quality. The advent of semiconductor technology in the late 1960s eliminated many problems.

In the early 1970s, the integrated circuit compandor was introduced and was incorporated into the wireless mic. At about the same time, the FCC authorized the use of frequencies in TV channels 7 through 13 for wireless mic use. Thus, the wireless mic's most serious problem—radio interference from other services—was virtually eliminated. Diversity reception was developed, which minimized dropout and greatly improved transmission reliability.

Today's wireless microphones provide quality and reliable operation. They are small, lightweight and rugged. (See Figure 1.) Even so, wireless mics are prone to pitfalls, most of which can be eliminated by careful planning.

Radio frequencies

There are no international standards for wireless mic radio frequency allocations or performance standards, such as transmitter power limits, frequency stability or RF bandwidth. The frequency bands typically used for wireless microphone systems are shown in Figure 2.

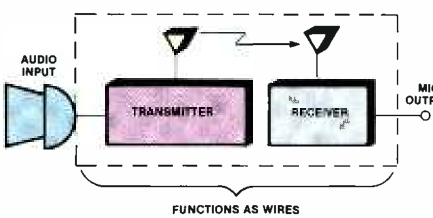


Figure 1. Block diagram of a wireless microphone.

Miyahira is president of HM Electronics, San Diego. Kutz is vice president of operations for HM Electronics.

The FCC regulates the operation of wireless mics in the United States, under the following rules (see Figure 3):

Part 15, Subpart D, allows low-power communication devices to operate in the 49.81MHz to 49.90MHz band. Power is limited to 10,000μV/m (approximately 1mW to 5mW) radiation at a 3-meter distance and a 5kHz audio frequency limit. This RF spectrum segment is susceptible to high levels of manmade noise. This noise is typically generated by auto ignition, fluorescent lights and dimmers. The band's low-power restriction imposed by the FCC only aggravates the problem. Also, because these frequencies are evenly spaced 15kHz apart, only three wireless mics can operate simultaneously without RF intermodulation products causing interference.

Part 15, Subpart E, allows wireless mics to operate in the commercial FM broadcasting band with only 50μV/m radiation at 15m. With this power restriction, it is not practical to use this band for professional applications in which reliable transmission performance is needed.

Part 90 allows wireless mics to operate on a shared basis with business radio services. Continuous radio transmission is authorized if the transmitter power is limited to 120mW. This is a significant improvement over the limitations of Part 15. The business radio service frequencies for wireless mics are: 30.76MHz to 43MHz (VHF lowband), 150MHz to 173.4MHz (VHF highband), 457MHz to 470MHz (UHF lowband) and 806MHz to 866MHz (UHF highband).

More recently, the FCC authorized the use of frequencies between 169MHz and 171MHz on a shared basis with other non-government and government operations, but with less susceptibility of interference. These frequencies were formerly reserved for hydrological or meteorological data transmissions.

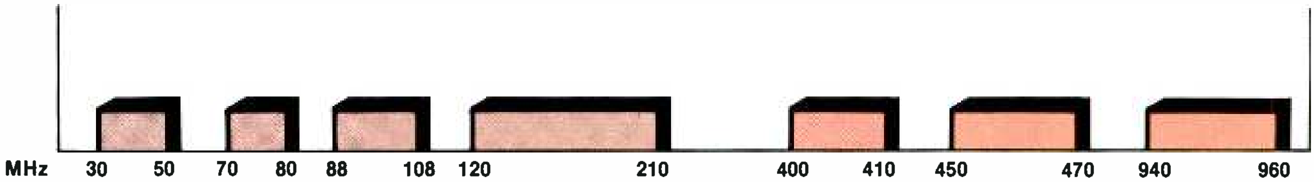
At 150MHz and higher, manmade noise decreases significantly. With the higher power, greater transmission bandwidth, many more available frequencies and the shorter antenna requirements, operation in the VHF highband (and higher) is more desirable than operation at lower frequencies. The major disadvantage with operation under Part 90 is interference from other business radio services, except for the limited frequencies formerly assigned to hydrological services. Station operating licenses are required and the transmitter must be FCC type accepted.

Part 74 restricts wireless mic use to broadcast, video production and filmmaking applications. Wireless mics can operate in the 174MHz to 216MHz range (TV channels 7 through 13) on a non-interference basis. This means that, for a given location, wireless mics can operate on unused TV channels. Transmitter power is limited to 50mW. Station operating licenses are required for broadcasters and filmmakers, and the transmitter must be FCC type accepted. VHF highband operation under Part 74 offers the best operating area for wireless mics.

RF frequency characteristics

The free-space transmission loss between a transmitter and a receiver with

Figure 2. International frequency allocation for wireless microphone systems.



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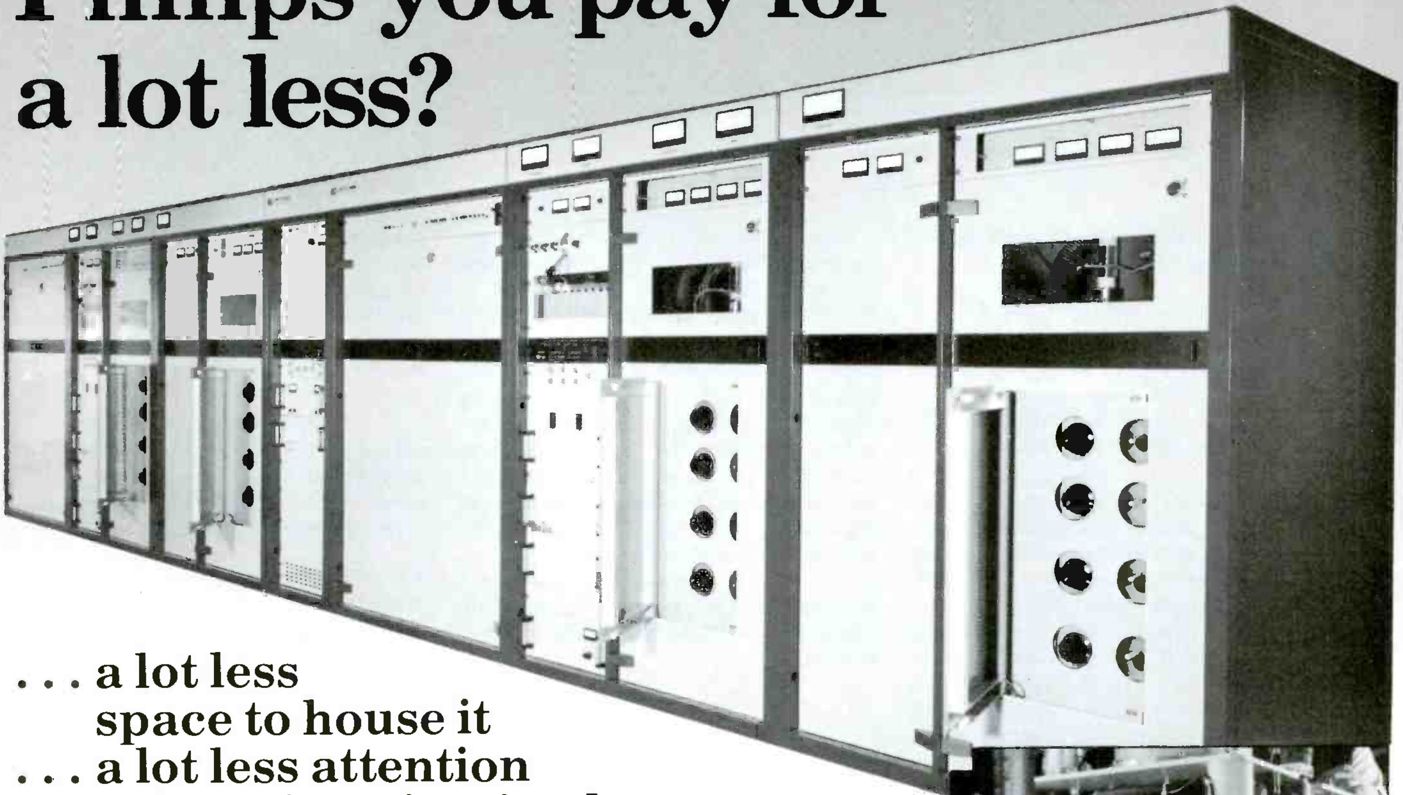

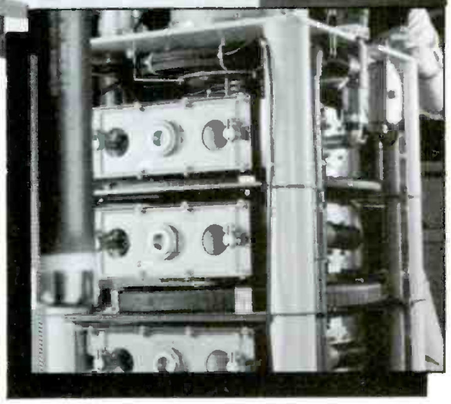

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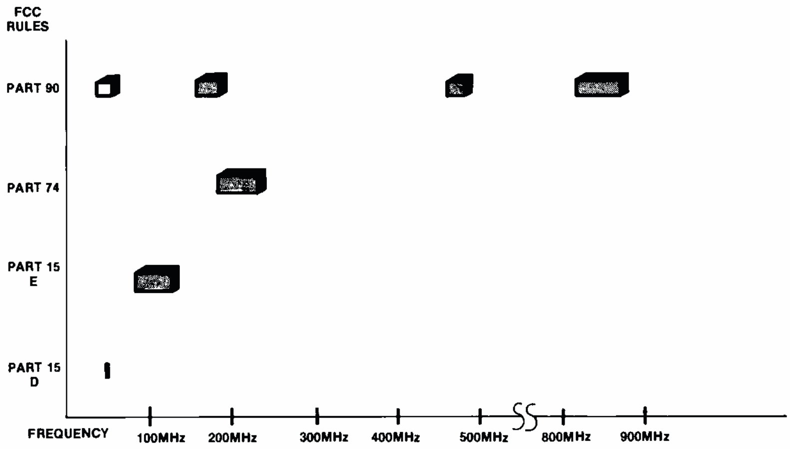

Figure 3. *Wireless microphone frequency bands for the United States.*

an isotropic antenna can be computed by the following equation:

$$\propto = -37.85 + 20 \log F + 20 \log D$$

Where: $\propto$ = space transmission loss in decibels
F = frequency in megahertz
D = distance in feet

This equation clearly shows that less transmitter power is required for an equivalent signal strength at the receiver as the frequency is lowered. A major difficulty for wireless microphone manufacturers is the design of efficient antennas for lowband VHF operation. However, at highband VHF, efficient radiators are quite practical. Consequently, the 150MHz to 216MHz band is usually more desirable than the UHF band.

Manmade noise decreases with increasing frequency, becoming asymptotic to galactic noise near 400MHz. Above 150MHz, manmade noise is not a serious problem for most applications.

Interference from other radio services is the major problem at both VHF and UHF. The only clear channels available are the unused local TV channels. For remote applications, this becomes a problem because a clear TV channel in one city may not be clear in another. Traveling groups, therefore, use the former hydrological frequencies as the best alternative.

Dropouts

A wireless mic transmitter radiates power in many directions simultaneously. The exact pattern depends on the specific mechanical configuration of the antenna system. The power (P_r) received at the receiver antenna is:

$$P_r = \frac{P_t A_{ra}}{4 \pi D^2_{tr}}$$

Where: P_t = Power transmitter
A_{ra} = Area of receiver antenna
D_{tr} = Distance from transmitter to receiver

This relationship is important to understanding the practical solutions and limitations that must be considered in any FM wireless mic system. Not all of the power (P_t) transmitted will reach the receiver. Transmission efficiency is also degraded by path losses from interfering objects (such as people and other equipment) between the transmitter and receiver, the transmitter antenna polarization and interfering signals from multipath reflections. These three elements affect the total power P_r received at the antenna A_{ra}. The total algebraic sum of these signals must be considered and the power at the receiver now becomes:

$$P_r = \frac{P_t A_{ra}}{4\pi D_k^2} + P_t \left(\sum_{k=1}^{n} L_k^{j\theta_k} \right)$$

Where: n = number of paths considered
L_k = amplitude of the K^{th} signal
θ_k = phase of the K^{th} signal

Note that the second term on the right side of the equation could be net positive or negative, depending on the relative amplitudes and phases of the signals arriving at the receiver via various paths.

The loss of reception at the wireless mic receiver is usually referred to as a *dropout.* This dropout is caused by several factors. If a transmitter is, for example, too far from the receiver, increasing P_t can help, but battery consumption and FCC regulations must be considered. The A_{ra} can be increased, but physical limitations and cost must be weighed.

Most dropouts are caused by multipath cancellations. Multipath occurs when the transmitted signal takes more than one path to the receiver. Several paths can occur when the environment in which the wireless microphone is operating contains metal or objects that reflect radio signals. In TV studios, multipath can be caused by cameras, lighting equipment or scenery. Due to the arriving signal's phase differentials, the resultant signal can be enhanced or totally canceled, thus creating *multipath dropouts.* One technique that is useful in minimizing multipath dropouts is *true diversity reception.*

True diversity reception

True diversity reception requires two or more receiving antenna systems. The conditions required to take advantage of diversity reception include:

- a single transmitter source,
- uncorrelated, statistically independent signals and
- multiple receiving antenna systems.

The success of any true diversity reception system depends on the degree to which the independently received signals are uncorrelated. If a true diversity reception system cannot produce uncorrelated, statistically independent signals, then a diversity reception system does not exist. The block diagram of a basic true diversity reception system is shown in Figure 4.

A single transmitter generates signals over paths D_{tr1} and D_{trn} that arrive at the diversity receiver for processing. A true diversity reception system can be implemented in many ways, but all systems

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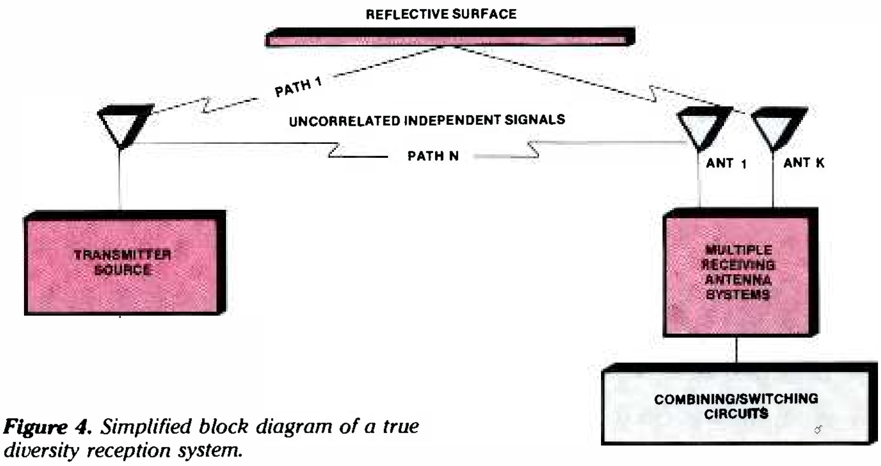

Figure 4. *Simplified block diagram of a true diversity reception system.*

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combine the received independent signals in some method. The particular combining technique chosen is based on cost and the degree of improvement required. The less predictable or less closely related the signals over paths D_{r1} to D_{rn}, the more significant the benefits provided by the diversity system.

