BROADCAST ENGINEERING

AN INTERTEC PUBLICATION

September 1990/$4.50

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SBE Show Preview
p. 98

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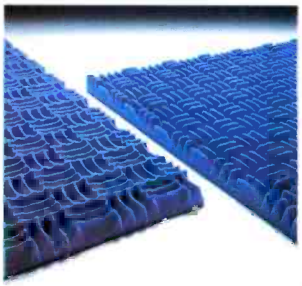

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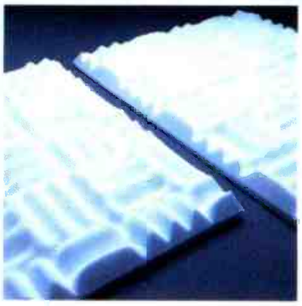

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Circle (1) on Reply Card

By Dawn Hightower, senior associate editor

Canadian DAB tests conclude

Just 90 years after Marconi's transoceanic reception of three recurring pulses at St. John's, Newfoundland, Canada has reentered the broadcast history books, as tests conclude on a summer-long showcasing of digital audio broadcasting (DAB).

The over-the-air tests of the European-developed "Eureka 147" DAB system ended last month in Vancouver, after demonstrations in Ottawa, Toronto and Montreal. The joint Canadian Broadcasting Corporation — Canadian Association of Broadcasters' project was to generate support for a transition from AM and FM broadcasting to DAB as soon as feasible. Propagation characteristics and technical performance of the system were studied at each of the four sites.

Engineers at France's Centre Commun d'Etudes de Telediffusion et Telecommunications (CCETT) invented the channel-coding called coded orthogonal frequency division multiplexing (COFDM). The marriage between COFDM and the West German Institut für Rundfunktechnik's (IRT) "MUSICAM" digital audio compression technique has resulted in a spectrum- and power-efficient, robust and multipath-free digital radio broadcast system.

A pair of COFDM encoder/modulators were provided by the Eureka project partners as well as two COFDM decoders. Canada's Rogers Broadcasting Ltd. provided a 1kW Thomson-LGT UHF-TV transmitter (with NTSC stages bypassed) to transmit the DAB signal and a 1kW Thomson-LGT FM transmitter for a simulcast analog FM signal was used for comparative purposes during the demonstration.

The Canadians appear committed to an early adoption of a DAB system; they and other nations have pinned their hopes on securing new spectrum for DAB from the World Administrative Radio Conference (WARC) in 1992. Several Canadian broadcasters noted that their fast-track approach is stimulated by concern that lagging behind the United States in adopting a DAB transition plan might leave them with too few channels to adequately serve their largely southern population.

The FCC recently released a Notice of Inquiry on possible U.S. implementation of DAB technology and will most likely remain at the top of the commission's agenda, along with HDTV and personal communications systems throughout 1991. Meanwhile, the Eureka hardware will return to the United States for its on-air premiere at the National Association of Broadcasters' Convention next spring in Las Vegas.

SBE looks to the 1990s

The Society of Broadcast Engineers (SBE) has initiated a strategic planning process that will result in a formal plan to guide SBE through the 1990s.

According to SBE president Brad Dick, "the process will be based on the recent

Continued on page 148

BROADCAST ENGINEERING

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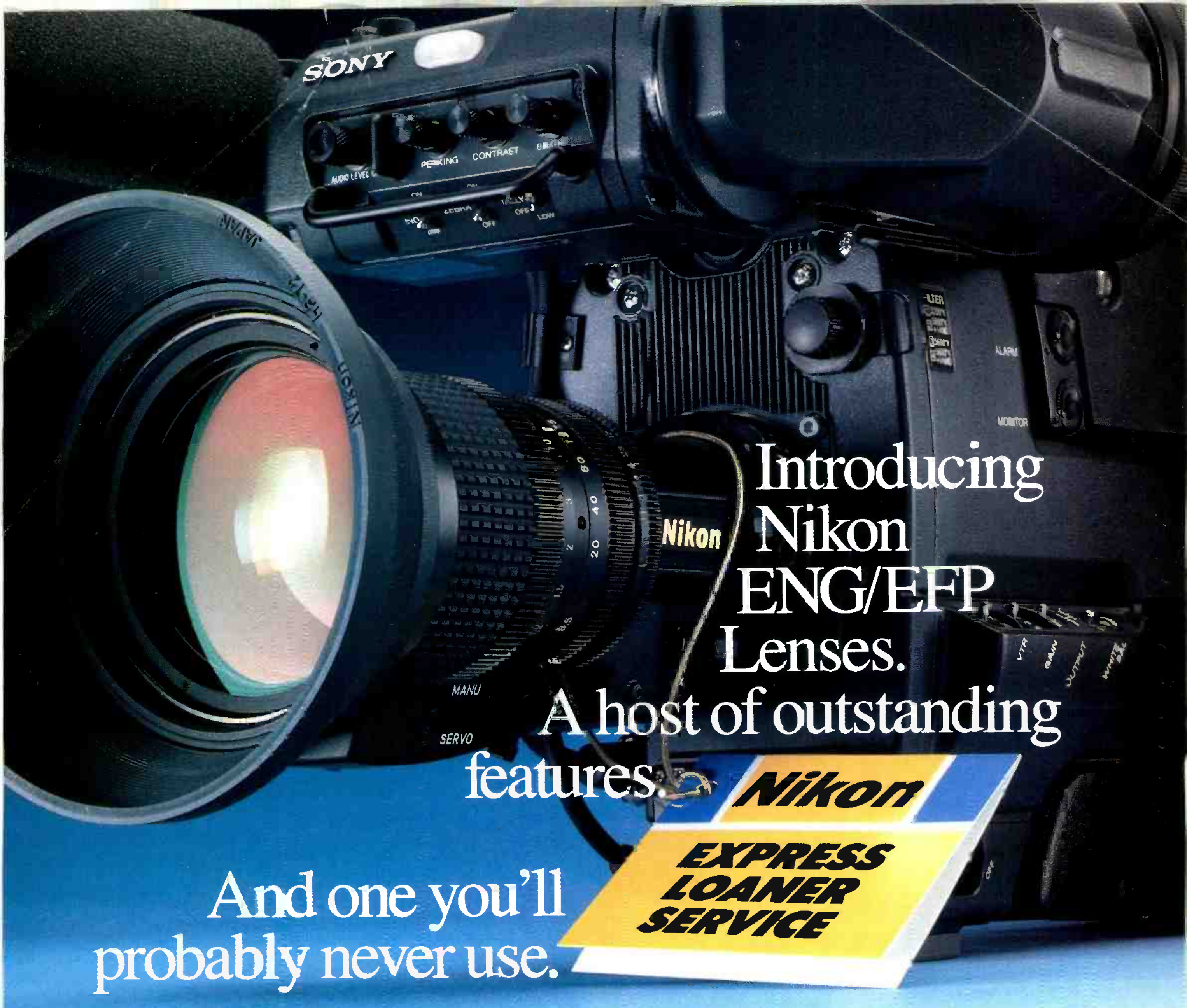

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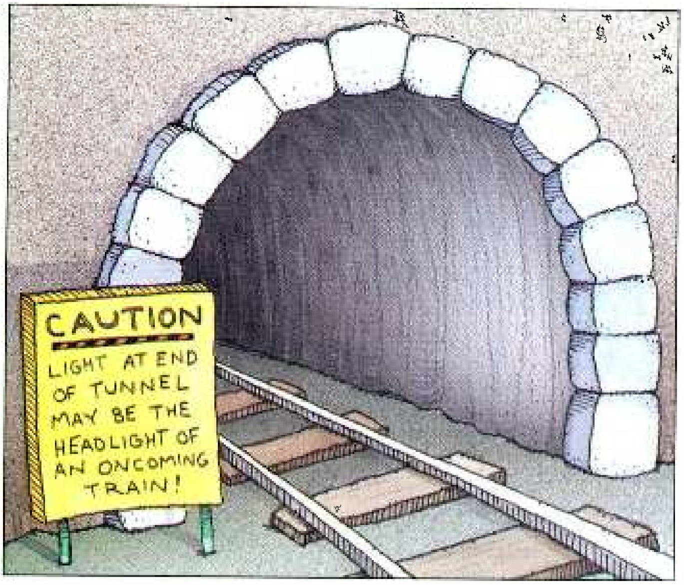
Circle (4) on Reply Card

The digital audio revolution continues

Now that DAT is finally a reality in the American audio consumer marketplace, radio is destined to become the last analog audio format.

The consumer push toward digital audio began with the CD, of course, whose startlingly robust and speedy acceptance surpassed many of the rosiest projections. Why? The CD's most valuable asset is its elimination of the *impulse noise* and *distortion* that was so annoyingly present in analog disc media. It solves other problems, but they are of secondary importance to the consumer; witness the continued strength of the theoretically inferior cassette.



Radio's fast track?

The lesson from this for broadcasters is clear. Consumer tolerance for *transient* types of degradation continues to dwindle. Signal-to-noise ratio, loudness and frequency response are less important than fading, splatter, interference and multipath. The ear can adjust to steady-state problems but can't easily ignore things that come and go, or interrupt. These, unfortunately, are symptoms that are impossible to completely cure in our current systems. While the consumer's taste for quality audio grows higher by the day, radio's product is lucky to hold a status quo, given growing spectrum congestion, SCA usage, audio processing warfare and downtown high-rise construction.

One white horse on the horizon, however, is digital audio broadcasting (DAB), and its hoofbeats are approaching fast. Although new hardware and spectrum are required, several digital radio formats have already been proposed and tested. They offer CD-like audio quality for terrestrial and/or satellite distribution, and one of them could become the broadcast piece of the consumers' next audio system.

DAB also offers broadcasters greater power efficiency and better coverage of problem terrain than FM, with no interference or multipath, plus spectrum efficiency better than FM. The multiplexed transmission schemes envisioned mean that participating stations can split their capital start-up costs. Receiving hardware should be inexpensive and attractive for home and car listening. This is, after all, a marketplace that snapped up CD players. This time, however, the programming is included free of charge. And that is where broadcasting's primary strength is reaffirmed. With the technical playing field thus re-leveled, radio's *service* function can resume its rightful place in the consumer audio world.

The road to U.S. DAB still is uphill, of course, with the regulatory obstacle of frequency allocation looming largest. Some broadcasters also fear its DBS potential. Nevertheless, the ball has begun to roll, with Canadian DAB tests taking place this past summer, experimental filings at the FCC, and the first U.S. broadcast demonstrations scheduled for NAB '91 in Las Vegas. The commission made it official last month by issuing a Notice of Inquiry on the subject.

Unlike HDTV, all of the excited conversation about DAB won't come to a screeching halt when the cost is mentioned. With visions of FM vs. AM and CD vs. LP fresh in our minds, this looks like one train we can't afford to miss.

Skip Pizzi,
BE technical editor

Chuck Steak – Our overzealous food critic. EQ Number: 72.

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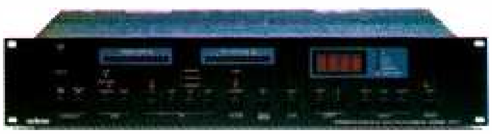

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LISTEN TO THE DIFFERENCE.

Evaluations become stricter

By Harry C. Martin

The commission now will consider all felony convictions in assessing the basic character qualifications of broadcast applicants and licensees. Previously, the commission had considered only the following adjudicated misconduct:

1. Fraudulent representations to governmental units.
2. Criminal misconduct involving false statements or dishonesty.
3. Broadcast-related violations of antitrust or other laws relating to competition.

The commission thinks, however, that a tendency to comply with the law in general is relevant to its public interest analysis. Therefore, evidence of any conviction for misconduct constituting a felony will be relevant to the commission's evaluation of an applicant's or licensee's character.

Not all convictions for serious crimes are considered equal by the commission. Although a felony conviction raises questions regarding whether an applicant or licensee has the requisite propensity to obey the law, the commission continues to believe mitigating factors must be considered in its deliberations.

Accordingly, the commission will continue to consider the willfulness, frequency, currentness and seriousness of the misconduct, the nature of the participation (if any) of managers or owners, efforts made to remedy the wrong, overall record of compliance with FCC rules and policies and rehabilitation.

Furthermore, although the commission previously considered only "broadcast-related" violations of the antitrust laws, because of the interrelationship of the mass media, it now believes that adjudicated violations of antitrust or anti-competitive laws involving any medium of mass communications, as defined in 47 U.S.C. 309(i), are also relevant to its licensing decisions.

Misconduct not enough

The commission stated it will refrain from making licensing decisions based on mere allegations of relevant non-FCC misconduct, even where those allegations have resulted in an indictment or are otherwise in the process of being taken before another agency or court. However, the commission will consider conditioning the grant of an application in any case in which a matter being litigated in another forum could result in an adjudication that an applicant before the FCC has engaged in relevant non-FCC-related misconduct, and an adjudication concerning that misconduct raises serious questions regarding whether the applicant possesses the requisite propensity to obey the law.

Where the commission has determined that a condition is appropriate, it will generally await the decision by the ultimate factfinder before taking any additional action. If that decision is adverse to the applicant, the commission will revisit the conditioned grant to determine whether it would have awarded that grant had the adjudicated misconduct been before it.

Implementation of these changes in the character qualifications policy will require modification of various FCC forms. Also, a new subsection (c) has been added to 1.65 of the commission's rules requiring applicants report to the commission information regarding pending adjudications of relevant misconduct. Accordingly, any material change in the status of a pending case, such as conviction or dismissal, must be reported to the commission within 30 days. The commission also has added a new 1.17 to its rules to clarify that all applicants, permittees and licensees, regardless of whether they are broadcasters, are prohibited from making any written misrepresentations or willful material omissions bearing on any matter within the commission's jurisdiction.

Filing rules clarified

The commission has clarified two aspects of its new filing rules as they relate to time-critical broadcast and common carrier applications, which are applications filed in response to a filing window or cutoff list.

For time-critical broadcast and common carrier applications requiring a fee, which were previously filed in Washington, the commission will now accept as timely those applications stamped in by the Pittsburgh lockbox bank before midnight on the next business day following the official deadline or cutoff date established by the commission. If the commission establishes a deadline of May 16, all filings received at the Mellon Bank in Pittsburgh before midnight May 17 will be considered filed on time.

Also, the commission explained that its back-up filing procedure was established only for time-critical broadcast and common carrier applications subject to fees previously filed in Washington, but which are now required to be filed in Pittsburgh. Furthermore, this procedure is available only if applications are delivered to Pittsburgh via Express Mail or another established next-day delivery courier service. Those filers sending their applications to Pittsburgh via first-class mail or by any means other than an established commercial courier service do not qualify under this procedure.

The commission also reiterated that in order to receive this back-up protection, the applicant must file two copies of the fee form (FCC Form 155), one copy of a legible proof of express mailing or courier receipt, one copy of the application/filing and one copy of the remittance (in that order) with the Office of the Secretary by 5:30 p.m. on the commission-established deadline. If multiple applications have been forwarded under a single courier receipt, copies of this receipt must be attached to each application filed with the Office of the Secretary.