Diversity classifications

True diversity reception techniques are classified by the method of processing and extracting the uncorrelated statistically independent signals. Common classifications for true diversity systems are outlined in Table 1.

The technique most commonly used for wireless microphones is *space diversity*. Space diversity can be implemented in many different ways, but the three basic requirements of diversity reception mentioned earlier must still be satisfied.

Polarization diversity is a special case of space diversity. Here, the receiving antennas must be orthogonally located in order to capture the uncorrelated independent signals.

For space diversity systems, two or more receiving antennas are required and they must be located at least ½-wavelength apart. The amount of separation determines the degree of the uncorrelated signals. Each antenna in the array provides an independent path that is combined to produce the desired signal improvement.

TRUE DIVERSITY CLASSIFICATION	DIVERSITY RECEPTION	TECHNIQUE
SPACE	X	SPATIALLY SEPARATED ANTENNA
POLARIZATION	X	ORTHOGONAL ANTENNAS

Table 1. *Classifications of true diversity receiving systems.*

Combining methods

The various combining methods for processing the independent signals are shown in Table 2. *Selection combining* results in switching to the incoming signal with the best signal-to-noise ratio. Figure 5 depicts a selection diversity combiner that can be used either before or after audio detection.

In *maximal ratio combining*, the input signals are weighted proportionately to their carrier S/N power ratios and then summed. The input signals must, therefore, be co-phased. A modification of this approach is *equal gain combining*,

COMBINING METHOD	TECHNIQUE
SELECTION (ALSO REFERRED TO AS SWITCHING OR OPTIMAL SWITCHING)	SWITCHES TO OPTIMUM INPUT
MAXIMAL RATIO (ALSO REFERRED TO AS VARIABLE GAIN)	ADDS SIGNALS WITH VARIABLE GAIN AMPLIFIERS
EQUAL GAIN (ALSO REFERRED TO AS LINEAR ADDER)	ADDS SIGNALS LINEARLY

Table 2. *Combining methods for processing signals of a diversity receiving system.*

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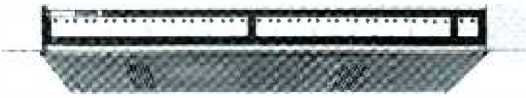

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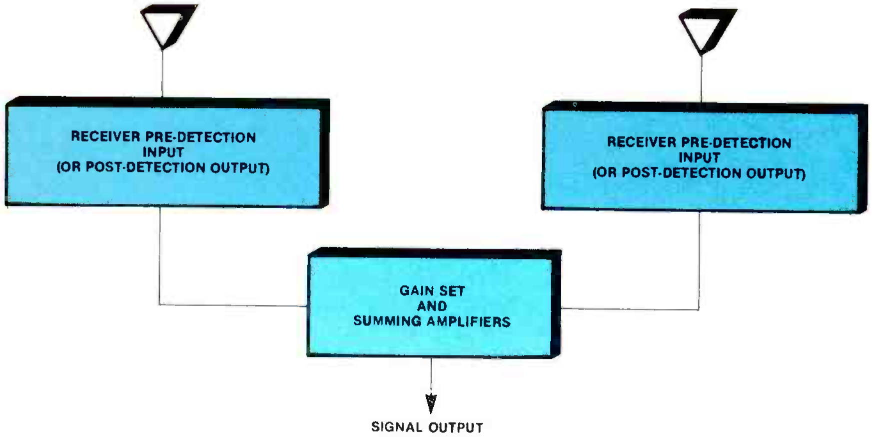

Figure 5. *Block diagram of a selection diversity system.*

in which all inputs are set equal to a constant unity value. A comparison of the combining methods and relative improvements are shown in Figure 6. Figure 7 is a block diagram for a system that allows either maximal ratio or equal gain combining.

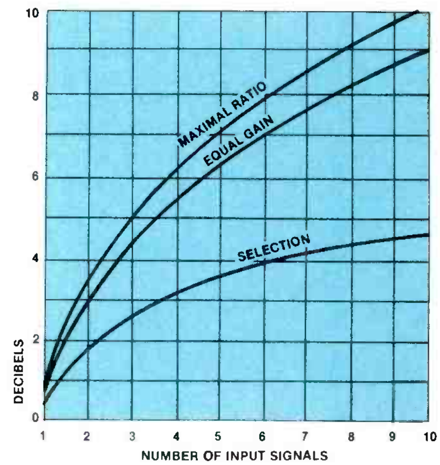

Figure 6. *Comparison of the predicted S/N improvement for three combining methods.*

Clearly, the maximal ratio combining method offers the best possibility for improvement over a non-diversity system. Unfortunately, it is also the most difficult to implement. Wireless mics typically use selection and equal gain combining diversity. The choice is based on reducing the probability of dropouts. Any of the combining techniques can be implemented in the receiver in pre- or post-detection. A comparison of the advantages and disadvantages of various combining methods is shown in Table 3.

Compandors

The audio compandor developed from the telephone industry's need to improve long-distance cable communications. First used in the New York/London radio circuit in 1932, the compandor provided a great improvement in signal quality and helped overcome the problems of static and limited dynamic range. The Bell System first used compandors on a wire line in 1941, further improving telephone transmission quality.

A compandor is a 2-part system consisting of a *compressor* that reduces the audio range by providing more gain to weak signals, and an *expander* that restores the signal back to its original dynamic range ratio. The degree to which the audio energy is compressed and expanded is referred to as the *compression ratio.* Wireless mics typically use a 2:1 compression ratio. Figure 8 shows how various audio signal levels might be processed by a compandor with a 2:1 compression ratio.

Audio compandors are available with variable gain amplifiers that respond to changing input levels. With these devices, a dynamic range of 100dB or more can be achieved. Without a compandor, a wireless mic is subject to noise

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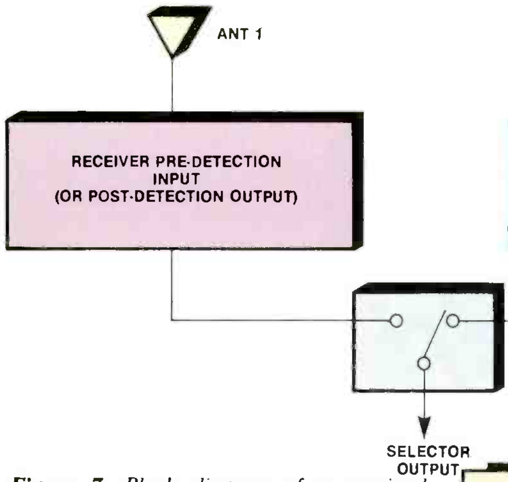


Figure 7. *Block diagram of a maximal ratio/equal gain wireless microphone system.*

from its transmission medium and the audio is seldom acceptable for most professional applications.

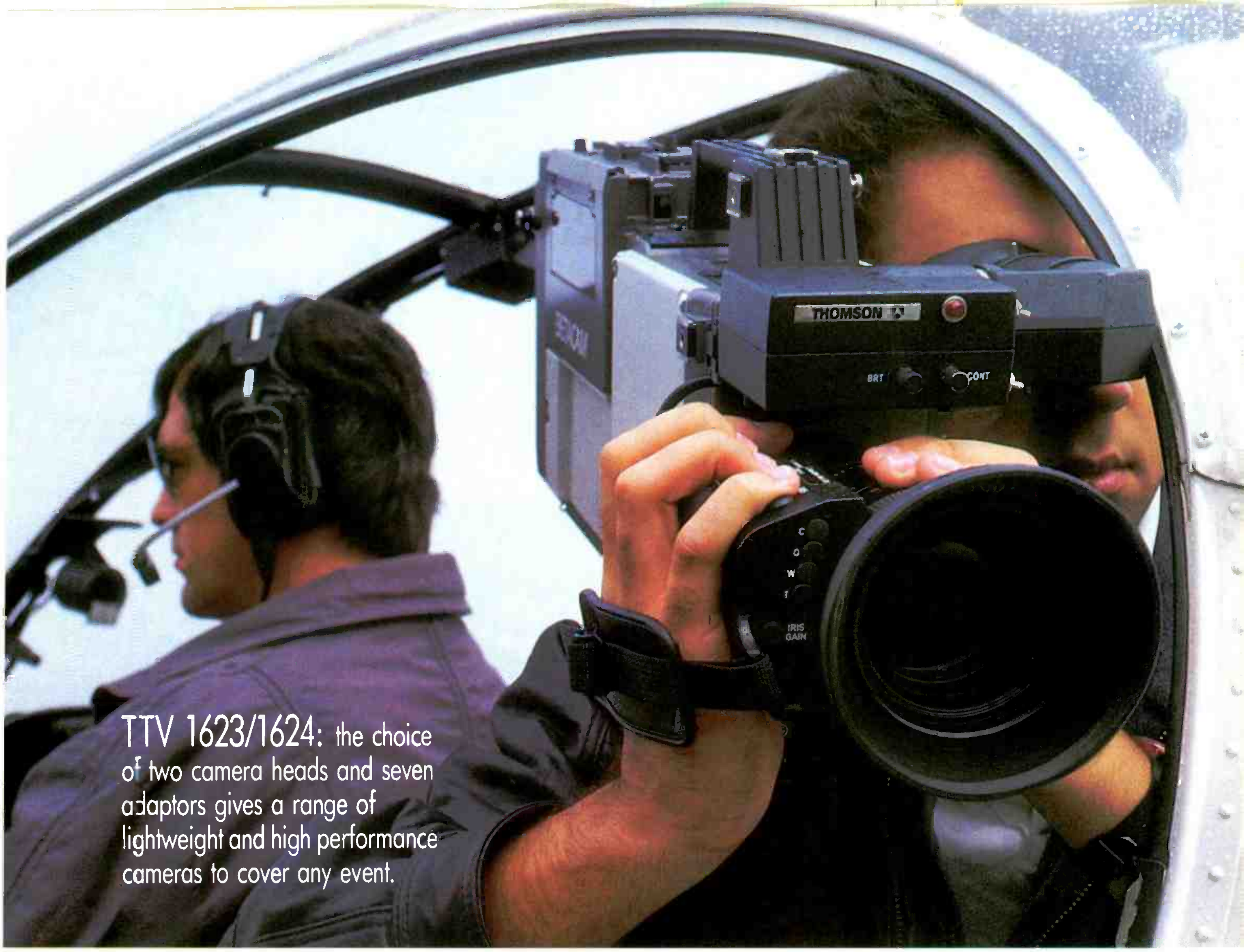
Compandor systems are subject to phenomena known as *breathing* and *pumping*. Breathing occurs with the release of gain adjustment as it returns to normal. Pumping is associated with the attack on the gain. Both occur when the expansion circuit mistracks the compression circuit. The result is signal expansion that is either greater than or less than the original compression along with unmatched time constants.

Pre-emphasis networks (similar to those for FM) are used to further improve the transmitted signal. The combinations of pre-emphasis and companding usually result in a better-performing system.

Some wireless mic systems use a limiter to prevent distorted signals. Although this approach may be useful, it is seldom sufficient for professional applications. With this design, the limiter limits the peak input signal without distortion from 30dB to 40dB. This means a source with 100dB dynamic range can be transmitted over the radio system with 60dB, undistorted. Obviously, 40dB of dynamic range is lost.

COMBINER	ADVANTAGES	DISADVANTAGES
SELECTION	•NO CO-PHASING REQUIRED	•SWITCHING TRANSIENTS POSSIBLE •HIGH COST WHEN IMPLEMENTED IN POST-DETECTION
MAXIMAL RATIO	•BEST IMPROVEMENT IN S/N	•COST AND COMPLEXITY
EQUAL GAIN	•IMPROVEMENT IN S/N •LOW COST	•CO-PHASING REQUIRED FOR OPTIMUM PERFORMANCE

Table 3. *Comparison of advantages and disadvantages of combiner methods.*



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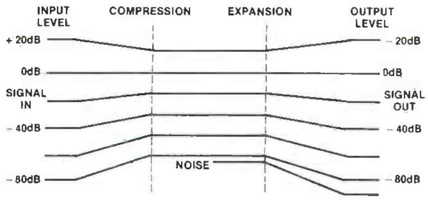

Figure 8. *Gain level chart for a 2:1 audio companding system.*

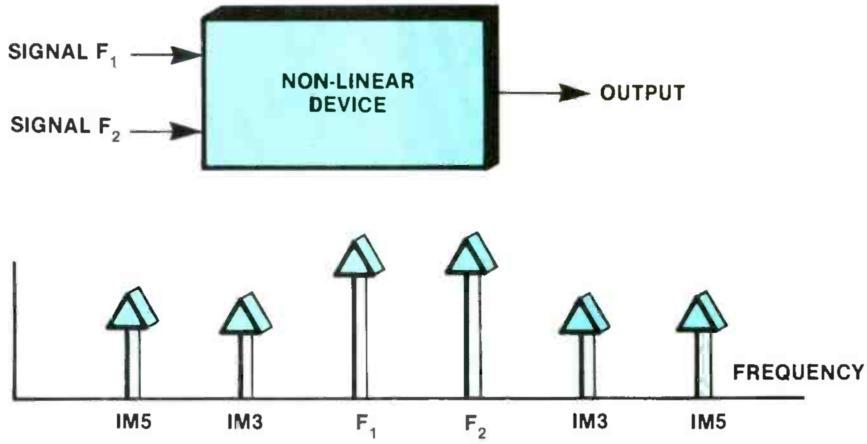

Figure 9. *Intermodulation is produced when two or more signals combine in a non-linear device.*

Multiple microphone systems

When using multiple wireless mics, consider the interference from other sources. These sources can include:

- transmitter spurs,
- transmitter and receiver intermodulation and
- splatter.