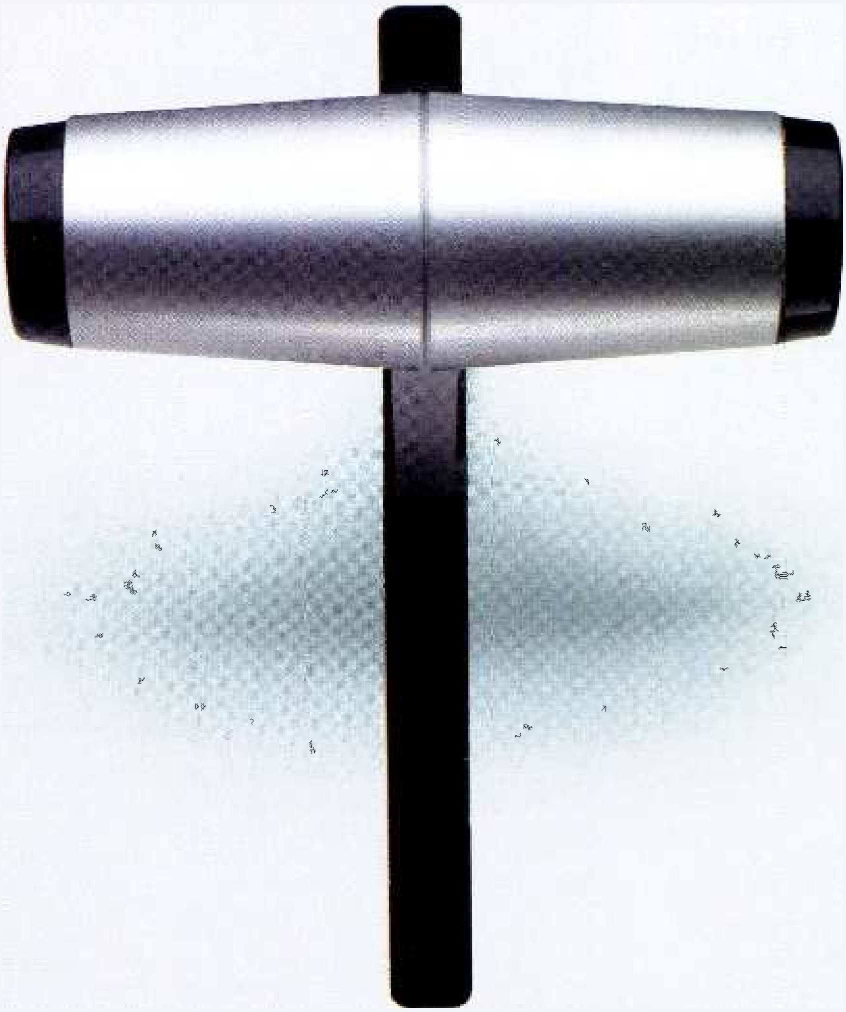
Indecent programming ban adopted

The FCC has unanimously adopted a report concluding that a 24-hour ban on indecent broadcast programming is constitutional "as it would be enforced by the commission."

In its report, the commission determined that the prohibition of indecent programming complied with the First Amendment, as interpreted under the U.S. Supreme Court's "compelling government interest/narrowly tailored restriction" test applied in a recent ruling pertaining to indecent telephone calls.

Martin is a partner with the legal firm of Reddy, Begley & Martin, Washington, DC.

Comfort.



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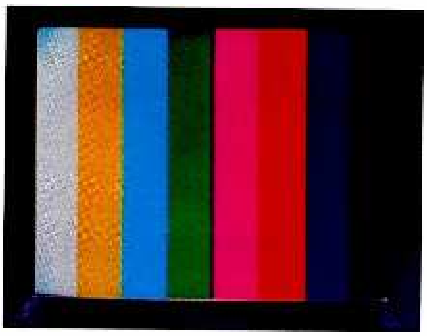

Keep equipment safe on the road

By Rick Lehtinen, technical editor

Fall is the season for football, followed closely by basketball, gymnastics and a host of other athletic events. Unlike our radio brethren, who can pull off a sports remote using little more than a cellular telephone and a headset, TV remotes require a lot of expensive, specialized equipment. Engineers can take basic steps to protect their inventory, and possibly themselves, while on remote.

Be smart

Although TV production equipment is expensive, in most cases the dollar loss of stolen equipment will be far outshadowed by the difficulty of getting by without it. Unless you like begging loaner equipment from local TV stations, or having to rent it at top dollar, preventive measures are advised.

Although TV production equipment is expensive, in most cases the dollar loss of stolen equipment will be far outshadowed by the difficulty of getting by without it.

Label each piece of equipment with permanently attached inventory tags and bright identification labels. Keep a file of which inventory number goes to what piece of gear. This not only will be of great help for maintenance records, but will also help keep equipment straight at large events where a number of different remote vehicles are working together. Also, proper identification will help protect you against theft from insiders who know the equipment's worth.

Equipment, guard thyself

Security is increasing at major public events. At the recent Goodwill Games, for instance, engineers had to clear several levels of security just to get to their posts. If they had to go to the floor, they needed to obtain floor passes from the unit manager, different passes for each day. Although this is a perceived hassle, it certainly works to the advantage of broadcasters who worry about their equipment.

One of the strengths of video is that you can see with it. A convenient method of watching cameras while the crew is off headsets is to point each camera at another one. One person, seated at the producer's station in the truck, can keep tabs on the entire complement of video gear. A similar arrangement could be worked out easily with announce mics, using audio oscillators of unique frequencies that form an easy-to-listen-to musical chord at the mixer. If the chord changes, a mic just went away.

In most major stadiums, there is enough activity the night preceding a game that equipment can be left in place fairly safely. Nevertheless, take the time to cover up things. Put a garbage sack over camera stations. If you can't lock up the announce area, cover things up with a tarp. Out of sight is out of mind. Besides, this is inexpensive protection against sudden rain showers and spilled soft drinks.

Rent a cop

Security isn't cheap. Fortunately, many municipalities are. Trained, uniformed police officers often can be hired in their off hours. These individuals are licensed to bear arms, and their presence can deter much criminal activity.

Leave your phone number with your guards. Walk them around to each camera position and point things out to them. Give them a list of the people who might request access. Ask stadium workers if they can leave a few extra lights on to simplify your guard's work. Usually there are cleaning people working, so this doesn't present much of a problem.

One of the easiest ways to avoid trouble is to carefully choose where you park your truck. You want something well-lighted, with easy access to the arena, but out of the way. If possible, avoid setting up where the general public has to parade by your rig on the way in or out.

It is common practice to leave equipment cases, egg crates, extra monitors and intercom stations at the ready just outside the truck. But if you are forced into a highly public environment, consider staging from a secured location inside the facility. Then police the area and lock your vehicle.

No one wants to be a victim, but the unusual working hours of engineering personnel may predispose them to it.

Visitors to the truck can be annoying. A good rule is to not allow anyone into the van when clients are working. When the truck is idle, you might permit a few people to walk through, but escort them at all times.

There is safety in numbers. If a drunk fan manages to get to the van's steps demanding to see a replay, four of you should tell him to contact the coach's office.

Personal safety

In recent years, the growing use of crack and other drugs has caused an upsurge in criminal activity. Millions of criminals are waiting to make victims out of travelers who neglect to follow the basic rules of safe travel. The key word here is "neglect."

Many good articles abound on keeping safe while traveling. Traveling engineers are advised to read these periodically to keep up their guard. No one wants to be a victim, but the unusual working hours of engineering personnel may predispose them to it.

If you are assigned to drive a remote vehicle, you probably carry enough cash with you to keep yourself out of trouble on the road. Keep it safe in your hotel's lock box on days when you are not actually behind the wheel. At least one remote truck has a safe hidden in the equipment rack. Use these devices.

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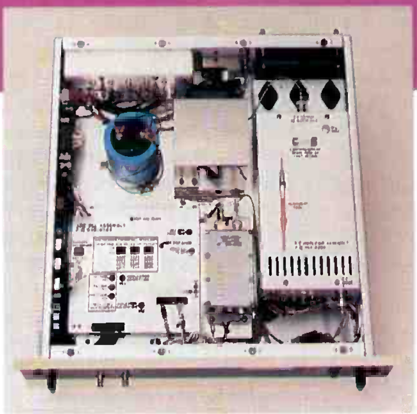

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Circle (7) on Reply Card

How to protect your antenna system

By John Battison, P.E.

In the "good old days" of radio, a broadcaster located a suitable piece of acreage, went through minimal zoning and planning formalities, and proceeded to erect an antenna system. All of that has changed. Not only is it becoming much harder to find suitable acreage, but it is becoming even more difficult to get a proposed site past the local zoning boards.

Even if it does scrape past the local town zoning board, sometimes other agencies, such as county and state boards, can hold up site approval. With more and more local authorities examining broadcasters' affairs, we now have the situation where even the installation of satellite dishes is banned in some cities, and I'm not even thinking about RF non-ionizing radiation problems with EPA.

We cannot affect zoning boards and city councils in these columns, but the direct and indirect effects of other influences on an antenna location usually can be dealt with by engineers. These influences include, but are not limited to, cellular phone towers, water towers, microwave relay towers, power lines, tall buildings and even adjacent broadcasting towers, such as LPTV or translator/booster supports. Almost anything that protrudes more than about 50 feet above ground near an antenna system is suspect.

About the only protuberance that is not added after an antenna system is erected is a water tower. The only thing that saves us from those is the water company's need to locate on high ground (I am thinking of the effect on AM operations, not FM or TV). If you *must* locate your DA near a water tower, it can be taken care of quite easily, and standard treatment will detune it.

Notification requirements

When an application is made for an AM, FM or TV station construction permit, the applicant must indicate its proximity to existing radiators. When an application is made for a low-power TV station, however, the question of another antenna's proximity does not arise. I'm not sure about cellular phone applications; the question may not be asked. Sometimes it seems that the station knows about it only as the tower is being built; at other times the cellular phone company takes the initiative. But LPTV and other towers can spring up like mushrooms. Microwave and mobile radio towers also have a disclosure requirement in the application, but it is not always followed.

Therefore, an AM station with a DA should keep a running watch on local building announcements and nearby construction. In the "good old days," stations had an engineering staff and a chief engineer. Part of the engineer's job was to keep a running watch on FCC releases and local zoning announcements to ensure that RF obstructions, such as towers, did not grow suddenly in nearby fields. Today, the few stations with a consulting engineer on retainer can have him keep a running watch on the station's behalf, but even this measure cannot cover unannounced construction.

An AM station with a DA should keep a running watch on local building announcements and nearby construction.

Watch for construction

This brings up an area where contract and full-time station engineers can demonstrate their usefulness to management. Don't hesitate to point out any nearby construction, especially towers, that could conceivably affect AM operations.

If a tower appears to be going up, make it a point to find out the owner's name and ask to see a copy of the construction permit (CP). If he won't or can't show you one, ask the station's attorney to get one from the commission. Also, make a careful set of monitor point measurements, and add some extra ones that the situation appears to indicate. These will give you powerful ammunition to use in case of arguments after the tower's erection.

A condition in the CP should state that the applicant must not interfere with existing operations and that it is his responsibility to rectify any problems that may result. If such a condition *is* there, you have a strong legal leg to stand on. If it is not, your management should go on record immediately to the FCC and ask for protection. It is much easier to get protection by putting your request in *before* the application is granted than *after*.

Snake in the grass

One other "snake in the grass" for broadcasters is *eminent domain*. This, fortunately, is a tool restricted to federal and local governments and public utilities. The latter are the hardest to combat, because they may, and do, ignore protests and proceed with construction while the court hearings are pending. In too many cases, radio installations are damaged by the heavy-handed use of eminent domain.

Without a word to the FCC, this broad and frequently damaging power allows a utility to take access to and erect a power line immediately adjacent, or even on, a broadcaster's antenna area property.

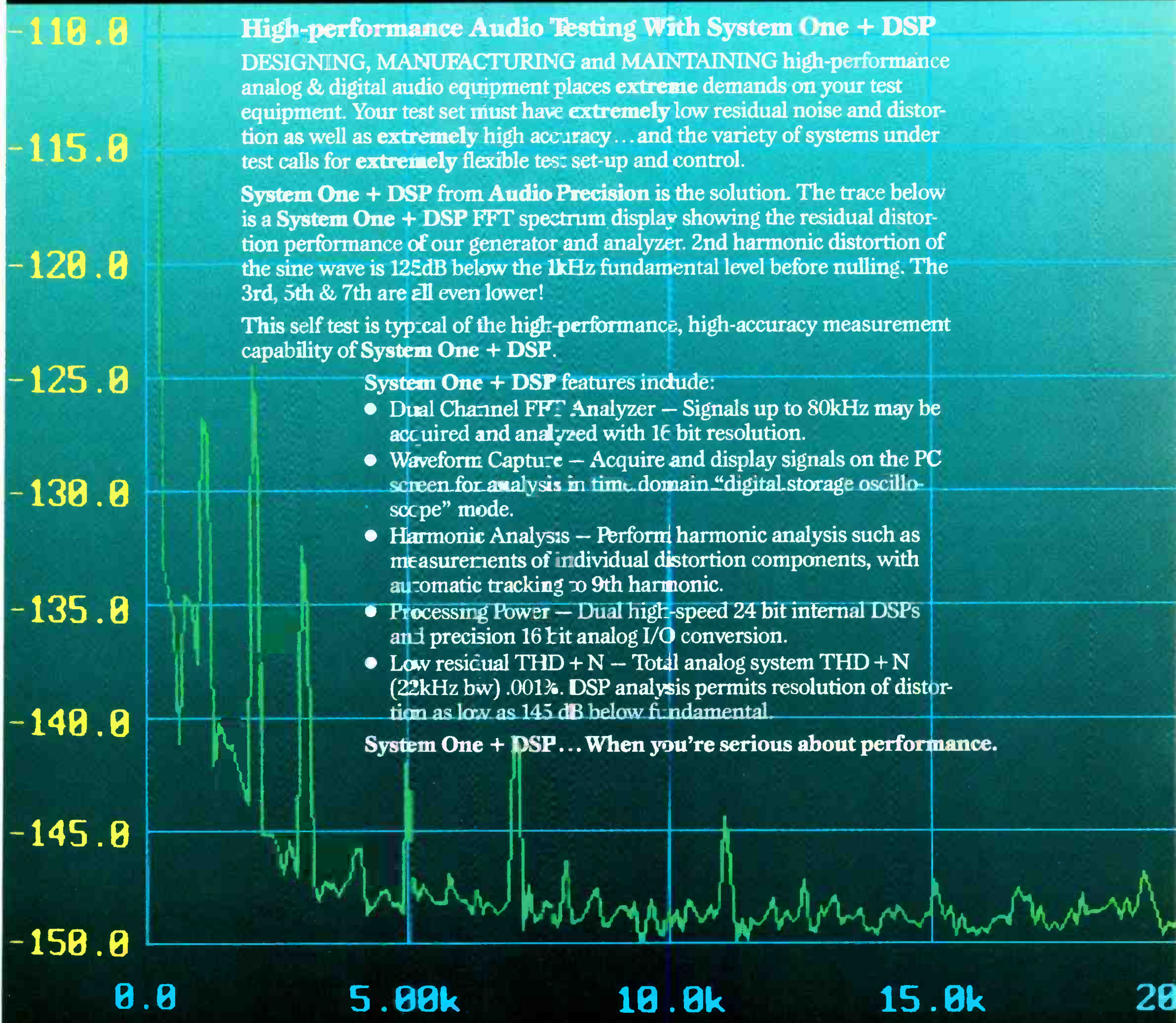
The Canadian engineering fraternity has performed a lot of research on this problem. Even in that large and relatively unpopulated country, utilities follow true to form and locate adjacent to DAs. The Broadcast Group of the IEEE also has published useful material on this subject. I have found that the wooden 100-foot poles with lower voltage lines cause a lot of trouble, perhaps more than the high wires.

The grounding wire on each of these wooden poles acts as an effective reradiator for stations operating near the top of the AM band. The easiest solution would be to cut these wires, but I never have met a utility that would allow this. The easiest solution is to place a special power-line ground detuning choke in the ground wire. It cuts the wire electrically at the station's frequency, which often is enough to solve the problem of reradiation.

Next month, we'll look at the issue of who pays for these modification costs.

Battison, BE's consultant on antennas and radiation, owns John H. Battison and Associates, a consulting engineering company in Loudonville, near Columbus, OH.

Extreme Measures



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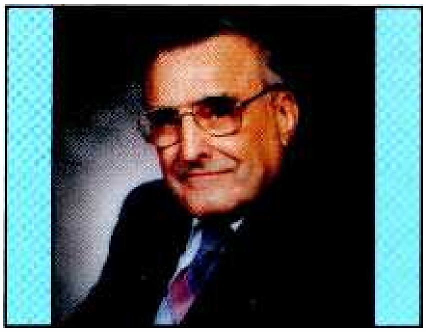
Uncommon engineers



Carl E. Smith

By Elmer Smalling III

Profile

- *Established Cleveland Institute of Electronics*
- *Received the government's Commendation for Exceptional Civilian Service for wartime contributions*
- *Developed the circularly polarized antenna*
- *Wrote more than 53 books and articles and has held 21 directional antenna seminars for the NAB*
- *Established Smith Electronics*

Eldon, IA, near Ottumwa, is the home of the famous "American Gothic" house. It is also the birthplace of an American electronics institution, Carl E. Smith. He grew up on farms in Libertyville and Lebanon, IA, graduating from Libertyville High School in three years with honors. In 1925, he attended Parsons College in Fairfield, IA, where he majored in pre-engineering and French. After Parsons, he attended Iowa State University in Ames. This year Smith will celebrate his 60th anniversary as an alumnus of Iowa State, where he received his BSEE.