The FCC requires that all wireless microphone transmitters conform to the following limitation:

$$\text{Maximum spurs (dB)} = -43\text{dB} - 10\log\frac{P_t}{1\text{W}}$$

Although an individual transmitter should conform to these specs, its performance may not be adequate when six to eight wireless microphones are operating together. Spurious signals are generated within the transmitter by mixing together the various signals created in multiplying the crystal oscillator frequency up to the carrier frequency. These mixing products, if they fall within the bandwidth of the receiver, will be heard as *birdies* or *squeals*. These spurious transmitter outputs are discrete spectral signals and usually cannot be easily removed. The higher the multiplication factor used to generate the carrier, the more numerous the spurs can become.

Intermodulation

Transmitter intermodulation, or IM, can occur when a carrier frequency from one source is coupled into the output stage of another transmitter. These two signals may combine in various ways, creating additional RF signals. Typically, if the output transistor operates non-linearly, the two signals can create a series of mixing products as shown in Figure 9.

The transmitted IM products may overload the receiver. If the receiver can't eliminate the interfering signals, the result may be the creation of squeals, birdies and an overall sensitivity degradation. These IM products can also be generated in the front end of the receiver. This may occur if the local oscillator signal leaks into the antenna.

When operating multiple wireless microphones, you can help identify the po-

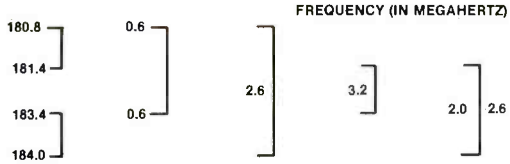

Figure 10. A sample calculation of IM compatibility for an event using four wireless microphones.

tential for IM through a simple calculation. First, list all the mic channel frequencies. Then calculate the differences between the carrier frequencies. If any two differences are the same or within 0.1MHz, IM may become a problem.

Figure 10 illustrates this process. The four frequencies are not compatible because there is a difference of only 0.6 and 2.6, respectively. Spurious signals, IF offsets and any known discrete frequencies in the environment also should be considered. A simple computer program lets you make the calculation quickly and accurately.

Evaluating wireless microphones

Published specifications have limited value in evaluating wireless mic performance. Depending on the manufacturer, specifications may be exaggerated or have qualified conditions that may not be appropriate for your application. Because RF power output is limited by the FCC, most systems operating in the same band provide comparable transmission range. However, other parameters more critical to performance and reliability should be examined carefully.

The following tests may prove useful as you evaluate different wireless microphone systems:

A-B test

Using a wired mic with an element or model number identical to your wireless mic's, feed both mic outputs into an A-B switch. If an A-B switch is not available, feed both mics into a mixer. Now test for:

- *Frequency response.* Both mics should sound identical, with one not brighter or duller than the other. The wireless mic should not sound better, but the same as the wired mic.
- *Gain.* Output levels should be nearly identical.
- *Phase.* With both mics placed near each other, a properly phased wireless mic will not show any cancellation.
- *Dynamic range.* Shout into the mic. Listen for distortion at high levels. Note any pumping and breathing action or other compandor characteristics.
- *Noise floor.* With the mixer gain for each mic set about equal, listen for overall noise floor differences.

RF test

Set the receiver squelch for normal quieting. Remove the transmitter antenna, if possible, to induce dropout. Listen for the squelch action when dropout occurs. A well-designed wireless mic will minimize the annoying sound of a dropout.

If an RF spectrum analyzer is available, check the transmitter spectral purity. A well-designed and properly aligned transmitter should not have any spurious signals within 15MHz of the carrier. This aspect is especially important in multiple wireless mic system installations.

If an RF signal generator is available, apply the generator output to the receiver input to determine receiver sensitivity. Next, offset the generator frequency by a few kilohertz to simulate transmitter carrier shift due to aging or temperature. Most manufacturers specify $\pm 0.005\%$ frequency stability. At VHF highband, this is approximately ± 8kHz to ± 10kHz.

Now apply a test tone to the signal generator and measure distortion. A high distortion level may indicate a narrowband or misaligned receiver.

A wireless mic cannot be better than, but only as good as, a wired version of the same type. Because wireless mics are sophisticated radio systems as well as audio systems, special care must be taken in setup. A thorough understanding of the system's features and limitations also is helpful.

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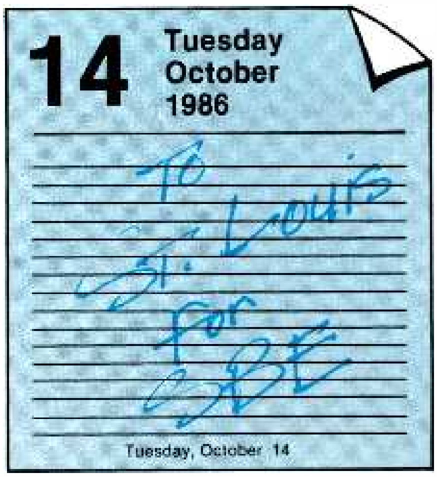


SBE convention to be showcase of activities

By Brad Dick, radio technical editor

The Society of Broadcast Engineers (SBE) will hold its first national convention Oct. 14 to 16 at the St. Louis Convention Center. The event will be a showcase for society activities and will launch the SBE into a new level of visibility in the broadcast community. The SBE regional conventions will continue to be an important element of society activities, but the October gathering will provide a central focus for the national organization.

The convention, directed toward the needs of broadcast engineers, will consist of two primary elements: a large exhibition of broadcast equipment and a hands-on technical conference. The exhibition will be comprised of about 225 booths with more than 110 equipment manufacturers in attendance. Because of the emphasis on engineering (rather than programming and management), many booths are being planned with the working engineer in mind. Attendees are assured of having ample opportunity to discuss equipment operation and application during the show.

Engineering conference

The **Broadcast Engineering** technical conference is being arranged by John Battison, well known through his work at the annual WOSU conferences. The technical sessions will cover topics ranging from new FCC radiation standards to folded monopole antennas. The conference will feature a balance between radio and TV sessions. In response to many requests, the hot new topic of zero setup for TV systems has been added to the conference. A special presentation on zero setup has been scheduled for Wednesday, Oct. 15, at 3 p.m. Engineers concerned about setup procedures for new equipment will want to attend.

The Wednesday luncheon will be a highlight of the conference. The featured speaker will be Tom Keller, vice president for engineering at the NAB. Also appearing will be Jim McKinney, chief of the FCC's Mass Media Bureau. McKinney will host a short question-and-answer session after the luncheon.

At the luncheon, Richard Rudman, SBE president, will present the first SBE Industry Award. The award recognizes an individual who has made a special contribution to the broadcast industry. The late Harold Ennes is the recipient of the 1986 SBE Industry Award, which will be accepted by his wife, Mary Lou Ennes. As most broadcast engineers know, Ennes—a long-time advocate for technical training—wrote many technical books, some of which were directed specifically at the special needs of broadcast engineers. The award is the highest industry honor SBE confers.

The **Broadcast Engineering** conference will run for three days, opening on Oct. 14, one day before the exhibits open. This will give attendees an opportunity to zero in on sessions of special importance to them. The convention center exhibit floor will be open on Wednesday, Oct. 15, from 9 a.m. until 6 p.m. and on Thursday from 9 a.m. until 3 p.m.

The 1986 SBE National Convention and **Broadcast Engineering** Conference will continue the tradition of the Central States regional convention of free admission to the exhibit hall. In order to cover expenses, a nominal registration fee will be charged for admittance to the engineering sessions. The fee has been set at $25 and will be used to cover the costs of organizing the program. An additional fee of $10 will be charged to those who wish to attend the luncheon on Wednesday, Oct. 15. Because this luncheon will be the centerpiece of the convention, interest is expected to be high.

Related events

The social aspects of the SBE's first national convention also are important. Several local SBE chapters have organized car caravans for travel to St. Louis. By car-pooling, the cost of getting to the convention can be made quite reasonable. At least one SBE chapter has chartered a bus.

Discount air fares are available on TWA from Apex Travel in St. Louis. Special 40% discounted fares can be obtained through Apex if you tell the operator you want the SBE discount. The SBE profile number for the special rates is 99-10405. To qualify for the rates, you must make your reservations through Apex Travel. Call 800-325-4933. Inside Missouri, call 800-392-1474. Discount rates also are available from both the St. Louis Sheraton and Radisson hotels.

The SBE will be holding several meetings in conjunction with the convention. In addition to the annual membership meeting that will take place on Tuesday at 5 p.m., chairmen, board of directors and past presidents meetings will be held.

A ham radio operator reception will be held immediately after the Tuesday annual membership meeting. The reception begins at 6 p.m. and will include a cash bar and door prizes. All amateur radio operators will want to attend.

A Wednesday evening reception, hosted by SBE, will allow everyone to

Broadcast Engineering

Technical Sessions Schedule

Tuesday, October 14

- 9:30 a.m. Continental breakfast
- 10 a.m. Opening remarks, John H. Battison, conference chairman
  Welcome, Richard Rudman, SBE president
- 10:30 a.m. New FCC/FAA tower marking and lighting rules, Lew Wetzel, Flash Technology
- 11:05 a.m. The travelers information service, Richard Crompton, LPB
- 11:40 a.m. Audio specifications—what do they really mean? Irv Joel, Irv Joel and Associates, consulting engineers
- 12:30 p.m. Lunch
- 1:30 p.m. The FCC answers back, John Reiser, FCC
- 2:45 p.m. Coffee break
- 3 p.m. Consultants round table, moderator, John H. Battison; panelists: Don Markley, John F.X. Browne, Lawrence Behr, Wally Johnson and Irv Joel
- 4 p.m. Engineering management
- 5 p.m. SBE national membership meeting
- 6 p.m. Ham radio reception

Wednesday, October 15

Radio sessions

- 8 a.m. Continental breakfast
- 8:30 a.m. The care and feeding of folded monopole antennas, Lawrence Behr, consulting radio engineers
- 9:05 a.m. Fine-tuning FM final stages, Geoffrey Mendenhall, Broadcast Electronics
- 9:40 a.m. Tuning and adjusting pulse-modulated transmitters for optimum performance, David Chenowith, Continental Electronics
- 10:15 a.m. Coffee break
- 10:30 a.m. Grounding to eliminate hum and RFI, L. Scott Hochberg, Logitek
- 11:05 a.m. Synchronizing AM transmitters, Oscar Reed, PE, consulting radio engineer
- 11:40 a.m. Digital audio basics, John Woram, Digital Audio Reports

TV sessions

- 8 a.m. Continental breakfast
- 8:30 a.m. Switchless RF combiner for TV, Greg Best, Harris
- 9:05 a.m. Recent developments in klystron technology, including practical applications, Nick Ostroff, Comark
- 9:40 a.m. A review of videotape formats, Jerry Bauman, 3M
- 10:15 a.m. Coffee break
- 10:30 a.m. Tuning and adjusting TV antennas with a spectrum analyzer, Don Markley, PE, consulting engineer
- 11:05 a.m. Stereo TV measurement techniques, Mike Coleman, Tektronix
- 11:40 a.m. Enhanced NTSC transmission and spectrum sharing with the land mobile service, John F.X. Browne, P.E. consulting engineer
- 3 p.m. Zero setup for video

Joint sessions

- 12:30 p.m. Tom Keller, NAB, and Jim McKinney, FCC, will speak at TV/radio luncheon
- 2 p.m. Question/answer session with Jim McKinney
- 5 p.m. SBE chapter chairmen's meeting
- 7 p.m. SBE reception

Thursday, October 16

- 8 a.m. Continental breakfast
- 8:30 a.m. Transformer rewinding techniques, Peter Dahl, Dahl Transformer Company
- 9:05 a.m. RF radiation and the broadcaster, Richard Tell, EPA
- 9:40 a.m. FM allocations and application processing, Harry C. Martin, attorney
- 10:15 a.m. Coffee break
- 10:30 a.m. The effect of antenna bay spacing on downward radiation, Robert Surette and Peter S. Hayes, Shively Labs
- 11:05 a.m. A variable-speed CD player, Bill Sacks, Straight Wire Audio
- 11:40 a.m. Computerized engineering information, Robert Kircher, Dataworld
- 12:30 p.m. Conference closing remarks, John H. Battison, conference chairman

gather in a relaxed setting. Scheduled are live band music, dancing, a cash bar and hors d'oeuvres.

Another group also is using the SBE convention as an anchor for its activities. The Community Broadcasters Association (CBA) has decided to hold its meetings in conjunction with the SBE show. The CBA announced its intention to participate with SBE in late July. The addition of the CBA is expected to add several hundred attendees.

The SBE National Convention and **Broadcast Engineering** Conference is ready to go. All indications point to a successful program for attendees, exhibitors and the society. See you in St. Louis!

The focus will be on film and TV

By Carl Bentz, TV technical editor

Not everyone who's in New York on Oct. 28 will be there to attend the 100th birthday celebration and rededication of the lady in the harbor. Members of the Society of Motion Picture and Television Engineers will be there for the 128th fall SMPTE technical conference and equipment exhibit, which runs Oct. 24 to Oct. 29 at the Jacob K. Javits Convention Center.

The technical conference and equipment exhibit schedule is unusual this year in that it will begin on a Friday, extend through the weekend and conclude on a Wednesday. Previous conferences always scheduled most activities during the week. The different format should allow attendees additional time and opportunity to take in the exhibits and technical program sessions.

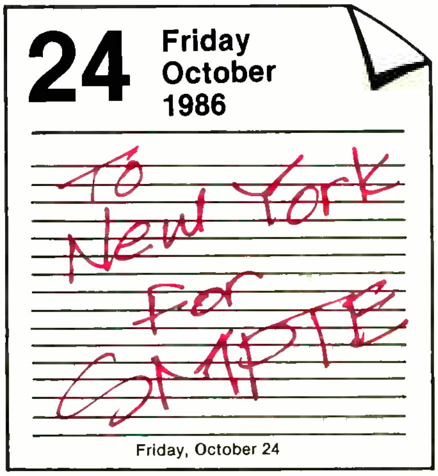
The technical program

Both film and television will be spotlighted during the week. Industry representatives from around the world will attend the program of concurrent sessions for the two imaging technologies. Six general topics form the tentative schedule for film and five topics will fill the TV session slate.

The theme for the conference is *Today's Technology—Tomorrow's Reality?* In answer to that question, a number of papers are being considered for presentation in the sessions.