Educational journeys

In 1930, Smith traveled east to RCA in Camden, NJ, where he took a student engineering course and attended post-graduate courses across the Delaware River in Philadelphia at the University of Pennsylvania's Moore School of electrical engineering. He returned to the Midwest in late 1931 to continue his education at Ohio State University, earning an MSEE in 1932 and his PEE in 1936. His thesis on broadcast antenna systems was the largest ever presented for the professional degree in electrical engineering.

After marrying in 1932, he took an engineering position with WHK radio in Cleveland, which would be his base of operation for many years. In 1932, Smith founded the Smith Practical Radio Institute in Cleveland to assist those who wanted to further their education and increase their technical skills. He held his early engineering courses in a single room before the sessions grew into the Cleveland Institute of Electronics (CIE), which he established in 1934. His first classes at Smith Practical Radio Institute consisted of about 12 students, far short of the 30,000 students enrolled in the Cleveland Institute program today.

Wartime contributions

In 1948, Smith purchased the Nelson Radio School, moved it from New York and merged it with CIE. By doing this, he was able to increase the number of subjects taught. Smith wrote most of the institute's text material, much of which was published for use by students and engineers outside CIE as well. His clear and concise teaching has made difficult subjects, such as calculus, trigonometry and advanced algebra, less threatening to electronics students and broadcast engineers. He remains chairman of the board of Cleveland Institute of Electronics.

During World War II, Smith moved to Washington to join the Army's operations research branch as assistant chief in the office of the chief signal officer. He led the military radar training effort that was to include such schools as Harvard and the Massachusetts Institute of Technology.

Smith convinced the Army and Army Air Corps to commit to radar training. He also wrote electronics and radar textbooks along with his staffs at Camp Murphy north of Palm Beach, Fort Monmouth in central New Jersey and Camp Crowder in southwest Missouri. Extensive antenna and propagation studies were conducted under his supervision, and teams of antenna specialists were trained by Smith and his staff for the European and Pacific theaters of operation. Smith received the government's Commendation for Exceptional Civilian Service for his wartime contributions.

After the war, he returned to WHK and WHK-FM as vice president of engineering, where he developed the circularly polarized antenna. In 1947, after thorough testing and submission of the data to the FCC, he received a license to operate using circular polarization in just 30 days.

A prolific history

Smith received a number of important patents for antenna design, including an electromechanical calculator for solving antenna equations, circular polarization of radio waves, the slotted cylindrical antenna, the spiral slot antenna and a low-loss antenna system using a counterpoise. He has written more than 53 books and articles and has held 21 directional antenna seminars for the NAB. His "Systematic Directional Antenna Design," published in 1946, includes more than 15,000 antenna patterns from which engineers can pick an antenna array that fits their application.

Smith has designed many high-power facilities for the Voice of America, such as two 100kW directional arrays in Munich and a 1MW system located on 6,000 acres in North Carolina. He has been a consultant to HCJB, the giant Christian shortwave station in Quito Ecuador, and engineered the 500kW station on Bon Air Island in South America.

Never too old to learn

In 1956, he established Smith Electronics as a consulting firm that would provide research, development and engineering services to government and industry.

Smith Electronics conducted AM field tests at WGAR in Cleveland and at other stations that resulted in the FCC's adopting the Magnavox system of stereophonic transmission for AM radio on April 9, 1980. On March 4, 1982, the FCC authorized AM stereo with a minimum of constraining technical regulations. In 1988, Smith sold Smith Electronics and founded a new company, Carl E. Smith Electronics, to continue his broadcast consulting.

Smith's career includes continual education, which is perhaps the reason for this octogenarian's great success and prolific output. His additional graduate education included stints at Case Institute of Technology and Ohio State University. He received his First-Class radio-telephone license in 1932, his amateur radio license, W8KJQ, in 1933, and was made a Fellow of the IRE (now IEEE) in 1955.

Every broadcaster has benefited from this uncommon engineer's contributions to the industry. His continuing research, consulting and educational efforts have helped make broadcast engineering a challenging and respected career.

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

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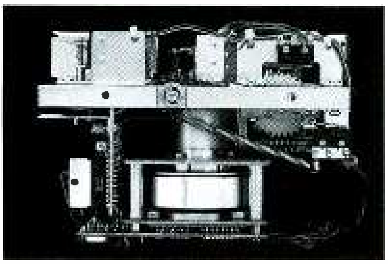

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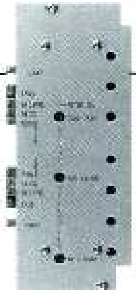

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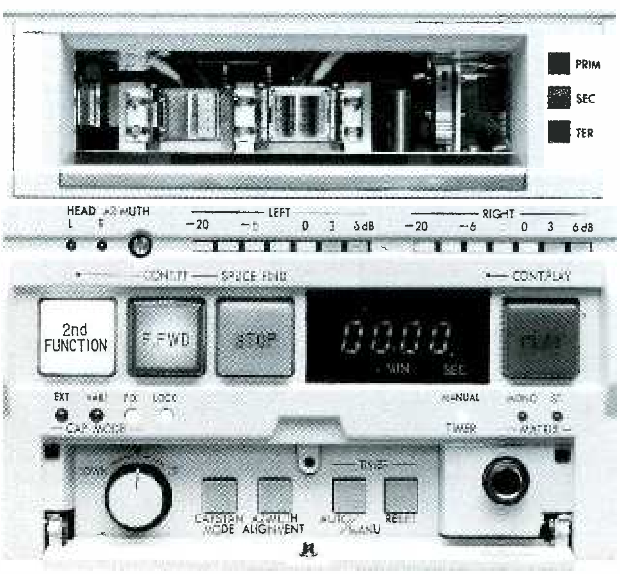

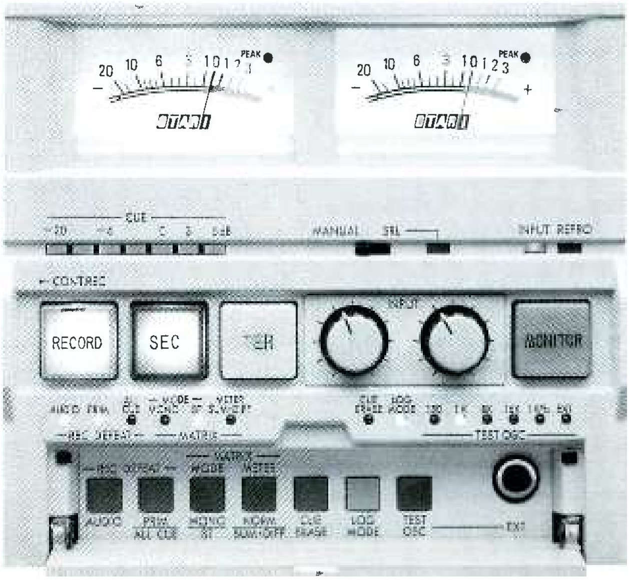

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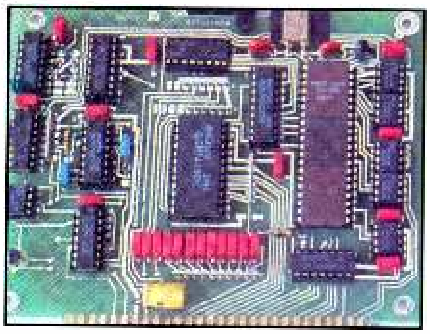
Part 1

Circuits



Use microcontrollers for station projects

By Gerry Kaufhold

Broadcast engineers always have been a creative breed. In fact, during the early days of broadcasting, many important innovations were brought about by working engineers who perceived better ways of doing things.

The FCC always has maintained detailed guidelines for the broadcast technical chain, but every other operable part of a broadcast facility is fair game for creative problem-solving.

As the field of broadcasting evolves, many opportunities are opening up for broadcast engineers to create unique ancillary equipment. For example, automation and robotics are entering broadcast facilities in a big way. Because no two broadcast operations are identical, each station will need to customize its implementation of these upcoming technologies.

This series will examine various ways that working broadcast engineers can use off-the-shelf microcontrollers to design and build cost-effective enhancements for their stations' operation.

Facts about microcontrollers

Single-chip microcontrollers are low-cost microprocessors that can be made to do amazing things. For example, most videotape machines contain several single-chip microcontrollers that manage such functions as head-rotation speed, tape tensioning and editing. Single-chip microcontrollers also are used to control printers, graphics displays and remote-control equipment. Since 1980, single-chip microcontrollers have been used for various functions in automobiles.

Single-chip microcontrollers cost less than $10 each, even in small quantities. After you have learned how to apply the techniques of microcontroller design, you will be able to attack numerous practical problems and create exciting, low-cost supplemental equipment for your station.

Examples of readily available devices are the Z-8 and the 6804/6805. These parts come in a variety of configurations and are available from several manufacturers. Local electronics suppliers probably carry one of these popular devices. The local manufacturers' representative might provide EPROM programming equipment or services, and perhaps a few sample parts to get you started.

Single-chip microcontrollers are low-cost microprocessors that can be made to do amazing things.

Embedded control

The popularity of single-chip microcontrollers recently has given rise to a new industry buzz word. Any microprocessor whose program resides permanently in EPROM or ROM, and is only expected to perform a limited range of specialized functions, is called an embedded controller. (See Figure 1.)

A chip like the Z-8 contains a Universal Asynchronous Receiver/Transmitter (UART) on board, so that with just a few external components, it can be connected directly to the COMM port of a personal computer. This powerful feature makes the Z-8 an easy-to-use processor for connecting a PC to a variety of external equipment, such as videotape machines or remote-control equipment. The UART of the Z-8 also can be connected to a modem for implementing remote controls that respond to dial-up lines from a personal computer back at the studio.

The field of embedded control is so new that many of the interesting and helpful functions that could be created for broadcast stations have not yet been invented. Because original equipment manufacturers (OEMs) will go after the big-volume business, the broadcast community must learn to apply these useful devices to the one-of-a-kind applications that are typical in broadcasting.

Kaufhold is a market development engineer for SGS-Thomson Microelectronics, Phoenix.

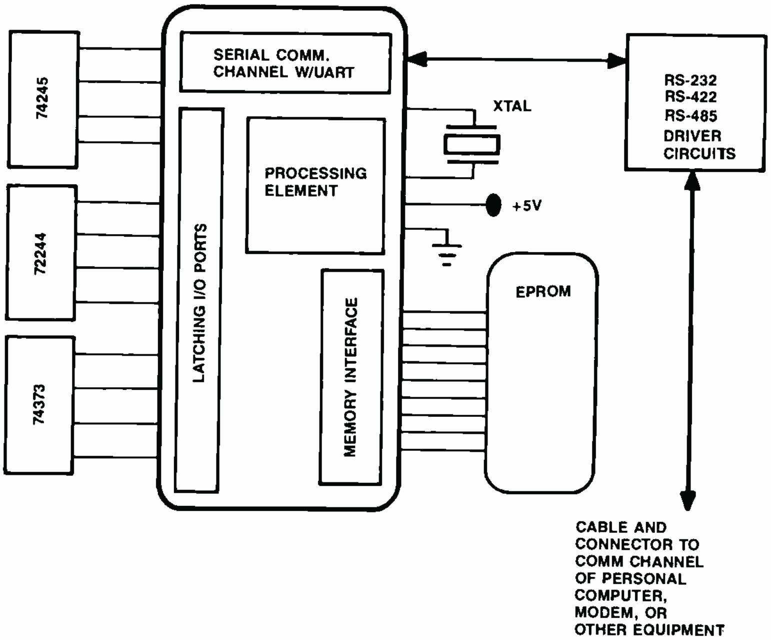
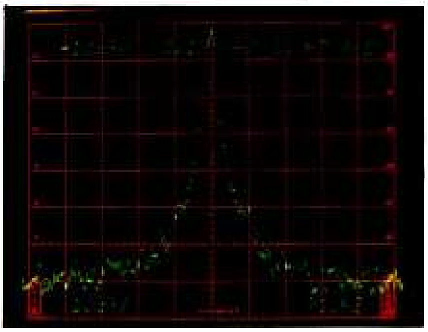


Figure 1. *A generic embedded controller using a single-chip microcontroller.*

Troubleshooting



Reviewing video basics

By Mark Everett

For the last three months, we've discussed the importance of system timing. One key is the proper use of a reference generator to lock your in-house system together. Let's discuss how easy it can be to create errors, even in a well-designed facility.

What reference?

Any production or post-production system needs reference signals distributed to the video sources used by the switcher. Example sources could include the following: cameras, time base correctors (or VTRs with built-in TBC), DVEs, character generators, frame synchronizers and production switchers. Many of these devices have at least one input for a reference signal.

In most cases, the device will have its own internal sync generator, which must be gen-locked to your system. Not all video equipment can use the same type of sync. Some equipment might require sync, blanking and subcarrier in addition to other pulses. Other equipment can work with only sync and subcarrier. Some equipment may operate properly with only a *reference* and then develop its own timing signals. The point is that everything requires some type of reference, but all references may not be the same.

I won't list every type of video product and its own reference, but there are some hints available. These rules apply to PAL as well as NTSC and are slightly modified for component systems.

Encoded color systems, such as NTSC and PAL, require at least sync and subcarrier to lock a color signal. The reason is that color video in both systems needs to lock the video in vertical, horizontal and color frequencies. There are some tricky ways to combine the needed references into one signal. Blackburst is the most common combination signal.

Blackburst is a composite video signal that includes sync (both horizontal and vertical), burst and other reference signals. Color bars or almost any other stable color video signal will probably work in place of blackburst for generator locking purposes.

Everett is manager of corporate communications with Videotek, Pottstown, PA.

Encoded video systems usually require blackburst, locked to the master generator for reference or gen-lock. If the system is black-and-white, then sync is usually all that is needed. Any component system will use a mixture of sync to some devices (switchers, monitors and production switchers) and color reference (sync and subcarrier, or blackburst) to cameras, DVEs and similar devices.

Label the confusion

One problem is that the industry doesn't use standard labels for the references. You may have to guess what a particular manufacturer means. For example, I've observed the following terms on video equipment: *Gen-lock, Reference, Ext. Lock, Ext, Ref.* and *Sys Vid.* Each of these labels actually meant the equipment needed blackburst.

If you're working with an encoded color system, sync or subcarrier alone won't work. There are a few exceptions to the rules on these labels. Many devices require sync and subcarrier. Sync has no color information, and subcarrier has no horizontal or vertical timing information.

If blackburst is used where sync is needed, the device probably won't work. Sync is 4V in amplitude and blackburst is only about 0.5V. The input amplifiers of the device may not have sufficient gain to handle the low-voltage reference signal. Or, in the case of using sync when blackburst is needed, the 4V signal may overdrive the input circuit. In both cases, genlock will not be possible.

If you're not sure about the type of reference needed, read the book. I know that engineers hate to do that, but sometimes it's necessary.

Timing the system

Now that we better understand the importance of the correct timing signals, let's decide how we're going to distribute them. One common mistake is in failing to account for the delays in the cable and signal processing equipment. Here is what can happen by failing to account for the delay in the interconnection cable.

For example, if you're using five feet of 8281 cable, which has a propagation factor of 66%, the delay will be 7.76ns. This represents 10° of subcarrier. It doesn't take many short lengths of cable plus the inherent delays of the processing equipment to ruin the video signal.

Let's connect together a working system and see what can happen. Using 100 feet of 70% velocity cable, connect sync from a generator to a TBC. Now connect subcarrier with 96 feet of 66% velocity cable from the generator to the same TBC. What is the resulting SC/H phase error?

The resulting SC/H phase error is 39°, before you even turn on the TBC. Thus, 100 feet of 78% velocity cable represents about 200° of phase delay. Ninety-six feet of 66% velocity cable is about 161° of phase delay. The two signals will be far out of time, yet the cable difference is only four feet. The cause of the problem is the use of two different types of cable in the example installation.

Had you used the same type of cable for both runs and still had a length difference of four feet, the SC/H phase difference would only be around 8°. Although that's not perfect, it's a lot better than the 39° error in the first example installation.

Other pitfalls

You also can get into trouble in other areas. A sync generator provides output signals with the proper timing relationships. One subcarrier cycle is at the zero crossing and going positive exactly at the same time the leading edge of composite sync (at line 10, field 1) is going negative. The measurement point is at the 50% point of the leading edge of horizontal sync or −20IRE. This condition exists in any sync generator that maintains subcarrier-to-horizontal phase (SC/H).

Therefore, any device that requires separate subcarrier and sync (or blanking) is open to system problems. The use of incompatible cables, not the device, is the problem. Cable type and path length are important.

The foremost design consideration is to begin your design with a stable, accurate and dependable sync generator. Then, be sure that the delays produced by all cables, connectors and equipment are accounted for in the final design. Also, be sure you use the proper equipment to check and time your system.