Unlike previous SMPTE conferences, high-definition television will not play a major role in the technical sessions. Following the failure of the proposed HDTV standard to achieve approval at the CCIR meetings in May, an increased interest in enhanced television can be expected. Some of the presentations will discuss advancements made in video encoding for improved NTSC and PAL imaging. Some papers will investigate high-definition transmission systems that are compatible with existing transmission standards.

Improved definition begins with the TV camera. The CCD as a pickup device, with and without shutter enhancement, and improved pickup tubes should be



topics of interest. Signal processing for effects and system flexibility will involve parallel video-analog components. Special signal amplitude and timing considerations for the growing use of video components will prove valuable for engineers moving into production without subcarriers.

As production equipment becomes more digital in design, the use of computers for processing and system control will become more prevalent. Discussion of computer applications in television

Tentative Conference Schedule

Sunday, October 26
A.M.: Lab practices—film and video, part 1
Computer applications for television
P.M.: Archival film and video
Digital applications for television, part 1

Monday, October 27
A.M.: Lab practices—film and video, part 2
TV sound systems
P.M.: Film and lab technology
Digital applications for television, part 2

Tuesday, October 28
A.M.: Film and video post-production, part 1
Enhancing the theater experience
TV camera systems
P.M.: Film and electronic production, part 1
Enhanced TV systems, part 1

Wednesday, October 29
A.M.: Film and video post-production, part 2
Audio: "Talkies are back"
P.M.: Film and electronic production, part 2
Enhanced TV systems, part 2

will cover some areas in which computer-assisted operations can enhance all aspects of the production. The interest in distribution of data in the studio for equipment control is expanding. Transmission of digital TV signals from the studio to the home via fiber-optics suggests the integration of numerous services in a network-oriented system.

Other presentations that are being considered involve adaptive equalization systems for digital-recording equipment; designing of new camera/battery interfaces; applications for videodiscs; improved VITS generators and inserters; high-performance TV cameras; and high-power solid-state TV transmission equipment. Random-access editing, 3-D imaging, video compositing and sync-pulse generation with logic gate arrays round out the tentative list of TV paper topics that have been received at SMPTE headquarters.

New film technologies and considerations for both low- and high-speed photography will be discussed. Perhaps your interest is in the increased use of electronic cinematography in the film industry or a better understanding of 80-bit SMPTE time code as applied to film. Along the lines of visual presentations will be a film mix theater for video and speaker directivity considerations for any size of motion-picture viewing environment.

In the background

With industry leaders from around the world to be assembled at the convention center, a number of the SMPTE working and study groups will meet to continue developing standards for many aspects of film and television. More information on setup in mixed component/composite video facilities can be expected, along with closer definitions of analog- and digital-component recording systems. Studies of the problems of component distribution in video facilities will continue, but because of the sensitive nature of some of the working and study group discussions, these meetings may not be

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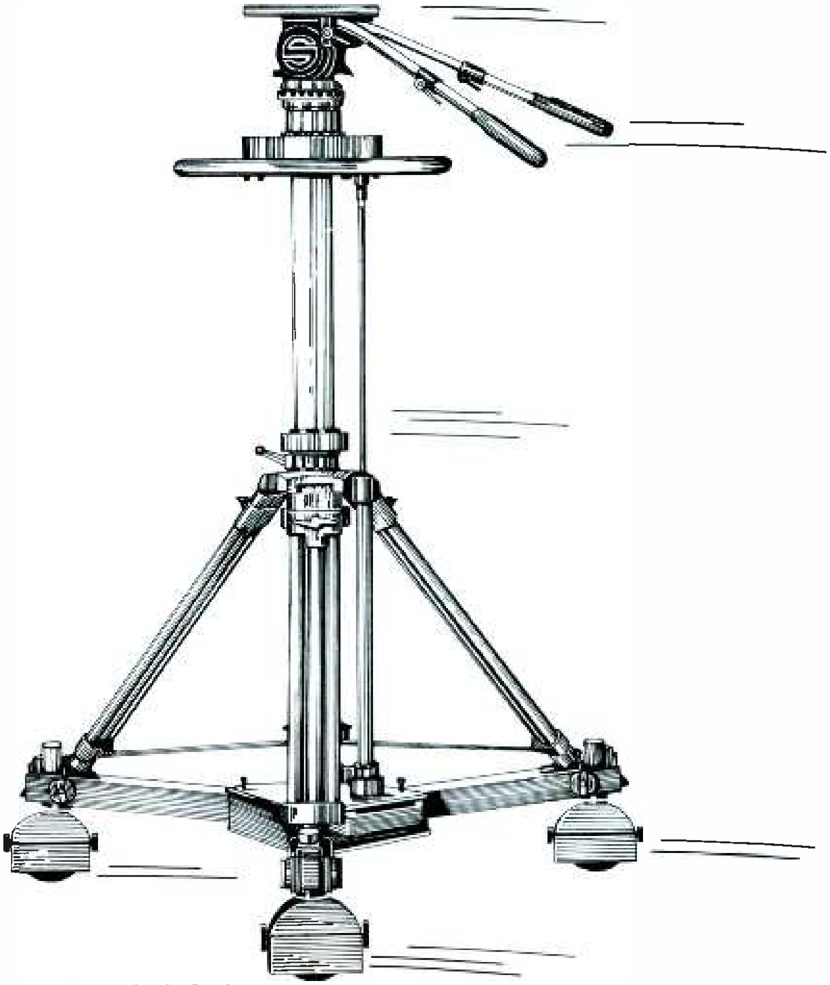

Circle (88) on Reply Card

open for public attendance.

A report on the SMPTE task force that was established in 1985 to study and analyze the society's standards procedures may be forthcoming. The task force consists of legal representatives from manufacturing and broadcasting companies that make up the SMPTE Presidential Advisory Council. One major goal of the group is to determine if more expedient methods are available for standards development.

The special events

The annual Eastman Kodak reception is scheduled for Friday evening. For those who have not attended one of these receptions in the past, be prepared for a pleasant evening and the chance to meet many SMPTE colleagues.

Roland Zavada will be the speaker for the SMPTE Fellows luncheon, Sunday, Oct. 26. He is the recipient of the society's Progress Award in 1985 for his work in developing Super 8, Instamatic and instant photography systems. Zavada has been a key participant in developing test procedures to optimize telecine setups with color films. He also was instrumental in safe action and safe title areas for TV viewfinder and monitor displays. Zavada is responsible for drafting standards proposals for Super 8 for the American National Standards In-

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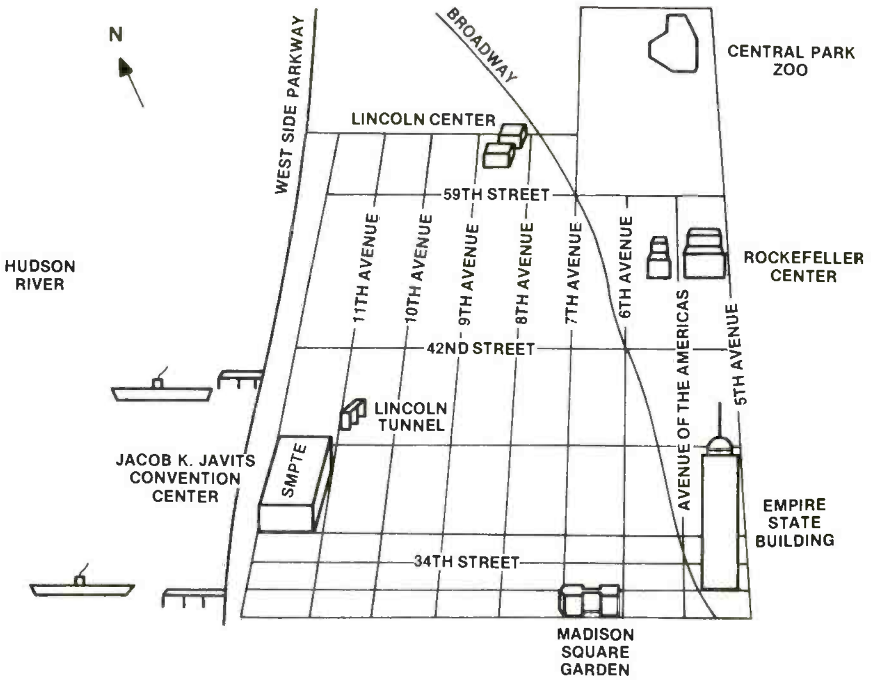
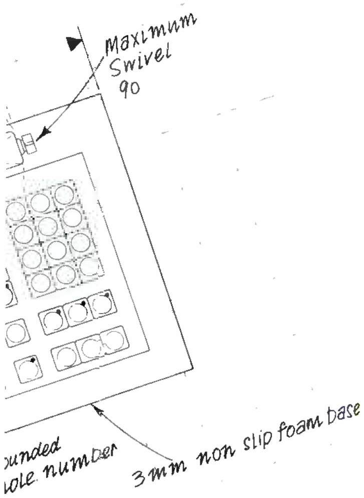
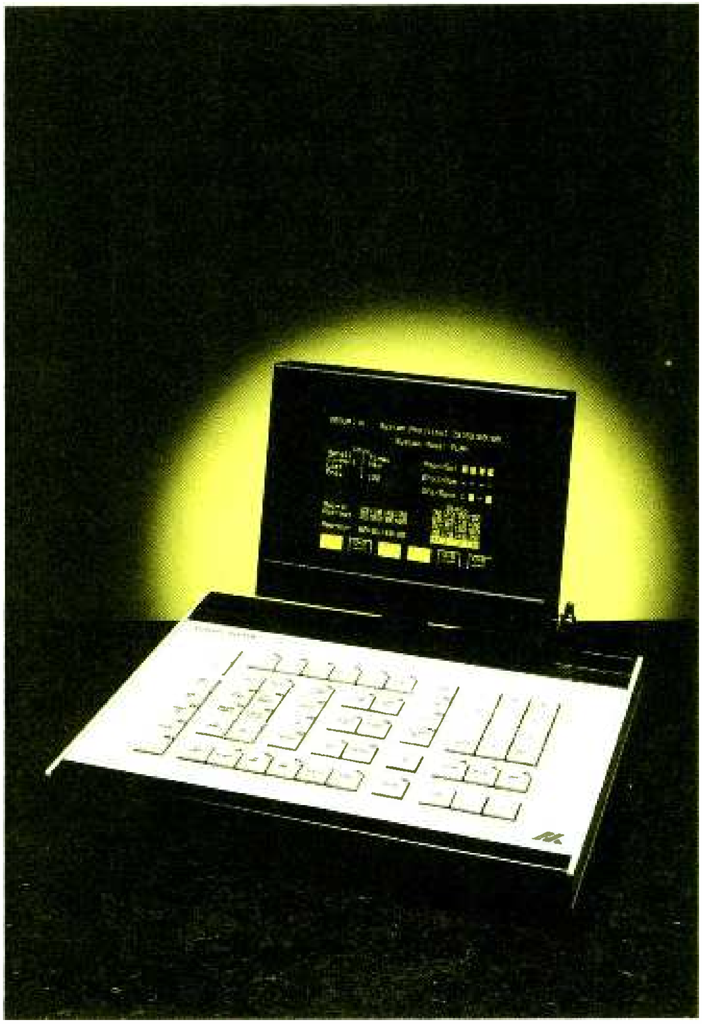


Figure 1. This sketch of a section of Manhattan Island shows some well-known landmarks and the location of the Jacob K. Javits Center.

THE PERFECT ECLIPSE

THE ECLIPSE EDITOR





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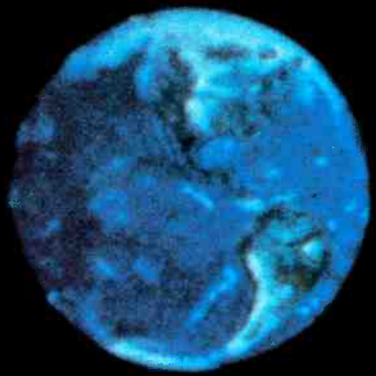

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Continued from page 124

stitute (ANSI) and the International Standards Organization (ISO). He has been a SMPTE member since 1962, and for eight years, served as engineering vice president for the society.

Attendees of the honors and awards luncheon, Monday, Oct. 27, will hear Dr. George H. Brown, a former engineering executive with RCA. During his tenure with RCA, in the era when color TV technology evolved, Brown was responsible for the company's research, engineering, patenting and licensing operations.

The exhibits

The list of equipment manufacturers continues to grow. Unlike past New York SMPTE conferences, this year's event is not confined to hotel ballrooms. Instead, the long-awaited Javits convention facility will play host. Approximately 300 exhibits will take up three halls on Level I. An area of 230,000 square feet has been allocated.

Equipment on display will include many of the latest analog- and digital-component video equipment; audio systems to complement enhanced video technology; and many established audio, video and film products. Plan to spend a good deal of time with the products on display to investigate where the industry is headed.

About New York

Many people attending the conference will be unacquainted with the Jacob K. Javits Convention Center. The center spans the area between 11th and 12th Avenues and 35th to 39th Streets near Manhattan's West Side. The simplified map (see Figure 1) notes several well-known New York landmarks, allowing a better reference to the convention center location.

Although the Javits center is advertised as the most modern facility available, it is not necessarily the most conveniently located for conference-goers. Most of the major hotels are along and east of Broadway, approximately two miles away. As a convenience for attendees, shuttle buses will be provided.

Housing for the conference will involve the New York Hilton, Milford Plaza, Marriott and Sheraton Centre Hotels. Society members will be able to enjoy a reduced convention rate when they return registration material requesting lodging.

For information

To get preregistration information and forms, contact SMPTE at its new location, 595 West Hartsdale Ave., White Plains, NY 10607; telephone 914-761-1100.

For information about New York, contact the New York Convention and Visitors Bureau, Two Columbus Circle, New York, NY 10019.

SBE helps form NFCC

By Bob Van Buhler

The Society of Broadcast Engineers, together with representatives from other major broadcast organizations, formed an industrywide National Frequency Coordinating Council (NFCC) at a July meeting in Washington, DC.

Representatives from ABC, CBS, NBC and Mutual met with trade associations including SBE and RTNDA to hammer out the details of the new organization.

The original plan was to form the NFCC under the auspices of the NAB as secretariat. The NAB seemed to prefer a task force arrangement rather than a formal organization with bylaws. At this writing, the group had not adopted a formal structure.

Some of the key points of agreement related to the policy, status and nature of coordinating at the local level. The council agreed that the key to the whole effort is the local frequency coordinator. The council also realizes that the human element cannot be replaced by a computer database. It takes a person on-site to be able to fully understand the local frequency situation.