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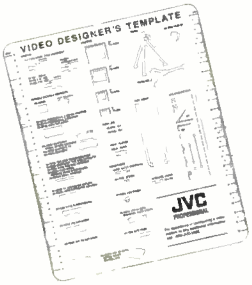

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Part 5

Management for engineers

Finances and today's engineer

By Brad Dick, editor

You should think about next year's budget all year long. Look for opportunities to help build your case for the items you need. If you fall short of money, people or equipment during the year, write a memo. Anytime you can't fulfill another department's request, document that with a memo to the other department and your files. That is the time to begin preselling your budget to others by showing that although you've tried, you've been unable to meet the needs of others.

As you develop a laundry list of needed items and support, prioritize it. List from the top down the support that will help you meet the unfulfilled needs from last year. This usually means that the most expensive items are at the top of the list. That's all right, because the list is for your use only. If you believe you need new tape machines, list them. It may be that after the budget process is complete, you have to settle for rebuilding them instead, but at least you've examined carefully the issue.

Begin the process early

Don't wait for the official announcement of budget preparation to begin your work. Now is the time to begin building your case on paper. Assemble any memos, lists of unmet needs, complaints you may have received about equipment or personnel shortages and your notes from last year. This documentation is the history part of your budget. Combine these with any planned production demands (for instance, new programs or regular remote broadcasts), governmental requirements or expected management changes. These documents represent the future part of your budget.

Now develop an engineering plan to meet the past year's needs, which you were unable to meet before, and the expected work for next year. Start with personnel requirements. This is often the most difficult area to expand because it represents an ongoing commitment. Calculate the needed fringes, supplies and other necessary expenses.

The easiest part for engineers is usually the documentation needed for new hardware. However, as we've discussed before, use your manager's language in your justification. Leave the techno-talk in your office. Such jargon does nothing to help sell your product to the client (boss) and may actually hurt your case.

About two weeks before management issues the yearly announcement of budget due dates, make your first pitch. Schedule a meeting with your boss to review the individual costs associated with each portion of your budget. Help your boss to become comfortable with what you're planning to submit.

This also is the perfect opportunity to identify key client (other department) needs. It may be that significant changes are being planned that would affect the engineering area. If so, you have time to prepare an optional budget to meet those changes. If you know about possible changes and don't develop contingency plans, someone else may do it for you.

Sales job

The sales pitch is the proof section of your budget. Include substantial rationale to support your proposal. The entire proof effort is there to define what your budget covers. Don't be afraid of being detailed and concrete. You must convince top management that your plans are current, accurate, complete and cost-effective. Follow these five major steps:

- *Review past performance.*
- *Analyze the trends.*
- *Review the status of current programming/projects.*
- *Evaluate the likelihood of approval for other projects.*
- *Present a year-long budget review.*

Each of these areas must be addressed in your budget preparation process. Let's take a closer look at each of them.

Review your department's performance. How has the engineering department's work increased in the past few years? Has the amount of local programming increased by 22%? Has the technical staff decreased by 12%? Look at industry trends. Have your technical salaries kept up with industry standards? (If you need resource material or documentation, watch for the upcoming October issue of *Broadcast Engineering*.) Use this as evidence to build your case.

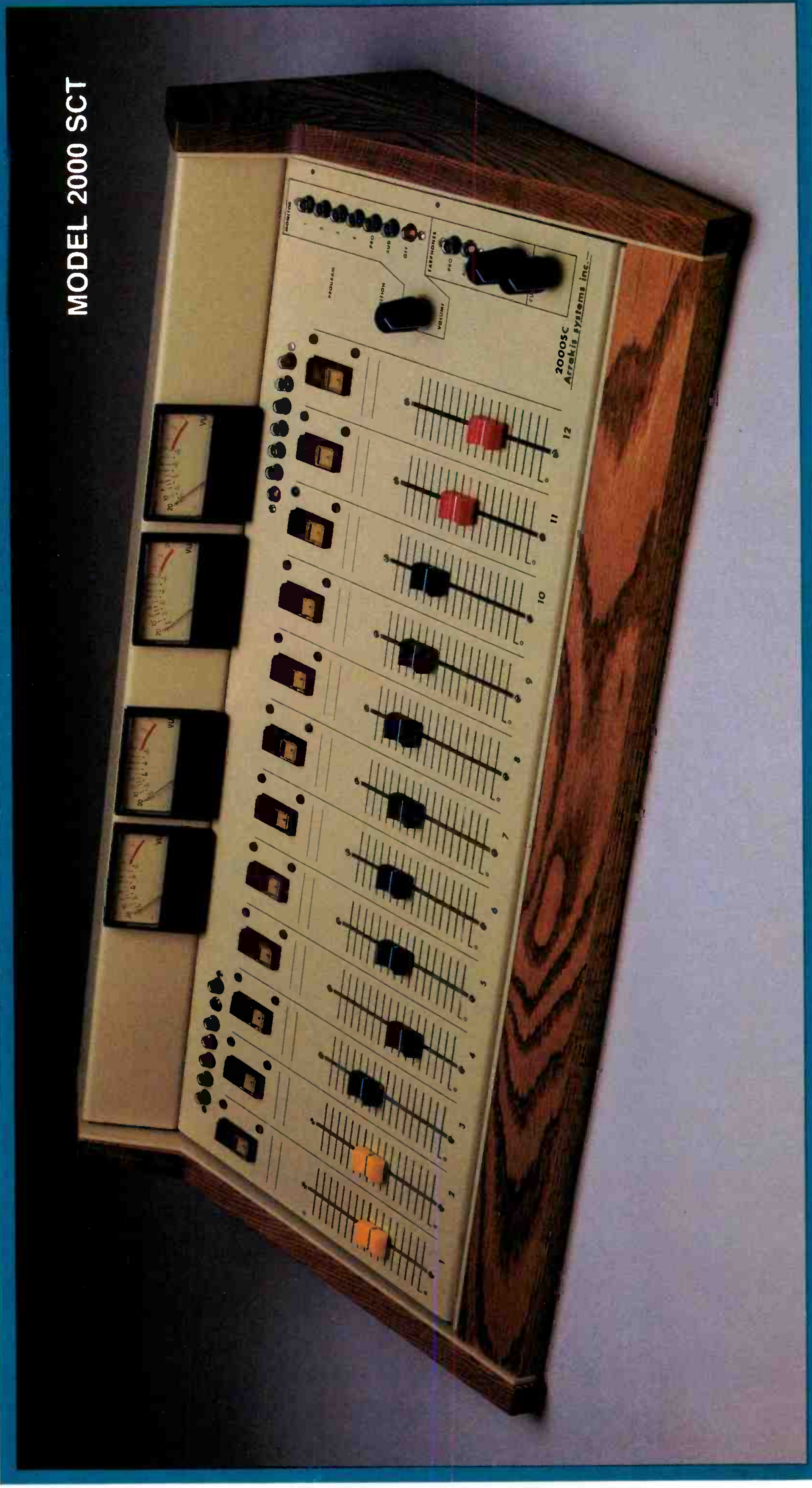
How are the ratings and sales for your station? If you don't know, find out. If ratings and sales are up, you should use that information to help justify additional support. If the opposite is true, be prepared to show why your department shouldn't be cut back. Be sure you know how the entire industry is doing. If the industry is on the upswing and your station isn't, the justification process may be different from where everyone is seeing a downfall. Show how your budget will affect the station's overall financial performance. Look for every opportunity to show how engineering contributes to a positive bottom line.

Review any current projects you're responsible for supporting. For example, if management previously committed to nightly broadcasts of the local weather report live from a remote location, remind them of that commitment. Use these commitments to influence specific portions of your budget. Because such items were already authorized, they must be paid off or management defaults. Be sure your budget begins by highlighting these previously made demands. The result is automatic approval of portions of your budget.

Have other projects been scheduled for which you will be responsible? Have adequate funding and resources been allocated to those projects? Anytime you can see ways to pin parts of your budget to an already-approved idea, do it.

Also, examine the likelihood of future projects being accepted. Although you can't predict the future, the Boy Scout motto, "Be Prepared," is always good advice. If you suspect that the news department is going to ask for funds to support an investigative feature staff, be ready to supply the technical costs.

Engineering departments often are caught in a budget squeeze when programming commitments are made without adequate planning for the technical costs. To avoid this, try to work with other departments all year. That will make it easier to pick up on their wants and plans throughout the year. Remember, you will be more successful if you can link your budget to performance and other station goals and objectives.



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Audio-video control systems

Whatever it may be, an audio-video control system is the key to an efficient station.

I have written the introduction for the Audio-Video Control System issue for three years now, and I still haven't figured out exactly what the words "audio-video control systems" mean. I have worked in many stations, even helped build a few, but I have yet to open a box that says "audio-video control system" on it. Where does such a system fit on the station block diagram? What is its part number in the manufacturer's catalog? Do such systems come in 19-inch configurations with rack ears and screw holes?

Facility control systems don't exist as individual devices at discrete locations, as do organs in the body. Rather, elements of the facility control system twist and meander through the whole station, like the ganglia of the nervous system. It is every place, and yet, no place. Perhaps the true location of the station's control system is in the design philosophy of the engineer or engineers that pieced it all together.

Today, there is mounting pressure to simplify, condense and streamline our facilities. Every piece of equipment must pull its weight all of the time. This spreads costs over many hours of use each day, and improves the bottom line.

We cannot achieve this kind of efficiency through arguing the merits of one tape format over another or one cart machine over its kin. This level of efficiency is a system issue, and can only be discussed after stepping back and looking at all of the station's equipment — interconnecting and controlling elements — as a whole. It is from this perspective that we will examine facility control systems.

We treat the Audio-Video Control Systems topic with the following articles:

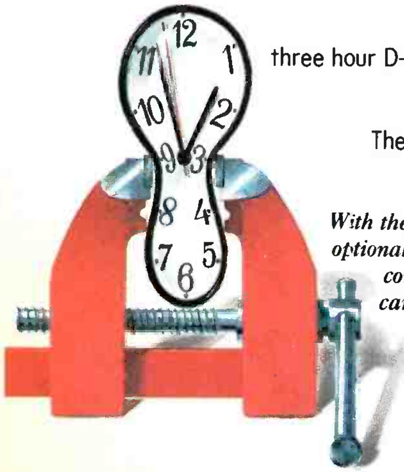
No matter how carefully we select each individual piece of production equipment, we must pay at least as much attention to the integration and control of those devices. In this way we can achieve the efficiency required in broadcasting today.

Rick Lehtinen

Rick Lehtinen,
technical editor

D-2 has expanded the li
Now it can co

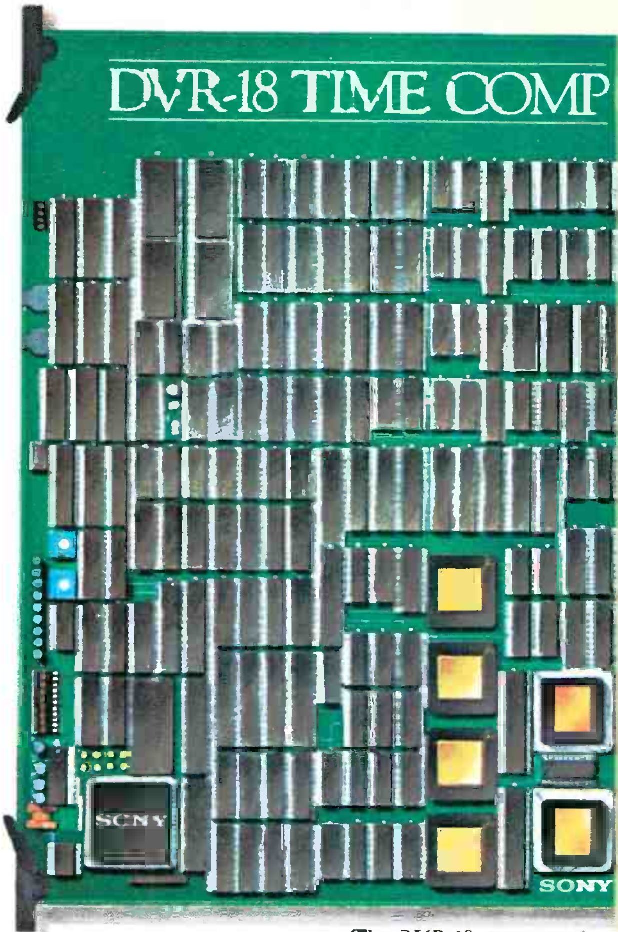
It was only a matter of time. Now Sony D-2 composite digital video offers broadcasters something they've been waiting for. Time compression. It's an option now available on the DVR-18, Sony's three hour D-2 VTR.



With the DVR-18's optional time compression, you can squeeze more out of the time you've got.

The DVR-18's time compression and expansion feature is remarkably advanced. A single plug-in module provides full audio data recovery as well as precise digital pitch correction for two stereo pairs of audio signals at the same time. For example, your main audio channels and your SAP. All without the need for any external equipment.

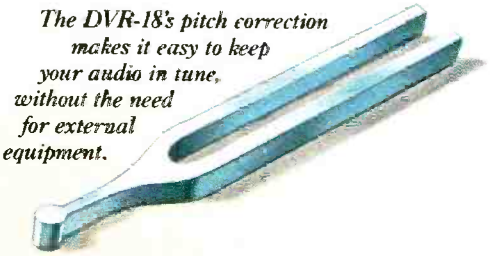
Plus, the DVR-18 gives you Sony's advanced picture processing for the highest quality video playback. And since it's digital, you'll get a time



The DVR-18 gives you the

compressed program without losing a generation.

Of course, the DVR-18's time compression



The DVR-18's pitch correction makes it easy to keep your audio in tune, without the need for external equipment.

and expansion isn't the only reason why broad-

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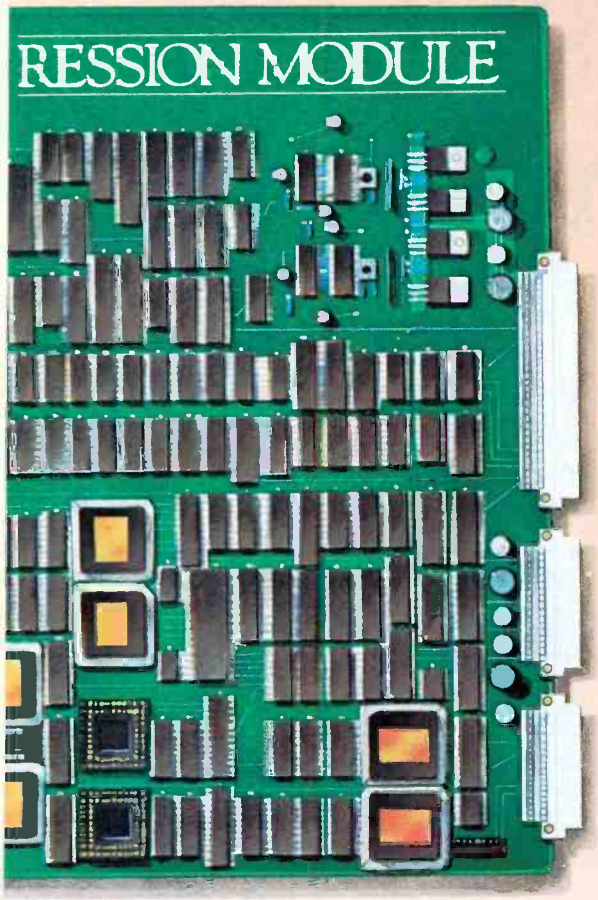
mpress them.



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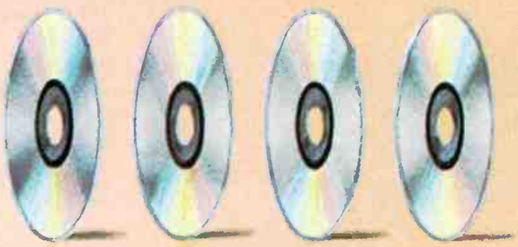

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Present and future facility control systems

Facility control systems: Use today, design for tomorrow.

By Don Reynolds

Control systems, both manual and automated, are the nervous system of any broadcast or post-production studio. When designing a facility control system, we are directly affecting the future of our facilities. Many issues must be addressed. How will the control be integrated into your system? How will production resources (VTRs and still-stores) be allocated? How will the control system actually control machines? Who has the authority to use which devices, and how is this authority to be delegated? Because a facility can only perform as well as its control, this important area deserves at least as much attention as the design of the routing and distribution system itself.

This article overviews some of the principles used in facility control.

Get a handle

In many cases, the control system used in stations is all that the operating personnel will ever see and touch. Whereas once broadcasting might have been a matter of firing up two tape machines and running back and forth to determine which playback was the most acceptable for air, broadcasting equipment today is so technically sophisticated that the quality of picture is rarely the issue. The critical element today is rapidly becoming one of productivity. How can each machine be most efficiently used?

If you're planning a new facility or expanding a present one to include new, more powerful production tools, you'll want to consider a few fundamental but easily overlooked issues before making expensive, difficult-to-reverse decisions. The more powerful the production tool, the more flexible a control system it will need. When weighing the pros and cons of each approach, determine which will meet both present and future needs, in addition to your budget.

There are several different control philosophies. Your needs will change over time. Therefore, when planning your control system, consider controllability, expandability and flexibility.

Reynolds is product manager for Dynair Electronics, San Diego.

Accommodating automation

As technology races ahead, automation becomes more and more prevalent. For many years videotape editing has been fully automated. Advances in station automation are dramatized by developments in automated cart systems, net delay systems, automated satellite terminals, studio robotics and increasingly comprehensive device control on the part of the newsroom computer systems. With the assistance of computers and robotics, station managers can now rest assured that revenue-generating commercials and programming will broadcast accurately and on time.

However, automation and computers still haven't replaced all manual activities in the broadcast and post-production environment. It is important to question how a proposed facility control architecture will handle movement of critical resources back and forth from automated to manual tasks. Sports events, live remotes and most ENG still require manual intervention. Therefore, your control system must be capable of rapidly switching from automated operation to special configurations in which the human has control, or at least override, of computer-generated commands.

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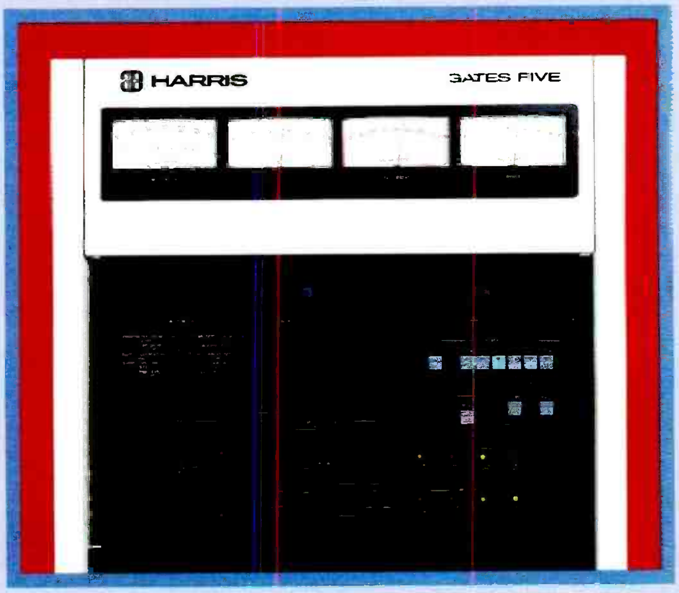

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ESbus

The best systems may be those that allow control of any production device from any control panel or port. One basis for this interchangeability is the ESbus. This industry standard, issued by the American National Standards Institute (ANSI), takes its name from the European Broadcasting Union (EBU) and the Society of Motion Picture and Television Engineers (SMPTE). (See Figure 1.)

ESbus is a flexible communications protocol that offers control of audio, video and film production devices. Embedded in the ESbus protocol are provisions for error-checking routines, which make the system extremely robust. For the most part, manufacturers have adhered to the ESbus standard. In two out of three aspects — hardware and addressing systems — they have followed the standard closely. However, in the third area — that of dialects, the standard has not been followed closely. Each product speaks a different dialect. Consequently, machines require dialect converters to allow communication with the control system.

The ESbus standard faces other limitations as well. The standard recommends that only 32 total machines and controllers be connected to a single control bus. Additionally, the system tends to be slow in larger applications.

Improving the ESbus

A few methods have been developed to overcome these shortcomings. Some studios use bus/LAN layers to maximize their system capabilities. A single high-speed LAN is connected to several ESbuses, resulting in increased communication speed. Others rely on a single high-speed computer with many ESbus ports that can each connect to 32 devices. All of these methods solve speed and number-of-device problems, but they also add complexity.

Another option for increasing speed lies in LANs operating outside the ESbus standard. Several companies have developed proprietary systems based on higher-speed hardware. Although the cost often runs significantly higher, these systems carry messages at a rate 20-50 times faster, but still only to a limited number of machines.

Control routing

Another less common yet effective approach takes advantage of a control routing switcher. (See Figure 2.) Rather than sending and processing messages through a central computer or LAN, the switcher makes a dedicated ESbus that includes only the production tools and controllers required for the current project, and sends messages directly from controller to machine.

With each controller and each con-

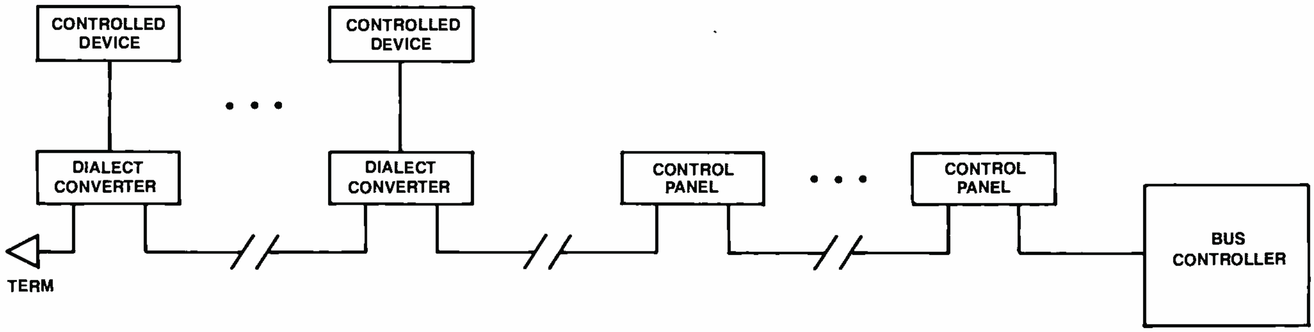


Figure 1. *The ESbus allows control of numerous tape machines from numerous control panels. Dialect converters facilitate non-ESbus protocol devices.*

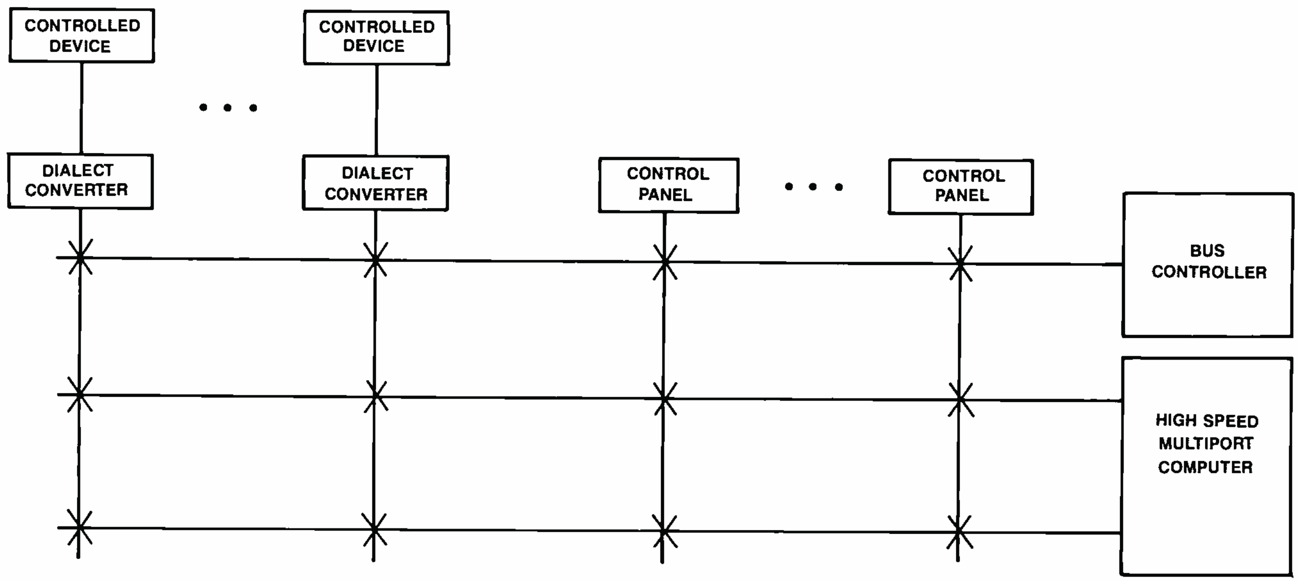
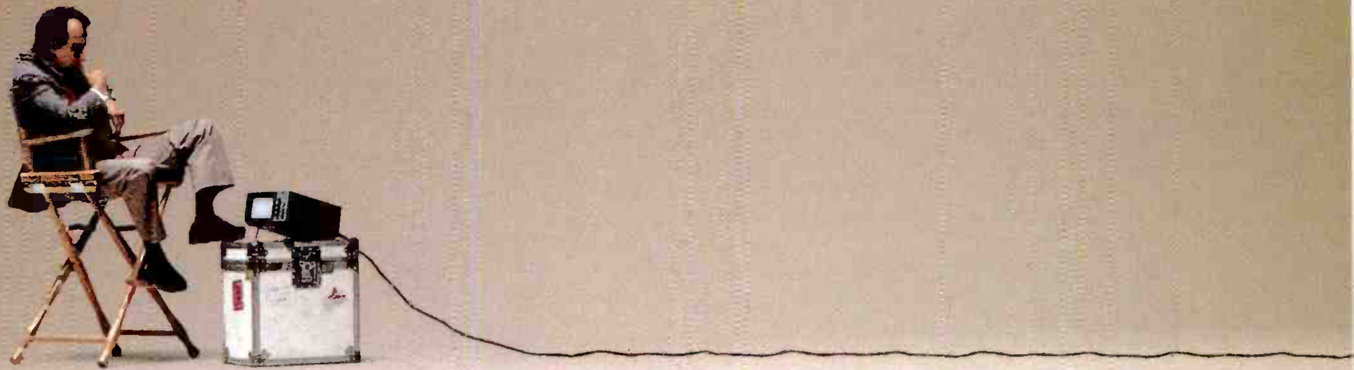


Figure 2. *A control routing switcher makes a dedicated ESbus among all the production tools and control panels required for a given project.*



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trolled unit individually connected to the switcher, the problems of network failure and adding devices are greatly diminished. This method has achieved popularity with some large broadcasters, along with government and military facilities for non-broadcast control and data routing applications.

With this approach, each production tool and each control panel are connected as "inputs." ESbus control ports, from automation or edit control computers, are connected as "outputs." The resource assignment system directs the switcher to connect machines and manual control panels to a control port via a switcher output bus. This bus then becomes an ESbus dedicated to the current project or broadcast schedule. This provides maximum flexibility in large systems by creating a number of small, simple systems so each project effectively has its own facility.

In effect, this system adds another layer to the router. (See Figure 3.) However, in a world where digital video, analog component video, multichannel audio and time code are all switched, switching facility control signals presents an additional logistical hazard, but not an insurmountable technical one.

Of course, control routing systems must start with enough expansion room to handle your future needs, just as does the signal router that goes along with it. The same is true of multiport computers and LAN systems. Thus, you must plan as far into the future as possible, and the system you choose should have the right balance between current system cost and its future expandability.

LANs

One inherent problem with LANs and buses is tap or device failure. With the ESbus, if a single device fails, or if you need to remove a machine from the bus, your whole system is down until reconnected. The proprietary systems have circumvented this pitfall to a small extent by using taps. In the event that one machine or controller breaks down, it can be disconnected from the tap and the remaining components can still function.

Although taps offer better fault isolation, they also have disadvantages. The units are moderately expensive and cumbersome to install and disconnect. Additionally, when the tap itself malfunctions, you could end up back in the original dilemma, and your whole system is down.

Resource assignment

After system architecture, another issue to consider is the machine assignment procedure. Who will have control over your production resources? Three philosophies for resource assignment are "central assignment," "demand-priority" and "delegate-accept."

In a central assignment system, one person maintains authority for machine delegation from a single location. This philosophy has been steadily gaining popularity as automation in the studio environment increases. The central approach offers a large degree of safety — it is nearly impossible for someone to "steal" control of a tape machine or to accidentally cut off a tape during broadcast or recording. However, the facility must have adequate status and scheduling functions to support the system. There must be considerable planning and management to make sure that use of resources is optimized while competition between users for resources is held to a minimum. Although such a system is certainly cost-effective, such intensive resource management is sometimes more than the staff of a busy broadcast studio has time to handle.

A simpler, albeit more dangerous possibility rests in the demand mode. Anyone can use a given machine at any time, no matter where they are stationed. But this also means anyone can step in and push

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the stop button at the most critical moment. To avoid these potentially disastrous consequences, the demand method is usually adapted to include a priority system. Each controlling device in the studio then receives a priority. Logically, those with the higher priority can override the current user. Although this adds a measure of safety to the system, it also includes another layer of system complexity. A specific individual needs to be in charge of assigning priorities and changing them when necessary.

In fact, both the demand and demand-priority systems are too dangerous for most operations. Attempts have been made by some to modify this approach with a "machine free" or "shelf" system. These methods require a resource operator to return a device to the "shelf" after it has completed a project. Unfortunately, station operations staffs are often too busy coping with their next project, or else they simply forget, to return the device to the "shelf." Either way, the control system considers the production tools busy when, in reality, they are not.

The final and most frequently employed resource assignment system is delegate-accept. A controlled device delegates its use to one specific group of control panels, say a cluster of three or four residing in a specific control room. The user gains control of the production device by accepting this delegation. This approach is popular because it provides greater flexibility than central assignment, yet avoids the risks inherent in the demand mode.

Signal router

The interaction between the machine assignment procedure and the signal router is another important issue. The router and the machine control system should work together. Several decisions must be made regarding the sequence of interac-

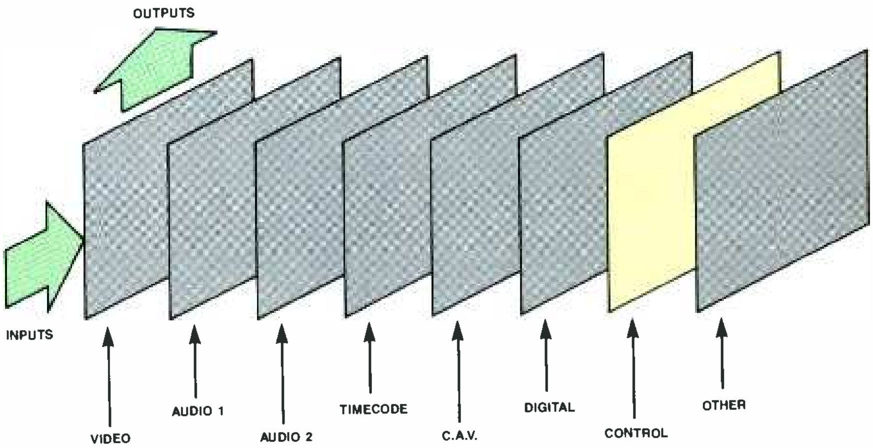
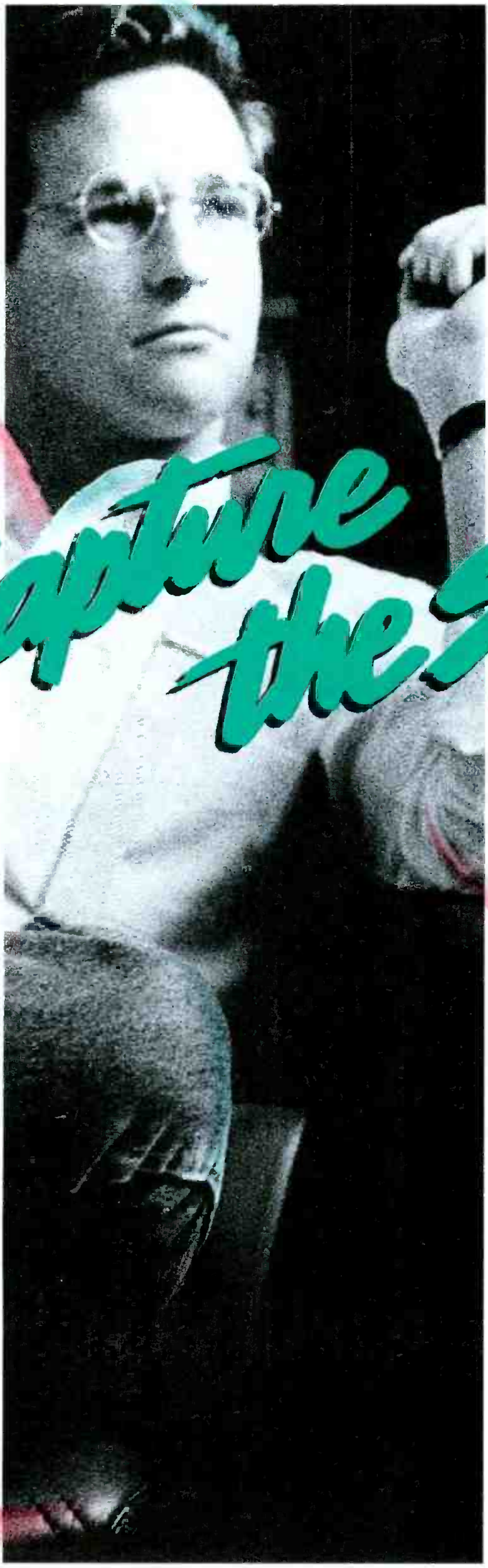


Figure 3. *Using a facility control system adds a layer to the signal routing system, but provides offsetting advantages.*



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tion. Should machine assignment to controllers lead or follow the signal router? What will occur if a signal switch is requested, but the control layer cannot comply because a machine is already delegated elsewhere, or because the remote/local switch on the machine is in the wrong position (that is, delegated locally)? Should the switch be executed anyway? Decisions concerning the machine assignment procedure and the signal routing system will affect the efficiency of your facility.