Other policy elements included the recognition of the need for a handbook of good engineering practice under Part 74. The publication would illustrate the proper use of ENG and 2-way equipment, the fundamentals of site engineering and microwave and 2-way protocol for semi-technical and non-technical users. NAB expressed some interest in helping prepare this document.

Gerry Dalton, SBE national frequency coordination chairman, participated in the development of a uniform software package. Because of the number of coordinators involved, it's important that a uniform data organization system be used. The software being developed will allow all frequency coordination committees to use a uniform data system, which will make data transfer easier. Although a national frequency database is not yet in the plan, uniform standards may some day make that possible.

An early NFCC goal is the rapid adoption of standardized database management software for the top 25 broadcast markets. With the widespread availability of IBM compatible PCs, the committee feels that uniformity will then eventually follow into most markets. The software should be ready for distribution to local committees by early 1987 or sooner.

The key goal of the NFCC is to provide a unified industry voice on the subject of frequency coordination. If the users are unified on such matters as policy and practice, then the FCC and other broadcast organizations will provide the needed recognition and support.

Van Buhler is chief engineer for WBAL-AM and WIYY-FM, Baltimore.

Special events

Tuesday

5 p.m.	*SBE national membership meeting.*
6 p.m.	*Ham radio reception, with door prizes and cash bar.*

Wednesday

12:30 p.m.	*Luncheon. Speaker will be Tom Keller, NAB. Special guests include Jim McKinney, FCC.*
7 p.m.	*Reception and cash bar.*

National convention

A wide variety of subjects will be covered at the SBE national convention next month in St. Louis. The convention, scheduled for Oct. 14 to 16, will mark the first time the SBE has held its own national convention.

John Battison, technical conference chairman, has provided a schedule that will answer many informational needs for both radio and TV broadcast engineers. Not only will the latest technical topics be discussed, but recent FCC regulations also will be covered.

The Wednesday, Oct. 15, joint radio/TV luncheon speaker will be Tom Keller, senior vice president, science and technology, NAB. A special guest at the convention luncheon will be Jim McKinney, chief of the FCC Mass Media Bureau. A couple of special surprises also are planned for the luncheon. The cost of the luncheon is $10.

An important RF radiation update session will be held on Thursday, Oct. 16. Richard Tell, EPA, will report on the latest RF radiation field tests. In case you missed the radiation session at the NAB, this update session is a must-attend event. Even if you attended the NAB convention, the RF radiation session will provide you with the latest information on measurement techniques and the results of the tests that were conducted this summer.

Exhibits

Sold out! That's the word from the national office. The St. Louis chapter has been successful in selling out all of the exhibitor space in the convention center. More than 110 exhibitors will be on hand to demonstrate their equipment.

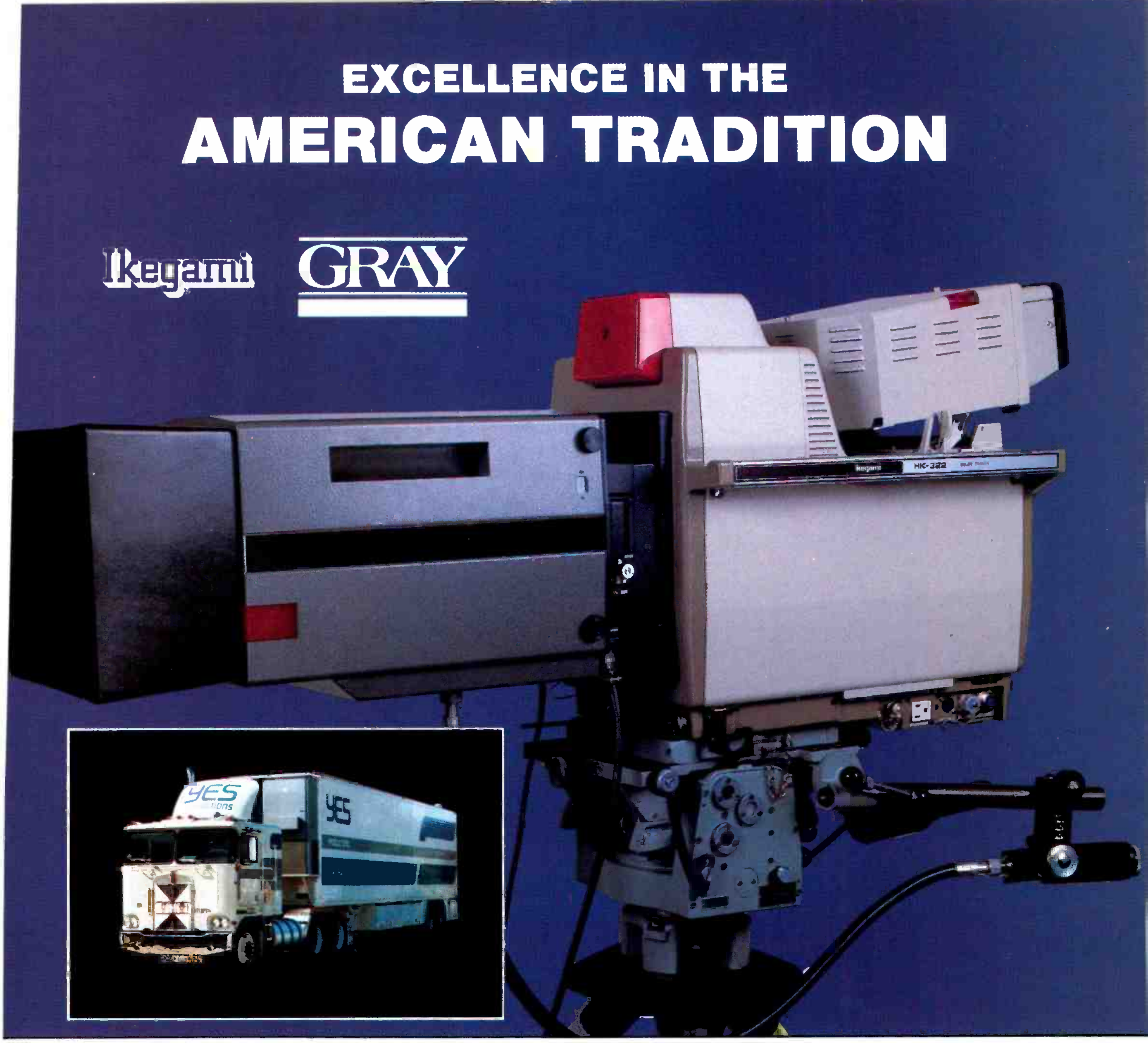
Unlike some conventions, the SBE convention will allow you the opportunity to really look over the equipment and ask questions. The exhibitors know that engineers will be attending the convention, so technical experts will be on hand to field your questions. Plenty of time has been set aside for touring the exhibits.

Related events

The ham radio reception will be held Tuesday evening just after the national SBE meeting. Door prizes and a cash bar will be available. A Wednesday evening reception will be hosted by SBE. Bring your spouse or a friend and visit with old friends or make new ones. There are plenty of activities to keep you busy for all three days.

Because St. Louis is centrally located, some chapters are organizing group travel plans. At least one chapter has chartered a bus. This is a cost-effective idea and allows additional social time during the trip to and from the convention. Other chapters are planning car caravans. If you travel with a group, the trip is more enjoyable and you can trade off driving. If you can borrow a company car, transportation becomes so reasonable your boss can't say no.

To keep the costs as reasonable as possible, special discount hotel rates are available from the Sheraton St. Louis (314-321-5100) and the Radisson Hotel (314-421-4000). Special 40% discounted air fares are available from TWA. Tickets must be ordered through Apex Travel, St. Louis. Call 800-325-4933. In Missouri, call 800-392-1473. Mention SBE and the profile number, 99-10405, when you call.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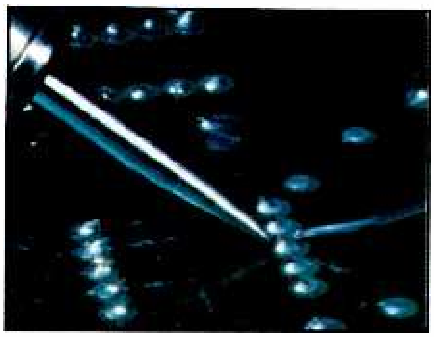
Circle (98) on Reply Card

Monitor modification eliminates squeal

By E. J. Alexander



Sometimes a small change can be made in an equipment's operation that will improve its performance. Although it's seldom proper to permit significant changes in an equipment's design, sometimes slight alterations are useful.

Such is the case with the TFT model 753 AM modulation monitor. The monitor is a common piece of equipment in AM stations, so the change I'm suggesting may be useful to many stations.

The modulation monitor produces an ear-splitting squeal when placed in the *calibrate* mode. Typically the monitor's audio output jack drives the control room speakers. So, when the monitor is switched to calibrate, anyone listening to the air signal is overwhelmed by this squeal. If the monitor's output jack feeds the station's entire monitor system, then everyone in the station is forced to endure this high-pitched tone while the engineer checks the monitor's calibration. There is, however, a simple modification to prevent this squeal.

Making the change

This modification mutes the audio output when the calibrate mode is selected. The only part required is a short length of shielded 2-conductor audio cable.

The calibrate switch has an unused SPDT section that can be used. By looping the audio signal through this switch, you can prevent the annoying tone. The switch simply interrupts the audio feed to the output amplifier, Z14.

The modification uses the front three terminals located toward the left edge of the PC board as shown in Figure 1. Do not use the outside back terminals. This unused section is connected to the PC board ground plane. Connect the cable to the switch as shown in the drawing.

To complete the modification, remove the original jumper from the PC board where the whistle filter switch would connect, if used. This modification assumes that the whistle filter option is not installed on the monitor. If the whistle filter is being used, it will be necessary to cut a foil on the PC board or break one lead of either capacitor C12 or R37.

Attach the shielded cable to the switch as shown in Figure 1. Be certain that you attach the shield to the ground plane at the back of the PC board. Also, be careful that you don't develop a solder bridge from the pads to the ground plane. The modified circuit is shown in Figure 2.

After the modification is completed, check out the monitor's operation. You should no longer hear the squeal when selecting calibrate.

Alexander is technical director for KARV-AM, Russellville, AR.

Another modification

While you have the cover off the monitor, you might want to make another small modification. Installing ECG-417 transistor sockets on the ends of the meter lamp power leads makes replacement of meter lights much easier. These sockets make excellent connectors for No. 7382 lamps. This particular lamp operates at 14V, 0.08A and is rated for 40,000 hours. Once you've made this change, replacing lamps will no longer require a soldering iron and a trip to the bench.

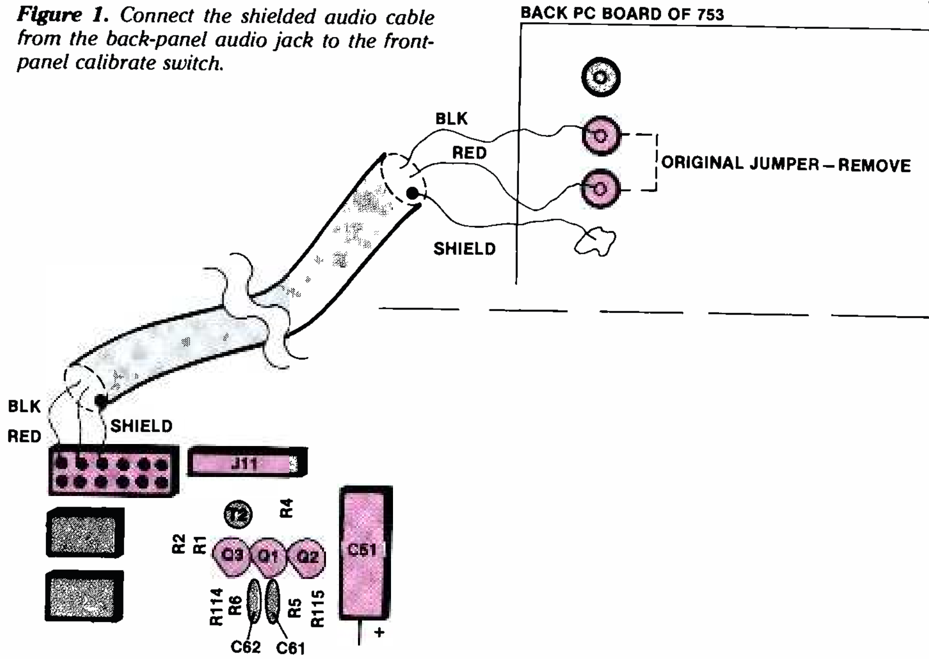


Figure 1. Connect the shielded audio cable from the back-panel audio jack to the front-panel calibrate switch.

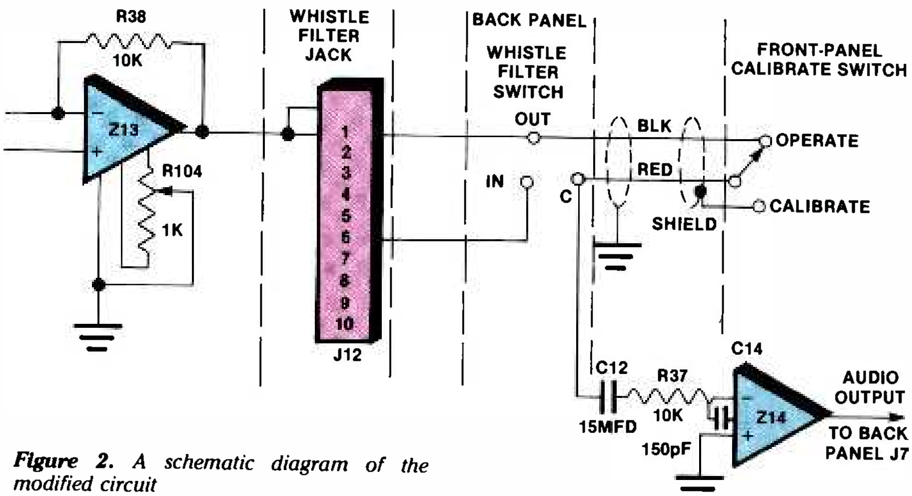


Figure 2. A schematic diagram of the modified circuit

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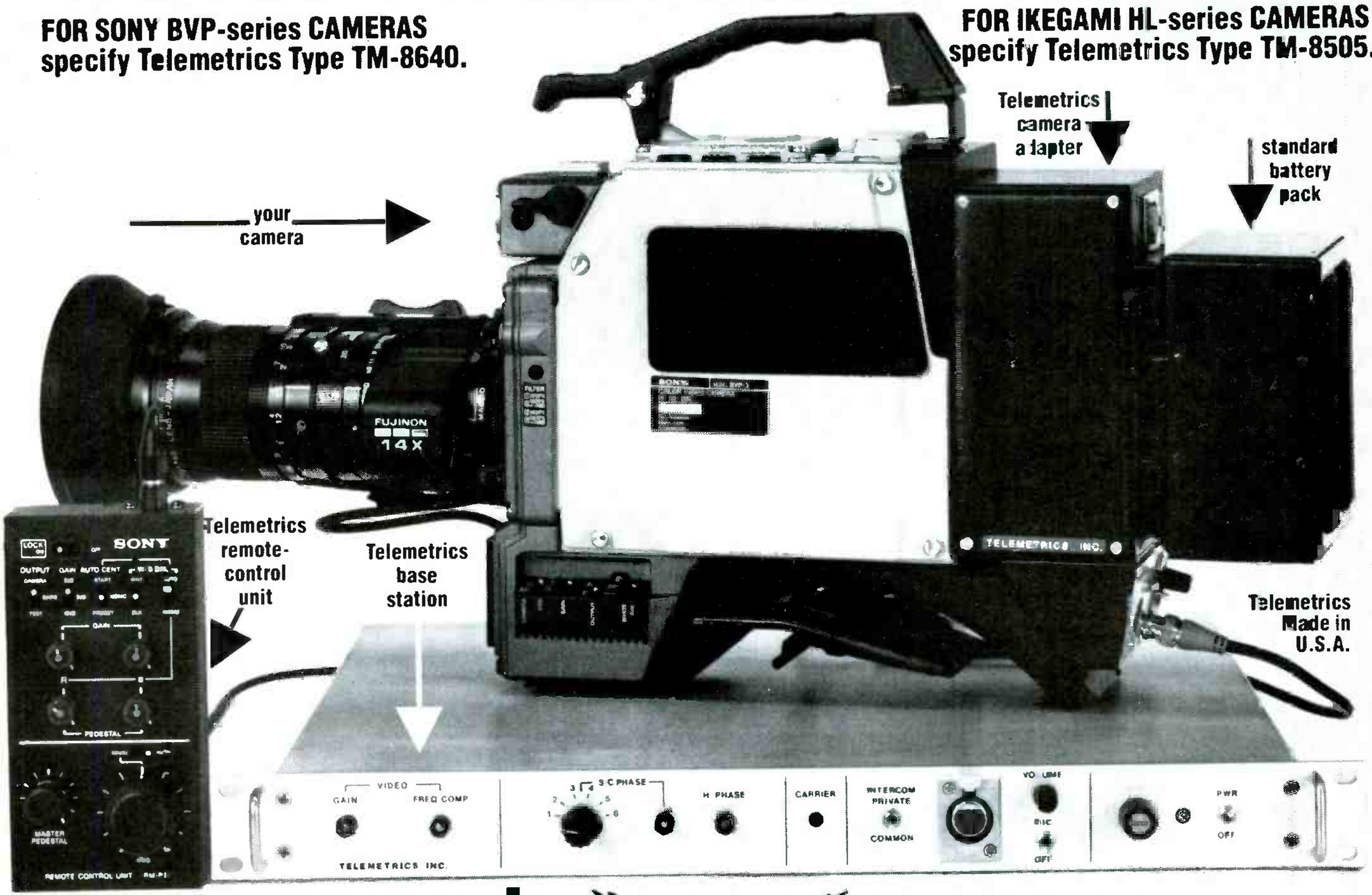

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People

Mark L. Sanders and **Donald F. Bogue** have been promoted to new positions with Ampex, Redwood City, CA. Sanders is vice president of marketing and new technology, a newly created position. He is a former vice president and general manager of the Audio-Video Systems Division (AVSD) since 1983. Sanders will examine the markets and technologies of each division, evaluate its resources and identify and develop opportunities for growth. Bogue succeeds Sanders as the vice president and general manager of AVSD. He is a former vice president and general manager of the Magnetic Tape Division for the past two years.

Saul Walker, Ralph Moss, Jerry Barnes and **Allen Rumbaugh** have been appointed to positions with Mitsubishi Pro Audio Group, San Fernando, CA. Walker is manager of broadcast marketing for the New York regional office. He is responsible for sales for the professional audio and film equipment. Moss is Eastern regional sales manager. He will support sales efforts for the professional audio recording products into the recording studio market. Barnes is an informal adviser. He will talk to potential users of Mitsubishi's digital audio products. Rumbaugh is regional sales manager for the Mid-America district, which includes the Southeastern United States and extends from Nebraska east to Virginia. He will be responsible for sales and promotion of digital audiotape recorders, analog music and film consoles and magnetic and optical film products.

Norman H. Pond has been elected as executive vice president of Varian Associates, Palo Alto, CA. He will continue as president of the Electron Device Group, a position he has held since joining the company in 1984.

Chris Foreman, Greg Braithwaite and **James Murray** have been appointed to positions with RAMSA, Panasonic Industrial Company's professional audio products operation, Cypress, CA. Foreman is marketing manager, responsible for the sound contracting and sound reinforcement segments of the professional audio business. He will direct the marketing programs and assist in product development. Braithwaite is central regional sales manager. He will manage the sales support structure of the Central United States. Murray is Western regional sales manager. He will be in charge of RAMSA's sales support network, interfacing on a regular basis with distributors and end-users.

Tom Harmon has been appointed production manager for Orion Research, Cleveland. He is responsible for manufacturing, testing and shipment of all products.

Thomas W. Knauss, James Ritz and **Jerry Williamson** have been appointed to positions with the audio systems division of Peirce-Phelps, Philadelphia. Knauss is sales engineer. Ritz is senior audio engineer. Williamson is a sales representative.

Frank Scarlata has been named acting general manager of the Detroit branch operation for Victor Duncan, Irving, TX. He also heads the national lighting program for the company.

Thomas Sutton has been named Southwest district sales manager for Sharp Electronics' professional products division, Mahwah, NJ. He will cover Texas east of El Paso, Mississippi, Oklahoma, Louisiana and Arkansas.

Suzanne Foster of Audio Kinetics Ltd., England, has been appointed marketing coordinator. She will continue to work in advertising and organizing exhibits. She also will be responsible for generating and coordinating all public relations.

Lori Heller and **Andy Lovell** have been appointed to positions with Radio Systems, Edgemont, PA. Heller is vice president of operations and Lovell is vice president of broadcast installations.

Ted Valand has been named to a position with BASYS, Mountain View, CA. He is vice president and general manager of North American operations. He will oversee the expansion of research and development efforts, develop and implement marketing programs and strengthen product and customer support for broadcast automated newsroom systems.

Adolfo Rodriguez has been appointed marketing product manager for System One audio test equipment for Audio Precision, Beaverton, OR. He is responsible for customer applications publications and technical marketing activities.

L. James Beckman has been appointed to a position with Shook Electronic Enterprises, San Antonio, TX. He will head the marketing and sales activities. Financial considerations for major investments in ENG, EFP and satellite news gathering is one of the first areas he will develop.

Roy Varda, Janice Haigney, Tom Carrigan and **Jim Martin** have been named to positions at Quantel, Palo Alto, CA. Varda is district manager for New York and south through Virginia. He will maintain network accounts in Manhattan and all other accounts in the Mid-Atlantic states. Haigney is district manager of New York and north, covering New York and New England. Carrigan is Southwest district manager. He will cover Southern California, Nevada and Arizona. Martin is special projects manager. He is responsible for new product introductions and the integration of Quantel products into existing systems.

Robert A. Slutske and **Gary Schultz** have been appointed to positions with Ampex audio-video systems division, Redwood City, CA. Slutske is senior product manager of video editing systems. He will manage the marketing, manufacturing and engineering of video editing equipment. Schultz is product marketing manager of editing systems.

Marconi receives IBA order

The IBA has placed an order for B7500 series UHF high-power TV transmitters with *Marconi Communication Systems*, Chelmsford, England. They will replace a number of the IBA's existing transmitters.

Kodak opens technology center

Eastman Kodak Company, Hollywood, CA, has opened a film and video marketing and technology center. The center will be a staging ground for delivering and supporting the implementation of new imaging technology. The facilities are built around the building that Kodak first occupied in 1927.

Conus receives SNG trademark

Conus Communications, Minneapolis, has announced that SNG has been designated as a registered service mark of Conus by the United States Patent and Trademark Office.

Broadcast Systems completes projects

Broadcast Systems Inc., Austin, TX, has announced the completion of design and construction of WNTZ-TV, Natchez, MS. WNTZ-TV signed on the air Nov. 16, 1985. The independent operation is built around BSI's DC-8 automatic video cart machine.

BSI also has completed studios for KSCH-TV, Sacramento/Stockton, CA. The contract called for design and construction of technical facilities.

Optical Disc delivers videodiscs

Optical Disc Corporation, Cerritos, CA, has announced the delivery of its PAL standard videodisc recording system to Paris. The ODC 620 delivery marks the first time single copy, fast turnaround videodiscs are available in Europe and in the PAL format. Installed at GESCO, ODC's European distributor, the system will serve as a demonstration unit for the growing European videodisc market.

Microdyne's CIM in use by TRN

The Tribune Radio Network, based in Chicago, is initiating a service to affiliates using Microdyne's Communication Information Manager, a system for electronic distribution of information via a single-channel-per-carrier satellite system from *Microdyne*, Ocala, FL. The CIM enables the network operator to make use of dead air time to transmit news flashes, weather alerts and text data to individual stations, groups of stations or to the entire network.

Database provides information

The Broadcasters Database, Houston, an information storage and retrieval service, is now accessible from more than 600 cities and 70 foreign countries. Broadcast professionals can obtain timely industry news and show preparation material as well as useful software that simplifies station operations. Many trades and periodicals are available electronically on the BDB weeks before they arrive in the mail.

The BDB features user support groups for Commodore and IBM computer users, but any computer with a modem and communications software can access the database via a local number. Support groups for Apple and TRS-80 users will be implemented in the future.

Abekas Video receives monitor award

A special Monitor Award for excellence in engineering achievement has been presented to *Abekas Video Systems*, Foster City, CA, for the manufacture and design of the A62 digital disk recorder. The recipient choice of the special award for engineering achievement rests with the chief engineers of Videotape Production Association full member facilities.

Agfa-Gevaert expands

The magnetic tape division of *Agfa-Gevaert* has expanded its technical laboratory at the Teterboro, NJ, facility. The lab has expanded its capability to do full-range, in-depth evaluations of ½-, ¾- and 1-inch videotape. It also has expanded its capabilities for evaluating mechanical and electroacoustical properties of audiotape by updating its lab equipment.

Anchor Audio purchases ROH product line

Anchor Audio, Torrance, CA, has announced the purchase of the ROH product line. The ROH operation will be moved from Atlanta to Anchor Audio's West Coast facility. ROH has manufactured intercom systems, audio distribution networks and audio line monitors for the broadcast and industrial market during the past 18 years.

Harris signs contracts

Harris Broadcast Microwave, Soquel, CA, has signed a contract to supply DALSAT, Plano, TX, with satellite microwave radio uplink equipment. Harris will supply 25 Ku-band video exciters. Delivery of the units begins this month with subsequent shipments over the next several months.

Harris also has signed a contract to supply Hunan, China television with a province-wide TV program distribution system. Built around the FV8F IF heterodyne microwave radio, the system consists of nine hops covering several hundred miles. It has two outbound channels and one return channel.

Harris has announced a contract award by TV station WITF, Harrisburg, PA, to supply a Microstar 23 system. WITF, an educational station, purchased the system as part of its instructional TV fixed service distribution system.

Quantel delivers standards converter

Satin, an all-digital broadcast quality standards converter from *Quantel*, Palo Alto, CA, is in full-scale commercial production and has been scheduled for delivery to its first United States buyer. The first unit ordered has been delivered to Tele-Cine in London.

Moseley and IMS form agreement

Moseley Associates, Goleta, CA, has announced an exclusive license agreement with Integrated Media Systems, San Carlos, CA. Moseley will manufacture and market the IMS range of smart audio switchers, analog-digital-analog converters and some industrial switchers.

Auditronics acquires subsidiary

Auditronics has expanded its product base with the acquisition of Tapecaster. The Tapecaster manufacturing operation has moved to Memphis, to a facility adjacent to Auditronics headquarters. The division was acquired in April 1985.

Apogee Electronics changes address

Apogee Electronics has moved to 1517 20th St., Santa Monica, CA 90404. The telephone number is 213-828-1930.

Ampex broadens facility capabilities

Ampex Magnetic Tape Division, Redwood City, CA, has unveiled a 6-inch tape-coating line at its Opelika, AL, manufacturing center. Line 9 is specifically designed for the development of new products previously done at Ampex's Redwood City headquarters office. In addition to tape production, the line will allow the Opelika facility to develop products to meet digital, video and instrumentation product needs.

Lake Systems expands operation

Lake Systems, Newton, MA, is expanding and consolidating its operation to renovated property at 287 Grove St., Newton, MA 02160.

Philips and Studer sign agreement

Philips, Netherlands, and *Studer Revox*, Switzerland, have signed a joint venture agreement for research and development of CD-related professional studio systems. Each company holds a 50% interest in the Studer and Philips CD Systems AG in Regensdorf, Switzerland. The management is formed on an equal share basis. Willi Studer is chairman of the board and Pieter Berkhout from Philips is the managing director.

Bogner supplies antennas

Bogner Broadcast Equipment, Westbury, NY, has supplied high-power antennas for channel 21 in Mobile, AL, and channel 33 in Pensacola, FL.

MBI Broadcast Systems receives contract

MBI Broadcast Systems, Brighton, England, has been awarded the contract to design, supply and install Iceland's first independent commercial radio station.

The State Broadcast Service's Channel One has MBI studios for its national news service and for local news opt-outs in Reykjavik, Keflavik and Akureyri. Channel Two is equipped with MBI mixers and other equipment. Sjonvarp, Icelandic Television, has two Syncon mixers made by MBI's sister company, Allen and Heath Brenell, and modified by MBI.

Matsushita forms new division

Matsushita Electric Corporation of America, Secaucus, NJ, has established the Panasonic Broadcast Systems Company, dedicated to sales, service and development of broadcast systems led by the MII recording broadcast format. The company consists of two main divisions. One is dedicated to sales and marketing and the other to service and engineering, which includes product development. Sales and service locations will include New York City, Atlanta, Dallas, Chicago and Los Angeles.