A demand mode system is probably the least useful. Who wants anyone pulling control of a source away from you when you have that source routed into your switcher? Demand priority is more serviceable, except that the priority must constantly be transferred to the control point requesting the selected device. Some stations have even experienced problems because of a conflict in priorities. Suppose a high-priority user, like the master control switcher, erroneously rolls a tape machine? The switcher may not have the buttons or relays needed to recue the tape, but all other control panels are of lower priority, and will be locked out. This indicates that the table of hierarchy must be carefully planned out.

Central assignment of signal routing and control implies delegating a controlled machine to a specific panel and a production switcher input. Operators may, for whatever reason, want to change the relationship between control panels and production device inputs, but they may find that a central assignment system doesn't provide the required flexibility. An adapted form of central assignment, which includes a delegate-accept system at the receiving end, can accommodate these situations. A central operator assigns control to a logical group, say a control room, which then has the ability to relate controllers to switcher inputs. Assigned resources are delegated to projects, such as control rooms or edit bays, and the operators in those areas establish which control panels go to which production system inputs. Therefore, in the long run, the delegate-accept system may provide the most flexibility for facility control.

Pros and cons for now and tomorrow

The effects of the control decisions you make for your new or expanded plant will be around for a long time. Carefully judge the different architectures, and weigh the pros and cons of each as they apply to your future operations. Prudently plan for growth, because your needs will certainly increase. Consider the importance of adaptability, as glitzy new production tools requiring even more control continue to appear on the market. Careful consideration invested in a system that will serve you well today will also help you far into the future.

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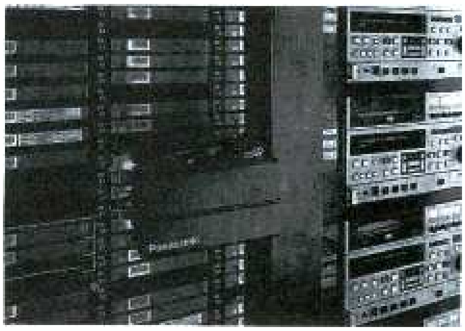

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Making the switch

Is now the time to go to wideband, large-matrix video switching?

By David L. Bytheway

The routing switcher has become a fact of life for most TV engineers. The increased flexibility and reliability brought to the production and broadcast facility is no longer a luxury. Meanwhile, recent trends in technology and production methods have enabled better switchers to be designed. Because a switching and distribution system is a central and often semipermanent part of any facility, the selection of a switching system should be carefully undertaken. Three issues to consider in today's purchases: How will a given device handle future needs for wide bandwidth switching? How large can I build this switcher? Is it expandable as my needs change?

Trends

With the advent of HDTV and digital audio, many engineers are wondering whether they should invest in wide bandwidth distribution equipment. Is it possible to use a wideband switcher for standard bandwidth applications? If so, are there any disadvantages to that kind of operation? Are presently available wide bandwidth switchers good enough to be used in the future when real HDTV signals are available? Are today's control systems flexible enough to add wide bandwidth switchers later without obsoleting the standard bandwidth equipment already in place?

A properly designed wide bandwidth switcher can provide excellent performance for standard bandwidth signals. In fact, they can offer some advantages and improved performance over standard switching matrices. Although some early wide bandwidth switchers had their problems, recent improvements have made possible some truly high-performance switchers. This newer equipment offers flatter bandpass, less time delay, better performance with multiple passes, lower crosstalk and better crosspoint isolation. All of these improvements enhance operation with standard bandwidth signals.

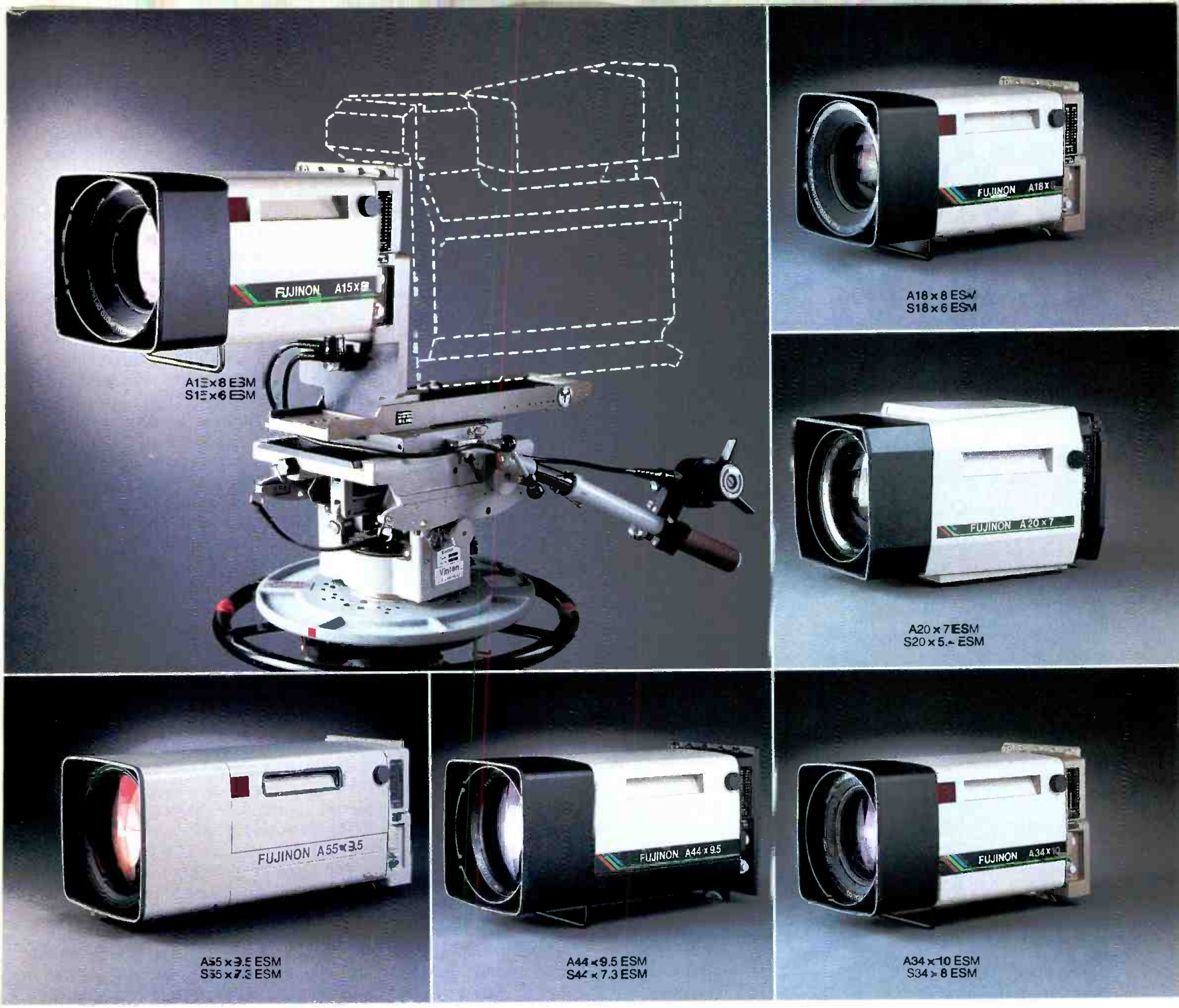
These advances also make the switchers truly capable of handling any of the proposed HDTV standards. It is now possible to get sufficient bandwidth for quality HDTV signals even with multiple passes through a matrix. The reduction in crosstalk, especially at 30MHz, is also of great benefit for HDTV operation.

Wide bandwidth switchers and other distribution equipment require some special considerations, including the use of quality cable and more attention to equalization. Minimizing cable lengths and the number of processing devices in line also helps. If a system is designed with care, the extra costs are small and performance will improve for standard and extended bandwidth signals.

Some newly available switcher control systems are downward-compatible with older standard bandwidth systems, and possess open-ended architecture that makes future expansion and enhancements the rule rather than the exception. Because most of the new video standards use component-type signals, you should consider a system that will allow the addition of more channels or levels of video matrix in the future. Many control systems will allow several different channels or levels of control, for use with multichannel audio, composite video, component video and time code or other data. With the addition of the three or four new levels that HDTV signals will require, less-sophisticated control systems will run out of capacity.

Another recent trend is the rush toward

Bytheway is senior design engineer for BTS Broadcast Television Systems, Salt Lake City.



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larger matrices. Just a few years ago, a large switcher was considered to be 100 inputs by 100 outputs. Now, switchers of 250 inputs by 250 outputs and larger are common. For example, one TV facility recently installed a system pre-wired for 400 inputs by 400 outputs. It has taken some changes in architecture and control systems to enable such large matrices to be built. The problems in constructing such a large matrix and maintaining performance are real. Standard methods of building switchers from years past simply will not work. New switching topologies as well as construction advances make these large switchers more practical and affordable.

Wide bandwidth switching

A video device is considered to be wide bandwidth if it has a -3dB point of 30MHz or higher. In practice, even wider bandwidth than this is desirable, because a typical video signal will have to pass through many signal distribution devices. Each device and its interconnecting cable will roll off the frequency response. The total system response is what matters. Moreover, the typical signal will make many passes through a switcher before it reaches its ultimate destination. So the real answer to how much bandwidth is enough for a switcher will depend upon the exact system configuration and the desired system performance under real operating conditions.

In wide bandwidth systems, details count. For example, when striving for good 30MHz frequency response, the relatively short length of cable between the switcher and the patch panel may require equalization. Switching systems that accommodate these specific needs will be more useful than those that are merely wide bandwidth-capable, but otherwise the same as standard bandwidth equipment.

Some other performance specifications are also important. For example, what is the linearity at 20MHz or 30MHz, not just at subcarrier frequencies? How does crosspoint loading affect frequency response at 30MHz? What is the group delay characteristic out to 30MHz? Although some specifications are relatively easy to make below 10MHz, the situation changes at 30MHz. A switcher truly capable of wide bandwidth performance will have good characteristics throughout the entire passband.

In the past, wide bandwidth designs generally required more power than their standard bandwidth counterparts. More recent designs make it possible to build linear, wide bandwidth switchers and amplifiers without substantially increasing power consumption. The resulting equipment also requires no more cooling than the standard bandwidth equipment it replaces. Beware, not all wideband equipment currently available incorporates these power efficiencies.

Advances in surface-mount construction have also made it possible to place much more circuitry in a given space. Also, such circuitry is generally more stable and predictable as well. Some physical constraints, however, limit the miniaturization that is possible. For example, in many video devices, the limit on size is determined by the number of BNC-type connectors that can be placed on a given rear panel.

Large switching architecture

Full-facility signal distribution has driven the size of a typical switcher to much larger configurations in recent years. Most manufacturers offer switchers between 160 and 200 inputs as the largest number of inputs in a standard matrix. This is usually limited by the number of matrix cards that can be placed in a 19-inch-wide equipment rack. (It can also be limited by the number of BNC connectors). The number of outputs is usually limited by the equipment rack space and the number of input DAs that can be tolerated. Generally, a switcher of 200 inputs by 200 outputs is the largest that can be built practically with standard architecture.

Standard architecture, the so-called "square matrix," uses a single crosspoint for each possible path through the matrix. This means that a 100 input by 100 output switcher will have 10,000 crosspoints. A 200 input by 200 output switcher will have 40,000 crosspoints. Small matrices can usually be built in a fairly straightforward manner. Once the number of outputs reaches a certain size, input distribution amplifiers are required to interconnect the matrix cards. A good rule of thumb states that input DAs are used for all matrices larger than 80 outputs in wide bandwidth switchers. (See Figures 1 and 2.) The total switcher performance will be a combination of the DA and matrix performance. Different manufacturers have different maximum limits on the number of outputs they configure before input DAs are needed.

Building a switcher larger than approximately 200 inputs by 200 outputs requires an alternative approach. One possible method is referred to as "cascaded switching." This technique adds inputs by using a secondary or "combining" switcher to group together the outputs of two or more switching stages that precede it. (See Figure 3.) It still provides discrete and dedicated crosspoints for every possible path, but does require each signal to pass through an additional crosspoint in the combining matrix. If the number of desired outputs is large, this method will also require input DAs (as described previ-

Continued on page 42

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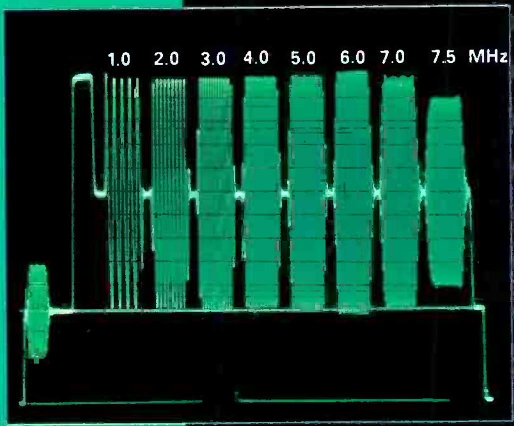
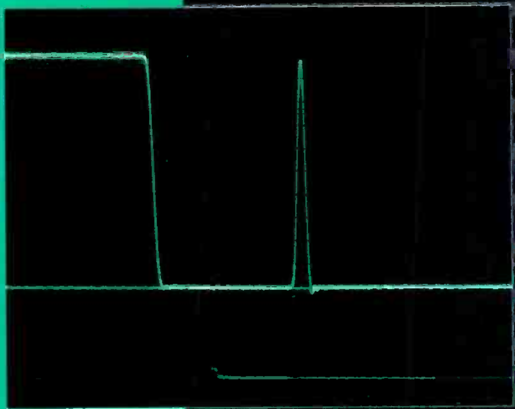


Flat at 7 MHz, the 7.5 MHZ Series shows ultra stable signal response at a full 7.5 MHz with little or no degradation.



The 7.5 MHZ Series faithfully produces a 2T K factor of less than 0.25%.

These photos show actual waveform outputs produced by an off-the-shelf 7.5 MHZ unit.