New products

Off-line station

The Television Systems Division of *Robert Bosch GmbH* is offering an off-line modeling station to extend the capacity of its FGS 4000 computer graphics system. The system allows a graphic designer to create various 2-D and 3-D objects for the choreography of animation sequences. The objects developed at the off-line station are transferred to the FGS-4000 via an Ethernet bus interface for final processing.

Circle (350) on Reply Card

Production console, recorders

Fostex Corporation of America has introduced the following products:

•The 16-track production console features switchable phantom powering for each mic input, automation updates, in-line monitoring, continuously variable parametric EQ from 60Hz to 1kHz and from 400Hz to 6kHz, and two auxiliary sends and a 3-position selector.

•The E series of recorders are microprocessor-controlled and feature gapless punch-out, a synchronizer port, built-in Dolby C noise reduction, built-in 2-position autolocator, real time counter, auto stop and auto play and an FET amplifier.

Circle (351) on Reply Card

Mixer

Audio Services Corporation has announced the ASC-MX4S-2 mixer. It features RF filtering, 2-second turn-on, headphone monitor with 10dB boost, 4-step 0dB, 10dB, 20dB and 50dB input pads, internal battery pack powering, 8dB increase in headroom and a gain structure that allows 10dB more dynamic range at the channel faders.

Circle (352) on Reply Card

Editing system

Soundmaster International has introduced the integrated editing system incorporating Syncro. The system is controlled by the IBM PC-based Soundmaster software. Syncro communicates with the host computer via its 5MHz data bus. Modular construction facilitates rapid field expansion to 16 or more units. Each Syncro contains an 8088 and 8087 microprocessor and on-board RAM. Features include variable-speed lock, programmable closures for external device tripping and simultaneous synchronization of all international time codes.

Circle (353) on Reply Card

Monitor cases

Porta-Brace has introduced a line of cases for portable monitors. The model No. MO 22U for the JVC 22U and the model No. MO 8020 for Sony PVM 8020 are constructed of padded nylon Cordura. Features include a deep fold-away visor that shades the screen and a fold-up adjustable incline pedestal that allows the monitor to be positioned on the ground or table at any angle. There is a pocket for batteries and ventilator flaps. Leather handles and shoulder straps are provided.

Circle (354) on Reply Card

Music microphones

Electro-Voice has announced the N/D series of music microphones:

•The N/D757 is a supercardioid mic with a 25Hz to 22,000Hz frequency response, −50dB sensitivity and 144dB range.

•The N/D457 is a hypercardioid mic with a 25Hz to 21,000Hz frequency response, −50dB sensitivity and 144dB range.

•The N/D357 is a supercardioid mic with a 25Hz to 20,000Hz frequency response, −53dB sensitivity and 141dB range.

•The N/D257 is a cardioid mic with a 35Hz to 19,000Hz frequency response, −53dB sensitivity and 141dB range.

•The N/D408 is a supercardioid mic with a 30Hz to 22,000Hz frequency response, −50dB sensitivity and 144dB range.

•The N/D308 is a cardioid mic with a 40Hz to 20,000Hz frequency response, −53dB sensitivity and 141dB range.

Circle (355) on Reply Card

Frame grabber

Artronics has introduced the 1024 Image-Grabber high-resolution 1,024 x 1,024 line frame-grabbing system. It is designed for configuration with the Presentation Graphics Producer system.

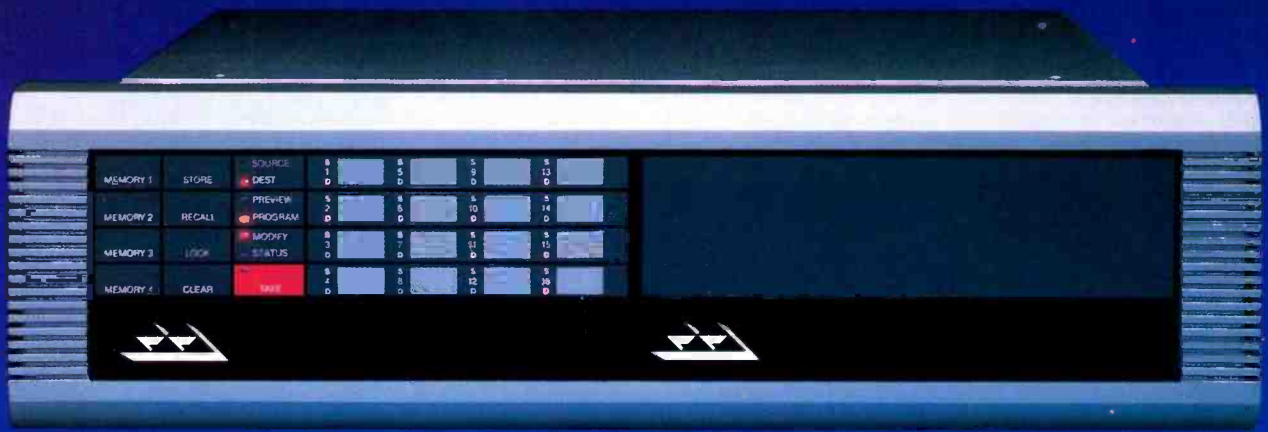
Circle (356) on Reply Card

Digital audio delay line and reverb software

Klark-Teknik has introduced the following products:

•The DN716 digital delay line offers 16-bit linear A/D and D/A converters with state-of-the-art noise and distortion per-

INTRODUCING



The Smart Switcher 256.

Is your patch cord system ancient history compared with the rest of your equipment? Moseley's Smart Switcher 256 brings you up to date with the performance you've come to expect from us and the features your facility needs.

Flexibility

Whether you're looking for in-room or in-plant audio switching, the Smart Switcher is just your size, with configurations starting from 8 x 8 to route your signal from anywhere, to anywhere.

Control

Choose your command point: front panel (remoteable up to 1000 feet), CRT, X-Y controller, or your own personal computer – you can even write your own software for custom applications.

Reliability

The last thing you want to do after a power-down is re-enter your set-ups – that's why non-volatile memory preset is standard on the Smart Switcher, backed up by a redundant power supply for added dependability.

Clarity

What good is the most accurate router if the audio quality is sacrificed? The same transparency found in Moseley STLs is built into the Smart Switcher, so your program arrives at its destination as clean as it began, with virtually no signal degradation.

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formance at 20Hz to 20kHz bandwidth. The system has a dynamic range greater than 90dB and has three outputs and features front-panel delay settings, control functions lockout switch, and is microprocessor-controlled with built-in auto-diagnostic service routines.

•New No. 2 software for the DN780 digital reverb system includes a full range of reverb styles with low coloration and wide stereo image, while maintaining mono compatibility.

Circle (357) on Reply Card

Production vehicle

Shook Electronic Enterprises has introduced a mobile TV production vehicle. It is 31 feet long and 8 feet, 9 inches tall and features all of the electronic equipment for C-band satellite uplink transmission. It is wired for primary input power switchable from delta to wye input for use with United States or European power standards. It is equipped with an on-board 40kW generator and 5m fold-up dish.

Circle (358) on Reply Card

Closed-captioning software

The Caption Center has announced the CC Writer software system suitable for all forms of closed captioning and video subtitling. The system runs on standard IBM PC hardware and addresses off-the-shelf video equipment. The system combines complete text-editing capabilities with features for manipulating videotape time code. The resulting captions can be precisely synchronized to the program. For video subtitling or open captions, the system supports the Chyron VP-1 character generator. English and French alphabets are included in the system.

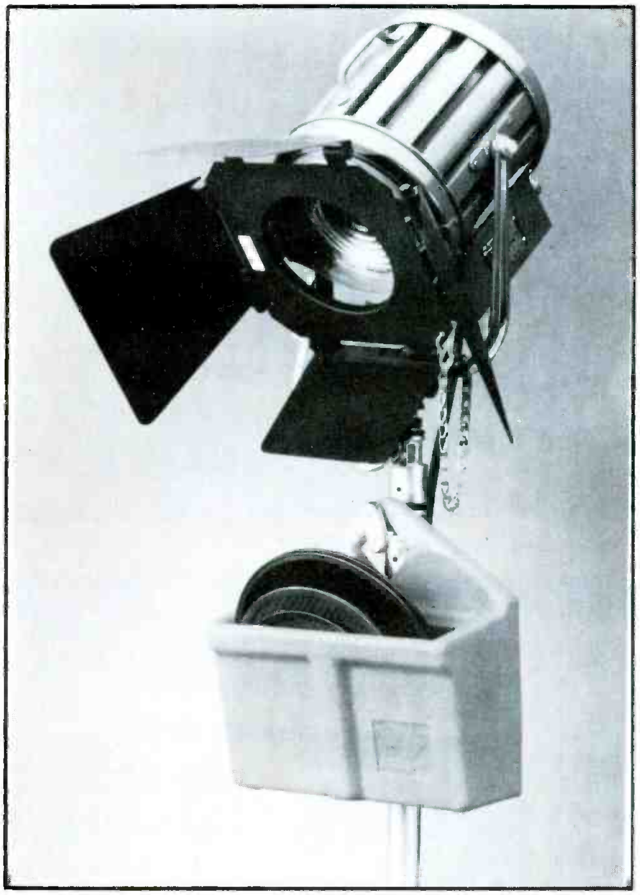
Circle (359) on Reply Card

Power conditioner

Topaz has introduced the ESCORT computer-grade ferroresonant power conditioner. Available from 70VA to 2kVA, the conditioner corrects voltage fluctuations as large as +15% and −35% of nominal line voltage to between +3% and −6% of nominal in only two cycles of line frequency. The conditioner features ultra-isolator noise suppression, provides up to 126dB of common-mode noise attenuation and up to 60dB of normal-mode noise attenuation.

Circle (360) on Reply Card

Scrim hangers



Nalpak Video Sales has introduced the Scrimpak. It comes in three sizes molded from crosslinkable polyethylene and hangs from the adjusting handles of a light stand. The SP-5 holds scrims/gel frames from 5 inches to 7.25 inches, the SP-8 holds scrims from 5 inches to 10 inches, and the SP-12 holds scrims from 12 inches to 13.5 inches.

Circle (361) on Reply Card

A-V distribution equipment

Omicron Video has introduced the following products:

- The model 273 component video distribution amplifier has ±3dB of independent manual gain control and ±1dB of VCA. The control voltage may be applied to the three amplifiers from a front-end mounted potentiometer or through a remote-control port connector. The tracking error is less than ±0.1dB over the VCA control range. Features include self-powered modules and loop-through input and eight outputs and BNC connectors.
- The model 220 dc-powered video DA has a power input of +11.5V to +17V. Features include loop-through one input/eight or six outputs, transparent performance and low power drain.

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Circle (108) on Reply Card

• The model 280 dc-powered audio DA has a power input of +11.5V to +17V. Features include balanced one input/balanced eight or six outputs, transformer-coupled outputs and low power drain.
• The model 470 dc-powered A-V distribution system has one video DA, one audio DA and one 5 x 1 AFV switcher. The system operates from the power input of dc +11.5V to 17V. Features include front-panel accessible, transparent performance, momentary push-button switches with LED indicator.
• The model 501 preset-take 10 x 1 video switcher accepts a take command to flip-flop program and preset bus selection to increase program flexibility of digital effects. It features vertical interval switching.
• The model 551 preset-take 10 x 1 component video switcher accepts a take command to flip-flop program and preset bus selection to increase program flexibility of digital effects.

Circle (362) on Reply Card

Multisubcarrier

Racon has announced the addition of a multisubcarrier to its Micropass line of 23GHz microwave communications products. The multisubcarrier allows users to use two duplex subcarriers in their microwave bypass telecommunications. The multisubcarrier can transmit multiple streams of voice and data in conjunction with video without the need for telephone lines or cables.

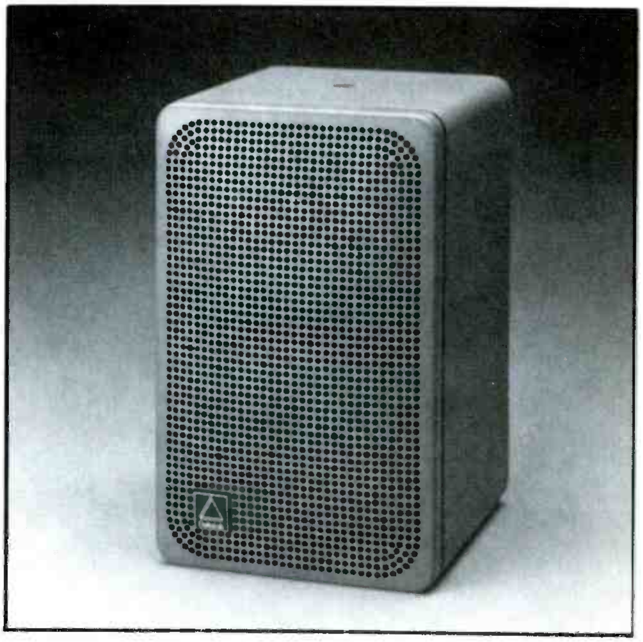
Circle (363) on Reply Card

C-band earth-station antenna

Miralite has introduced the Miralite T1 antenna. It is a 3.7-meter C-band earth-station antenna system designed to absorb terrestrial-based microwave signals. Specifically formulated tuned microwave absorbing materials are designed to react with and suppress off-axis interference currents.

Circle (364) on Reply Card

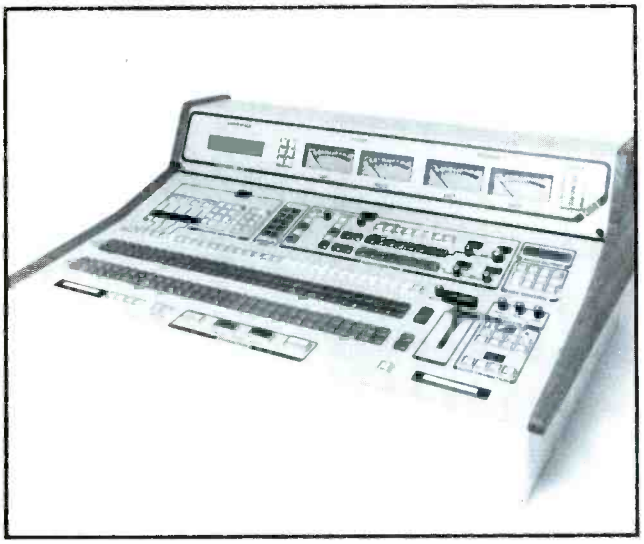
Studio monitor



DeltaLab, the Pro Audio Division of Analog & Digital Systems, has introduced the M1 field studio monitor. It is a 2-way acoustic suspension model that employs a 1-inch soft dome tweeter of polyester fibers, and a narrow magnetic voice coil gap. The monitor also features a protection circuit that is triggered by thermal or electrical overload.