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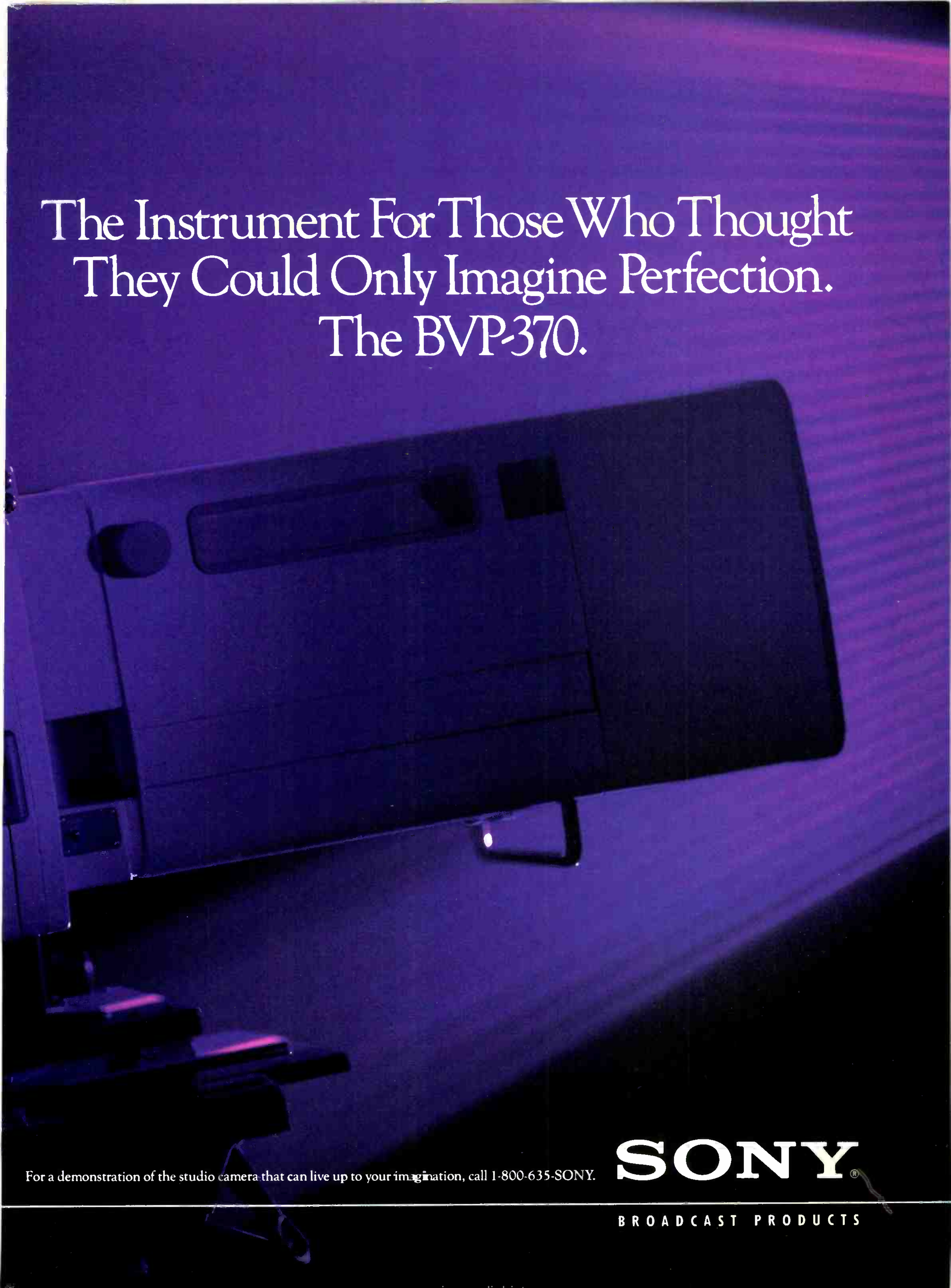
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Continued from page 38

ously) to feed multiple combining matrices.

Another method called "multiple stage switching" can provide crosspoint count reduction. This approach can result in significant cost and size savings. One implementation called "3-stage switching" uses a variation of a technique first described by Charles Clos at Bell Labs. With it, large switching matrices can be built that do not use input distribution amplifiers or combining matrices. Figure 4 shows a portion of a 200 input by 200 output matrix built with 3-stage architecture. Each small matrix building block is connected to each subsequent matrix by a single cable. This method has the advantage of reducing the total number of crosspoints required substantially. It has the disadvantage of requiring each signal to pass through three separate crosspoints. As a result, the individual performance of each crosspoint must be good, to ensure adequate overall performance.

Also, the control system for this type of switcher must be intelligent. Three-stage switching requires a lot more sophisticated control than do standard square matrices. The control system must find a path from the desired input to the desired output. There are a number of possible paths. In order for the switcher to be non-blocking (i.e., avoiding a situation in which no possible path is available for a given switch), the control system must be able to keep careful track of all signals and paths, and have the ability to create paths if necessary. Transparent rerouting of already-switched paths is generally required for this. Several switching systems built with this architecture are now operating in the field at broadcast installations.

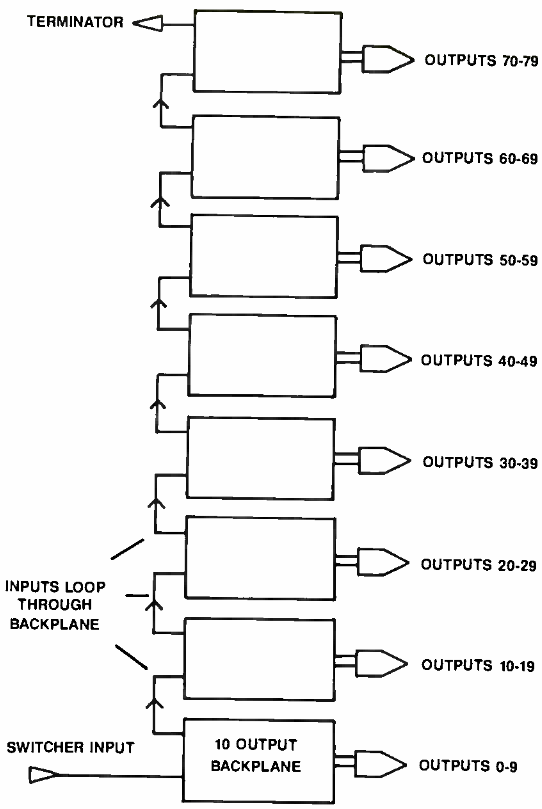

Figure 1. *A typical 80-output switcher, showing input looping structure. Here, each backplane contains 10 outputs.*

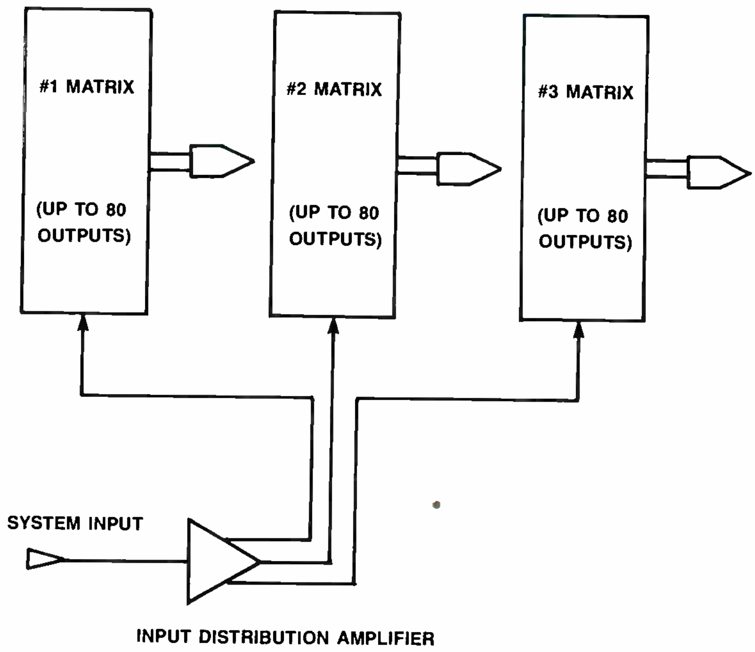

Figure 2. *An input DA can be used to feed each input to multiple matrices in order to provide more outputs.*

Signal performance

An ideal switcher would have perfect specifications: no distortion, no noise, no crosspoint loading and perfect isolation. A real switcher should be as transparent as possible. Crosstalk and other interaction between signals should be absolutely minimized.

Distortion

Distortion or non-linearity in video switchers is usually specified in terms of differential phase and differential gain. Typically, modern switching equipment will have differential phase specifications of less than 0.1° and differential gain specifications of less than 0.1%. This particular distortion measurement is best-suited for specifying distortion in composite-type video signals. Many wide bandwidth designs compromise differential gain and phase in preference for bandwidth. Newer topologies allow high linearity and wide bandwidth.

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"one-sided." This means that the error that is created can be in one direction. If a signal makes multiple passes through a matrix with this one-sided non-linearity, the total error will add directly and become quite large. The ideal is to have a low differential gain and phase error, with a random variation around zero. This will result in very low errors, even with multiple passes through the matrix.

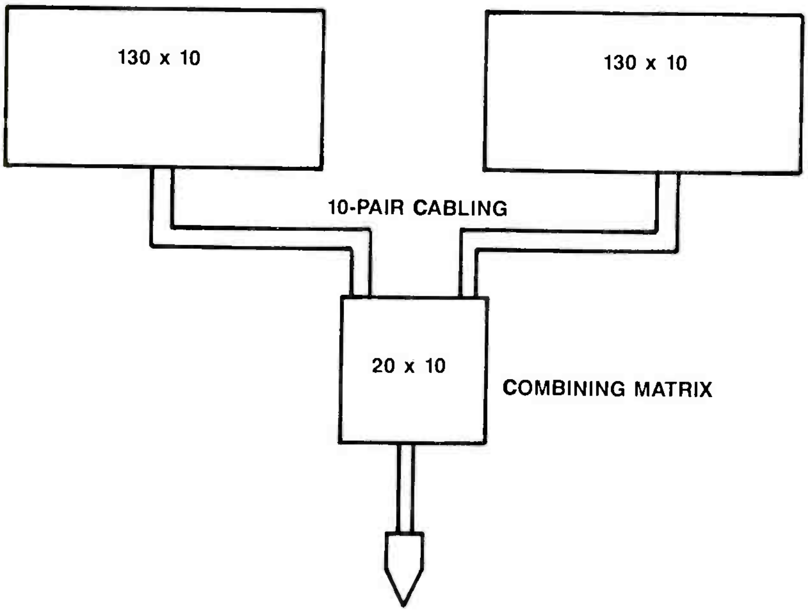

Figure 3. *A combining matrix structure permits large numbers of inputs to be accommodated. A 260×10 system is achieved by combining two 130×10 matrices with a 20×10 combining matrix.*

Crosspoint loading

Crosspoint loading is a degradation that occurs in a signal when it is switched to many outputs. The signal may pass quite transparently through the switcher when it is switched to a single output, but as it is directed to more and more outputs, its quality may deteriorate. Some switchers will show frequency response and delay changes to the signal as additional outputs are switched on. Other specifications can also suffer under these conditions. This test is a measure of signal isolation within the switcher, but unlike crosstalk measurements, which define the leakage of signal from one path into another, crosspoint loading defines the integrity or "discreteness" of each limb in a branched path.

Crosspoint loading is rarely specified, however, and most published switcher specifications only apply to measurements made when one output is switched to one input. Figure 5 shows an example of crosspoint loading in a wide bandwidth

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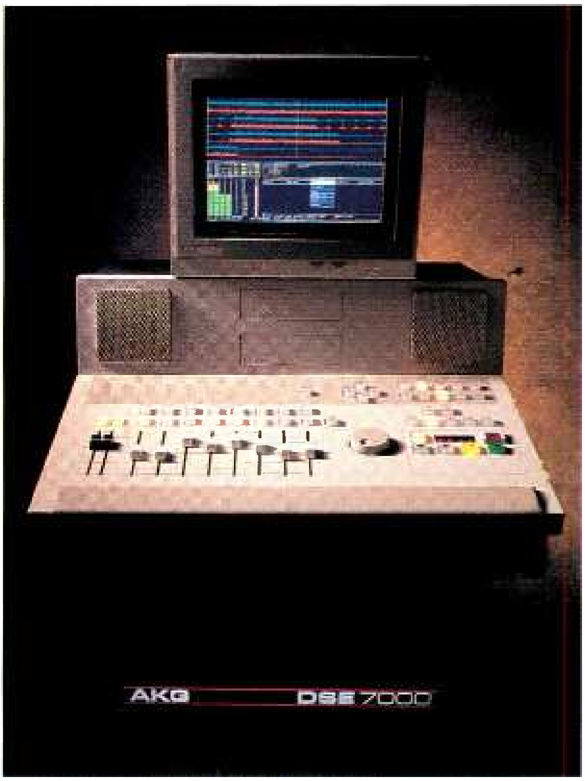

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switcher.

Flatness of bandpass

The flatness of the bandpass is especially critical in a wideband switching system. The shape of the bandpass is also important. Desirable results of frequency response tests will have little response peaking, with few—if any—ripples in the passband and a smooth rolloff shape beyond the passband. Ideally, each device in the signal path should share this smooth and well-controlled response; extended bandwidth in each device will also help ensure that the resulting system bandwidth is wide enough.

Frequency response can vary in a switcher. For some systems, response will vary depending upon the position of the matrix card in the backplane of a chassis. Different paths through the matrix may exhibit different frequency responses. Simple component variations can also cause significant response anomalies. And, as seen above, crosspoint loading can affect frequency response. In large switching systems, multiple passes through the matrix can cause even relatively minor frequency response errors to become significant. Figure 6 shows an example of 10 passes through a wideband switcher having adequate response.

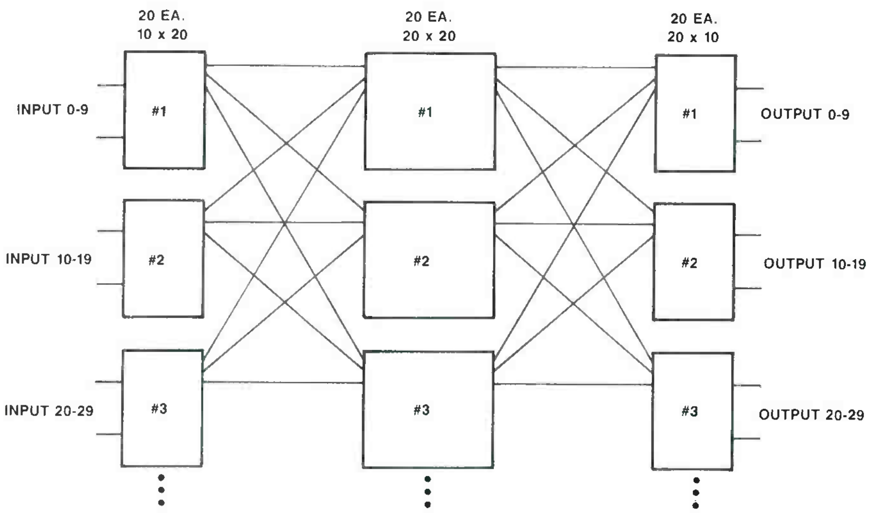

Figure 4. *A portion of a 200x200 3-stage switcher, showing the number and dimensions of each matrix module and their connecting paths. Each path shown is a single cable. The number of crosspoints is reduced from the 40,000 needed by a square matrix of this size to only 16,000.*

Delay performance

In order for a system to be transparent for NTSC/PAL-type video signals, it must have good delay characteristics. Most modern switching systems offer less than $\pm 1°$ of subcarrier phase shift from all inputs to a given output. No matter what input is selected, the width is wide enough.

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switcher will have the same time delay for each signal. Some switchers also specify the delay matching between outputs or groups of outputs. This is important for those who need to use several synchronized outputs, such as for feeding a production switcher. Some systems provide delay adjustments, but these almost always compromise frequency response.

In a switcher with a looping input structure, each output group will usually have some built-in circuitry to adjust time delay relative to the other output groups. To achieve uniform delay on all possible paths, some external cable adjustments are required. These are usually done between the switcher and the patch panel. It is possible to zero-time a switcher as large as 200x200 in this way.

The time delay should also be the same for all frequencies within the passband of the system. This performance parameter is specified as group delay. Although no system is free from some group delay error, the best systems will show low or flat group delay, regardless of signal level, crosspoint loading or signal path variations. Group delays of less than 2ns within the passband will give good performance.

DC coupling and clamping

In order to provide clean switching characteristics, most video switchers provide some type of signal clamping. With the different types of video signals in use today, the type of clamping available is an important issue. Standard composite, component, wide bandwidth and other types of signals all have different requirements. A standard sync-tip clamp will work with many of these signals, but not all of them. This is the reason to consider DC coupling in a switcher. In such a system the video signal will be passed through unaltered. A DC-coupled switcher is more difficult to design and produce, but it is usually more stable, and it is not restricted in the type of signals it will pass. Some systems provide optional clamping circuits, which allow each input to be configured as needed.

In wide bandwidth systems, details count.