Circle (365) on Reply Card

Master control



3M Broadcasting and Related Products Division has introduced the 324 master control on-air switcher that can be used as a stand-alone master control. It provides 32 audio-video inputs, four assignable inputs with alphanumeric readouts and full audio over and under capability. Features include full analog VU meter with digital peak indicators, four programmable user-definable transitions, a backup system, eight audio inputs with auto cart start, A-V auto transition, three video buses, split A-V for all inputs, manual fader, two matte generators and a machine control interface.

Circle (366) on Reply Card

Adaptive/interactive software

Lake Systems has announced the latest repackagings of La-Kart adaptive interactive software. It will demonstrate three new solutions to automation needs with the applications-identifying names of Broadcaster, Multicaster and Compiler. Each solution is a proprietary software program resident on an industry-standard floppy disk. Loading any one of them into the La-Kart operations control center's 68k microcomputer transforms it into a dedicated automation system with functions identified by the related descriptor.

Circle (367) on Reply Card

Dubbing console

The Winsted Corporation has announced a compact dubbing console. It will accommodate either ½-inch or ¾-inch frontloading VCRs. It can hold up to eight VCRs and their electronics.

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For attendee registration information circle (600) on Reply Card

Fiber-optic twin channel

ITT Cannon has introduced the fiber-optic twin channel product line. It is a lightweight fiber-optic interconnection system and consists of duplex plugs, simplex plugs, adapters for duplex-to-simplex and duplex-to-duplex connections and a device receptacle for PCB or bulkhead applications. The line features a patented jewel ferrule alignment system, a keyed mating interface and an operating temperature range of −40°C to +85°C.

Circle (369) on Reply Card

Audio-processing product

Kahn Communications has announced the Good n Loud audio-processing product. The unit is a patented device for providing +125% modulation without rough distorted clipping sounds. The system produces a wave that is free of odd harmonic distortion and also reduces even-order harmonic distortion. It provides increased modulation by expanding the entire positive-going modulation rather than clipping the negative-going modulation.

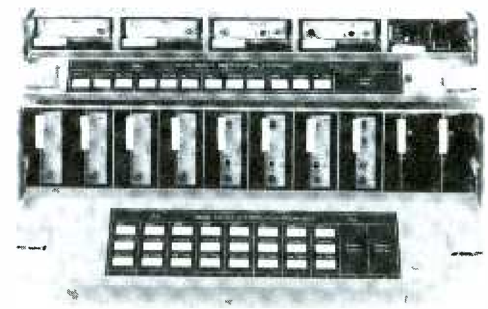
Circle (370) on Reply Card

Voice processor with mic pre-amp

Symetrix has introduced the 528 voice processor. LED metering indicates interactive dynamics processor gain reduction, de-esser activity and output level. Features include mic pre-amp, compressor/limiter, downward expander, parametric equalizer and de-esser. The downward expander prevents pumping, reduces noise from cart machine solenoids and paper rattling.

Circle (371) on Reply Card

A-V DAs and editing software



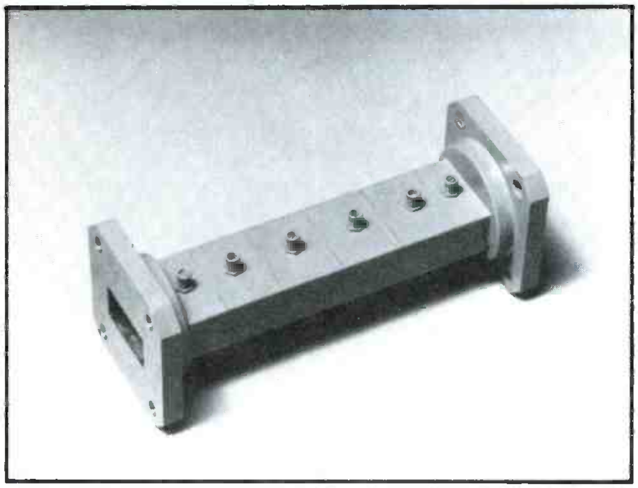
Grass Valley Group has introduced the following products:

- The 8510R remote gain video DA allows local, remote or summed control of both video (±6dB) and chroma (±4dB) when mounted in the model 8500T2R tray. Front-panel selections include control mode, the gain choices and equalization for up to 500 feet of Belden 8281 or equivalent cable.
- The 8552R remote gain audio DA provides switch-selectable gain ranges from +10dB to +30dB, in three steps.
- The V3.0 software for the GVG and ISC editing systems features 4-level event highlighting, emphasized critical status and error, increased number of displayed EDL lines, faster list

and screen display and user-friendly menu. Control of the Abekas A-62, the Panasonic MII format VTRs, Lynx/timeline interfaces and Lexicon has been added.

Circle (372) on Reply Card

Ku-band downlink and uplink filters



Microwave Filter Company has introduced the following products:

- The bandpass filter 5282-2 that passes the commercial Ku-band downlink (11.7GHz to 12.2GHz) and suppresses the Ku-band uplink (14GHz to 14.5GHz) and commercial mobile communications band (10.55GHz to 10.68GHz). Uplink and mobile band suppression is 70dB nominal. VSWR and insertion loss are 1.25:1 maximum and 0.5dB. The 6-inch unit is designed in WR-75 waveguide with cover flanges.

• The bandpass filter 5283-2 passes the commercial Ku-band uplink (14GHz to 14.5GHz) and suppresses the Ku-band downlink (11.7GHz to 12.2GHz). VSWR and insertion loss are 1.25:1 maximum and 0.75dB maximum. The 5-inch unit is designed in WR-75 waveguide with cover flanges.

Circle (373) on Reply Card

Compact routing switchers

Utah Scientific has introduced a series of compact routing switchers. The CAA/CAV-20/10, available in audio/audio or audio/video 10-input x 10-output or 20-input x 10-output configurations. Features include up to four separately addressable levels, two coax party lines, plus two RS-232/422 ports, and sync tip clamping on video inputs and outputs.

Circle (374) on Reply Card

Aperture response test charts

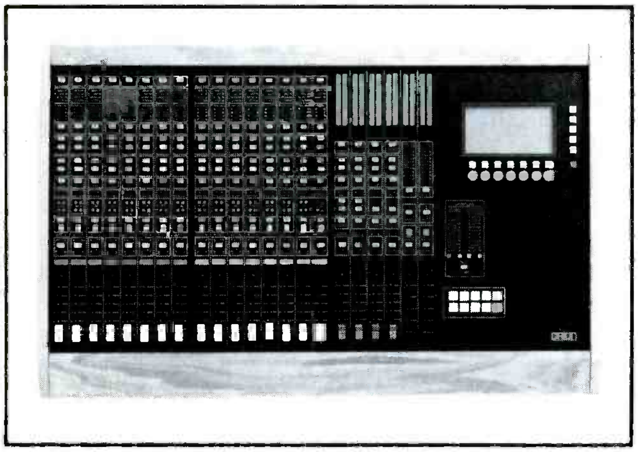
Porta-Pattern has added the RCA P200 and P300 aperture-response test charts to its range of test images. These charts were developed to permit accurate evaluation of TV camera-tube resolution and also for use in setting up the tube assembly for minimal effect of spot ellipticity. Both charts are based on a technique of using non-vertical lines in a special resolution-measuring pattern.

Chart P200 facilitates camera-tube beam focus adjustment for minimum astigmatism and allows accurate performance measurement of the tubes of the highest resolution with virtual independence of video amplifier bandwidth.

Chart P300 allows accurate specification of the camera-tube resolving power using the modulation transfer function theory.

Circle (375) on Reply Card

Audio mixing system



Orion Research has announced the AMU series TV audio mixing system. The system is available in eight to 32 stereo inputs. Auxiliary sends, monitors, submasters and masters also are stereo. The system has analog rack-mounted electronics separated from an all-digital control panel by a serial cable. Automated features include ReMem, a recall memory system and SoftMap, an input-to-fader routing system. The system also includes a CRT output.

Circle (376) on Reply Card

Noise-control product

Alpha Audio has introduced the SONEX 1, a flame-resistant, noise-control product. The product is made of a porous acoustic melamine material that meets class 1 requirements for both flame spread and smoke density, yet retains the anechoic wedge properties for noise reduction. The product will be sold in 2-inch-thick 2'x4' uncoated panels. It comes in four sheets to a box.

Circle (377) on Reply Card

Computerized electronic video editor

United Media has announced the expandable Comm-ette A/B roll computerized electronic video editor. The editor allows the user to upgrade progressively from control track to SMPTE/EBU time code, and from two to three machines including time-code generator and full switcher control. The editor provides 250 event memory, list management with ripple, list input and output, disk control, variable speed search and jog, built-in interfaces for 1-inch, ¾-inch or ½-inch formats, automatic assembly sequential or checkerboard, and pulse readers or automatic transition control with 10 preprogrammed commands.

Circle (378) on Reply Card

Satellite video source identifier

QSI Systems has introduced the Star-2400 satellite video source identifier. It will display 24 characters consisting of the 10-digit telephone point-of-contact, transmitter license number, user alphanumerics and a 2-digit operator number. The telephone and operator numbers are front-panel programmable with the remaining 12 characters programmed via internal DIP switches using the ASCII 64-character menu.

Circle (379) on Reply Card

Video slide image system/video camera lifter

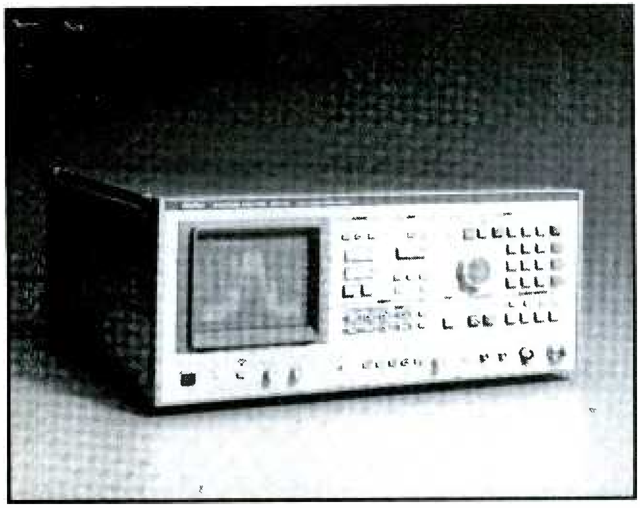
Interactive Motion Control has introduced the following:
•The video slide image system provides precision movement of magnified images from 35mm slides or 2¼-inch transparencies. The zoom lens is computer-controlled and the

system can be mounted on an optical rail or video animation stand. System features include projector, light source, positioning stage and a Canon lens. Up to 16 axes can be controlled.

•The computer-controlled video camera lifter features stability, speed and portability. The lifter provides up/down movement of a camera mounted on a nodal-point head with pan/tilt/roll. Components include a 9-foot-tall column and a 3-foot extension arm. The rotational axes provide +360° of rotation at up to 45° per second. A Canon lens is included.

Circle (380) on Reply Card

Microwave spectrum analyzer



Anritsu America has introduced a series of microwave spectrum analyzers that can measure from 10kHz to 140GHz. Designated as the MS710C/D/E/F, the four analyzers have been updated to include 300Hz and 100Hz resolution bandwidth, a 100dB dynamic range and improved stability. Up to nine measurement setups can be stored in memory. The series have direct plotting capability and are fully GPIB programmable.

Circle (381) on Reply Card

Oscilloscopes

Tektronix has introduced the following products:

• The 2245 and 2246 general-purpose oscilloscopes feature 4-channel, 100MHz bandwidth, 2mV sensitivity and a 2% vertical and horizontal accuracy. The scopes also have auto-level trigger, A and B readout intensity controls, and a low-noise vertical system.

• The 2400 series of portable oscilloscopes—the 150MHz 2445A, the 250MHz 2455A and the 2465A—feature automation, single-button setup, save/recall setup memory, setup sequencing, setup transfers without a controller and increased bandwidth. The scopes feature four channels with dual-delaying time bases and on-screen measurement cursors.

Circle (382) on Reply Card

Mounting mixers and consoles

Soundtracs has introduced the following products:

•A range of 19-inch rack-mounting mixers with modular construction.

•The CP6800 24-track console equipped with an on-board computer system automating the routing and patching of the desk against SMPTE time code. It features a monitor, disc storage, SMPTE reader and an 8-way events controller.

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News
Continued from page 4

both the compatibility of equipment and ease of program interchange. The group's documents will define the colorimetry, optical/electronic conversion, scanning parameters, blanking waveforms and other details of the high-definition TV signal. Other documents will define studio level interfaces for this signal, in both analog and digital terms. The timing reference signal for the HDTV studio also will be defined.

Keith Field of the Canadian Broadcasting Corporation is chairman of the ad hoc group.

SMPTE adds student chapter

Manhattan Community College in New York has formed a student chapter of the Society of Motion Picture and Television Engineers (SMPTE). The college, a part of the City University of New York, had its application approved at a meeting of the Society's Board of Governors.

Baylor University, Pasadena City College, Rochester Institute of Technology, Sam Houston State University and the University of Southern California at Los Angeles are the other educational institutions that are officially represented in the SMPTE with student chapters.

A-V Software Fair will be in Japan

The International Audio Visual Software Fair Promotion Council, in cooperation with the Japanese Ministry of International Trade and Industry, will present a preview of tomorrow's audio-visual age at the International Audio Visual Software Fair '86, Oct. 24 to 29, at the Osaka Castle Hall and the Hotel New Otani in Osaka, Japan.

The fair covers a vast field of visual software from videotapes and videodiscs to computer graphics and videotext programs. Its objective will be to promote the development of the Japanese visual software industry and to provide a forum for international information and business exchange.

More than 50,000 visitors from around the world are expected to attend. A wide range of participants at the fair will include film and video distributors, audio-visual equipment manufacturers, technology developers and representatives from TV stations, advertising agencies and production houses.

IEEE sponsors 36th broadcast symposium

The 36th annual Fall Broadcast Symposium sponsored by the IEEE Broadcast Technology Society will be held on Sept. 18 and 19, at the Washington Hotel, Washington, DC. A broad range of technical subjects will be covered.

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