Slew-rate limiting

Slew-rate limiting is the reduction of bandwidth with increasing signal level and frequency. For example, a system with slew-rate limiting might have a bandwidth of 30MHz for a signal level of 100mV but only a 20MHz bandwidth for a signal level of 700mV. Generally, not only is the bandwidth affected, but so are many other parameters, such as time delay, group delay and waveform distortion. This is especially true in the region where the excessive rolloff occurs. A well-designed system will have the same bandwidth and other parameters for all signal levels up to full video level. This is equivalent to saying that the full-power bandwidth is the same as the small-signal bandwidth. Systems capable of wide bandwidth performance will not exhibit slew-rate limiting for any signal within the passband up to full video level.

Crosstalk

Crosstalk is one of the most important performance parameters in a switching system. It is also one of the most difficult to design for. Wide bandwidth systems are even more challenging in this respect. In standard bandwidth systems, crosstalk is usually specified at the subcarrier frequency. In wide bandwidth systems, the crosstalk all the way out to 30MHz is important. With present technology, it is not possible to obtain the same isolation performance at 30MHz as can be obtained at 3.58MHz. Adequate performance at 30MHz can be obtained, however. The advent of surface-mount technology is one factor among many involved in making this possible.

Many think that total system video crosstalk at -45dB or lower is not visually detectable on a monitor. Making a switching system that is capable of this performance at 30MHz is not easy, but some systems are available that can achieve this level of performance.

Wide bandwidth in a standard bandwidth application

Is there such a thing as too much bandwidth? Some worry that a switcher with a bandpass out to 80MHz or 100MHz may pick up stray RF energy that will be passed throughout the entire facility. This is a valid concern. A number of design methods can be employed to help control this problem. For example, good grounding techniques, adequate bypassing, careful shielding and the use of quality double-shielded cable are some methods that help. Also, if the switching system is linear and well-controlled in the high-frequency end of the passband, especially in the rolloff region, RF pickup and detection will be minimized. In many cases, the bandwidth can be intentionally rolled off where needed to aid in particularly troublesome applications.

Large system performance

What kind of performance can be expected from a large switching system? It is possible to build a 10x10 matrix with much better performance than a 200x200. When systems become large, they suffer from reduced crosstalk performance, increased delay scatter, more frequency response variation and sometimes more signal distortion. Much of this reduction in performance is because of the large physical space that is required to build such a

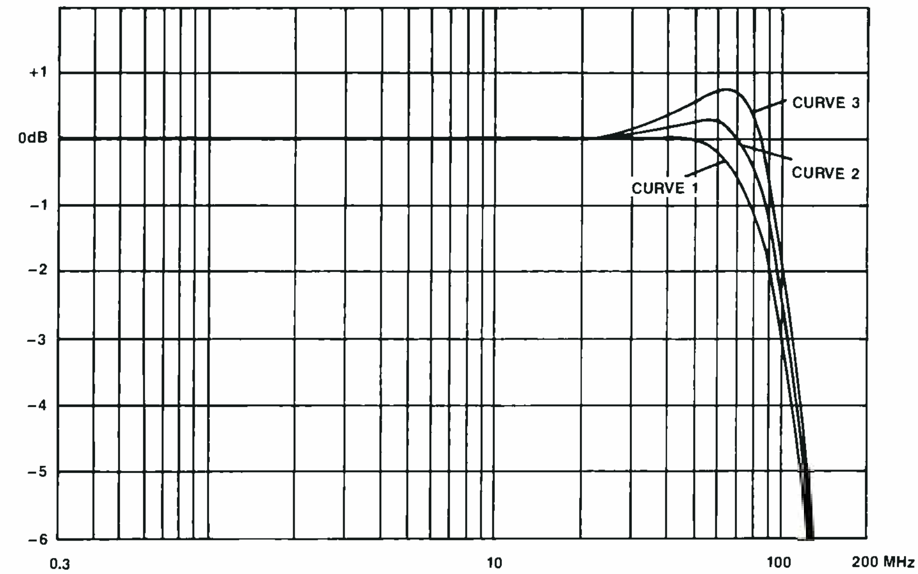

Figure 5. *The effect of crosspoint loading in a wideband switcher. Curve 1 shows a single input switched to a single output. Curve 2 shows a single input switched to five outputs and curve 3 shows it switched to 10 outputs.*


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Digital
A New Perspective

The all-digital system: the next step

The concepts embodied in digital technology will redefine broadcast and post-production operations in the 1990s. Digital technology represents much more than simply the entrance of a new recording format. It establishes an entirely new way of designing and building a system. All-digital implementation is the next step for broadcasters and post-production operators.

How digital systems make things easier

Reliability. Today's digital products pack an incredible amount of electronic circuitry into one chip. The result is much smaller size, lower power consumption, less heat generation and fewer individual components. For these reasons, digital technology is inherently more reliable, which means less downtime and less maintenance, resulting in greater on-line availability.

Consistency.
As reliable as digital circuits are, they are also consistent. Digital signal processing is very straightforward; there are fewer things to go wrong and fewer set-up adjustments to be made. Digital signals are predictable, and therefore performance is consistently good, from the start, and over the long haul.

Flexibility.
By eliminating the constraints of analog signal processing (signal-to-noise degradation, chroma-to-luminance delay, etc.), each piece of digital equipment becomes far more useful. Producers need not be constrained by how many generations down the final product might be.

Efficiency.
High reliability, consistency and flexibility of digital equipment all add up to this: the all-digital system is "on-line" when you need it. Downtime and set-up time are minimized, and many analog considerations are eliminated. There are fewer constraints placed on the efficient use of your facility. The system does not control you, you control it!

To everyone with their video it's time to

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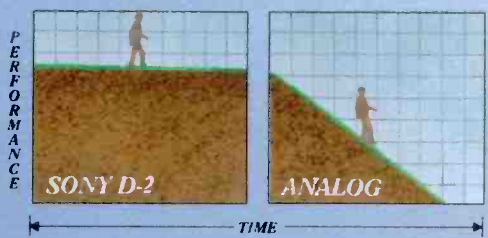
D-2 takes the amazing possibilities of digital technology and makes them a practical reality.

In fact, revolutionary is the only way to describe it. D-2's digital world is a place where performance is consistently extraordinary. Where every tape copy is as good as the original. Where audio is as important as video. And where machines operate without the need for constant adjustments.



D-2 maintains consistently high performance.

In the digital world, a D-2 VTR does its job just about perfectly. So you can too.

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D-2's picture quality is exceptional from the start, and it stays that way consistently. Here's why:

D-2 effectively eliminates dropouts.

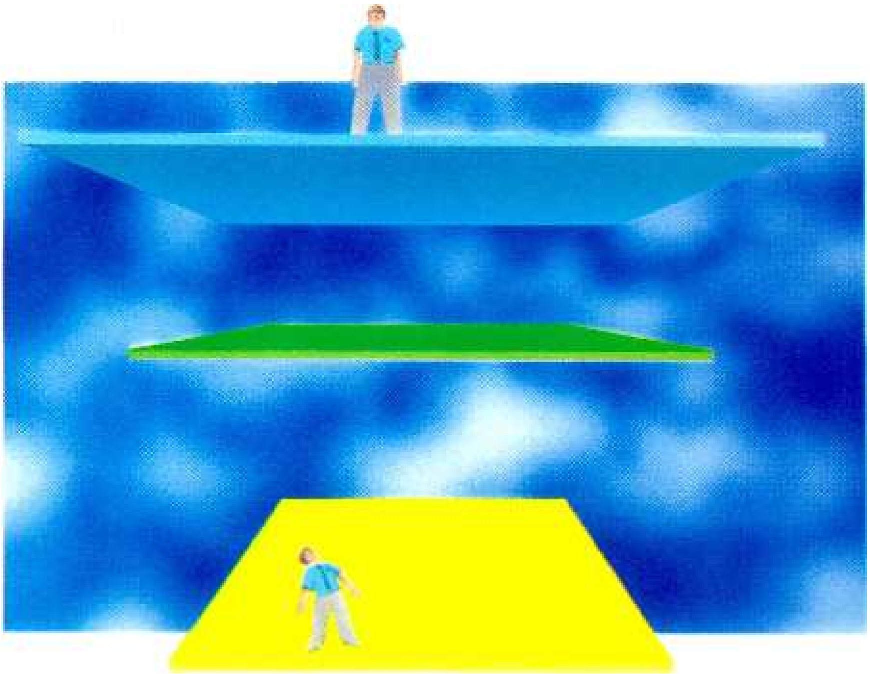
D-2's unique error correction and concealment system means you'll never have to worry about dropouts.

D-2's digital transparency is another clear advantage.

And copies of D-2 tapes aren't dubs.

Aspects of the all-digital system

What do we mean by the phrase "the all-digital system"? First, we're talking about the ability to generate audio and video directly in the digital domain, in such equipment as state-of-the-art graphics systems and audio synthesizers. Next, we're talking about the ability to record, store and retrieve those digital signals, and the ability to process the digital information (as in digital multi-effects systems, still-store boxes, production switchers, etc.). Finally, we're talking about the ability to interconnect the myriad types of equipment without reverting to the analog domain. Once we're in the digital domain, let's stay there.



Digital signal generation

Most video and audio signals originate in analog form. But, because of the transparency of digital signal processing, the sooner the signal is converted into digital form, the better. Today's most advanced cameras utilize digital signal processing right in the camera head. Soon cameras will produce direct digital output. Digital audio consoles for mixing and processing prior to digital recording are already common. Most computer graphics systems generate images in digital form, and the quality of these images is limited only by present analog-world considerations. It won't really matter to the all-digital system whether the origination image is live-action or computer-generated. The fact is, the signal representing audio or video, at its earliest, will be in the digital domain.

Digital recording is better than analog recording

Digital recording is a reality with the D-1 (component) and D-2 (composite) tape formats.

Digital recorders are more cost-effective than comparable analog machines because they are inherently more reliable, more consistent and more efficient. Being cassette-based and requiring fewer machine set-up routines, digital VTRs allow more freedom for the tape operator. With four audio channels, digital VTRs can provide new, cost-effective avenues for audio production, sweetening and programming. Tape life is greatly increased, too. The number of usable passes is far higher than with any analog tape format.

The quality of digital recording is much higher than its analog counterpart's. Digital recordings have a higher video signal-to-noise ratio, and moire is eliminated. Audio performance is at the level of compact discs. And the multi-generation aspects of digital are unparalleled (over 20 generations without any noticeable degradation).

Digital recorders offer some unique features. Perhaps the most significant feature, never possible in analog, is error correction, the ability to produce absolutely accurate playback of the recorded material, even when tape wear or damage would normally render an inaccurate playback. Error correction, along with the consistently high signal-to-noise ratio of digital processing, produces "clones."

Another feature of a digital VTR is its signal-monitoring capability. Each VTR can act as its own tape evaluator, giving the operator a consistent and reliable means of tracking the performance of each tape in the system. Future developments in sophisticated digital diagnostics will allow

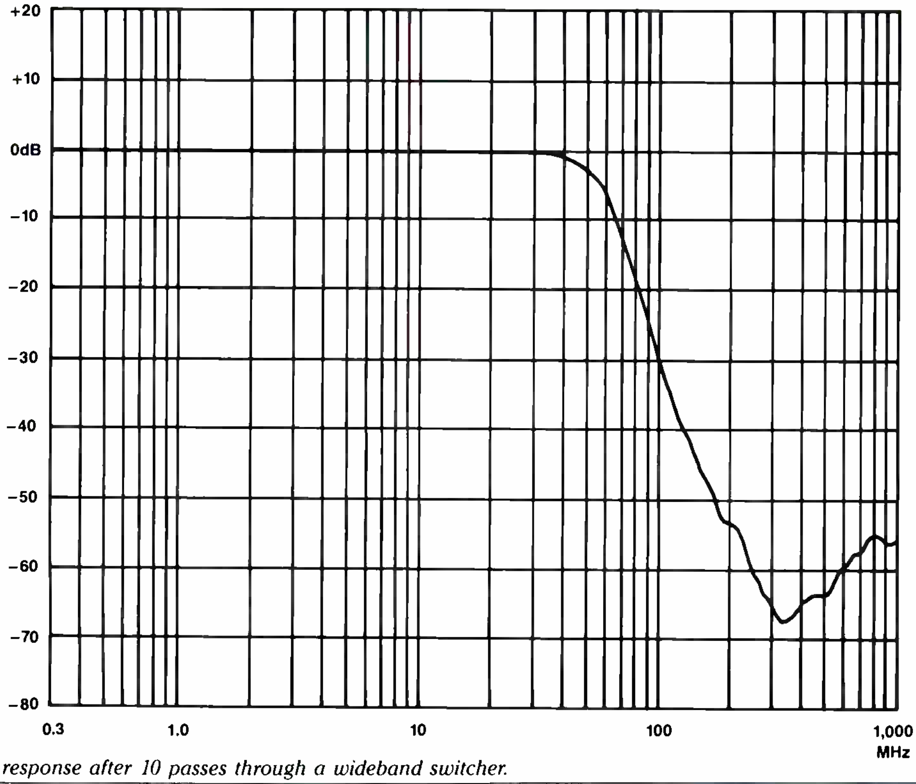


Figure 6. *Frequency response after 10 passes through a wideband switcher.*

large matrix.

In a large square matrix, much of the degradation is the result of needing input DAs and a lot of internal cabling. For example, if the input DA has 0.1% differential gain error, and the switcher has the same error in the same direction, the resulting performance will be 0.2% differential gain. All specifications add up in this manner. The key to building large matrices is to design each of the building blocks with high performance so that the overall result is still acceptable.

To build 3-stage switchers requires even higher performance, because there are effectively three matrices in one switcher pass. There are some advantages in 3-stage switching, however, that are not immediately apparent. For example, a properly designed 3-stage switcher will inherently provide the same time delay for every possible path through the system. Transparency can be high because no input DAs are required, and because each of the building blocks used is a small switcher that can be built with high performance.

Control systems

After a switcher's signal performance, the next important consideration is the control system. These can vary widely in flexibility and features. Some important issues: the size of matrix that can be controlled, the number of levels or channels, the number and type of control panels, the physical distance over which the control panels can be placed, the ease of reconfiguring the control system, downward compatibility with existing matrices, the ease of expandability in the future, the reliability and redundancy of the system, the interface with other control systems and equipment and the availability of machine and switcher control.

Multiple-stage switching can provide crosspoint count reduction.

Important advances have been made in recent years in all the areas. Control systems are now available with more open architectures, which allow much easier expansion and flexibility as needs change. Adding a new control panel or changing mnemonic names is not the difficult task it once was. Some new systems even allow reconfiguration of the entire control system in just a matter of seconds.

One of the most important advances is the ability to add new switching matrices or levels easily. It is also possible to have more than one matrix with different control points on the same control system. And much larger matrices can now be controlled. It is not uncommon to find switching systems with more than 10 levels or channels of control and large matrices (200x200) for each level. New features, such as "path-finding," are also available. Path-finding allows two or more matrices to be interconnected with tie lines while the control system operates them as a single matrix, automatically finding paths between them when needed. A 3-stage matrix can be operated as a single standard matrix as seen from the control panel.

Summary

Important advances continue to be made in video switching and signal distribution. Not all developments are in the digital video world. Analog signal distribution will be with us for a long time yet. Increased performance for standard bandwidth video as well as the ability to handle future wide bandwidth signals is available now. Also, more open architecture for the matrices and the control systems helps to enhance long-term compatibility and future expandability. Careful consideration of the signal performance and the control systems will be rewarded with reliable and flexible service in a video distribution switcher.

Fiber optics in the broadcast industry

Optical interconnection is becoming a reality for broadcasters.

By Michael W. Pugh

When Lewis Carroll wrote *Through the Looking Glass*, he envisioned a strange land of wonders for his well-known protagonist, Alice. Back then, the marvels of communication that come to us today through another kind of glass would have seemed equally fantastic. But, in truth, our technological world is being altered by transmission through the "light-lines" known as fiber optics.

Amazingly enough, the foundation of fiber optics actually predated Carroll's musings by a couple of years. In 1870, John Tyndall, a physicist and fellow Briton, showed that light could be bent around a corner through a curved spout of running water. He had discovered the principle of total internal reflection, the basis for fiber optics as we know it today.

Later experiments by Alexander Graham Bell used light beams traveling through air to transmit speech. Solid glass was first used in the 1930s, the 2-layer "cladding" method of light guidance developed in the '50s, and the laser implemented as an efficient light source in the '60s. Highly pure, low-loss glass fibers were the last refinement in the '70s, making fiber-optic transmission practical and advantageous for many applications.

Soon, fiber will become the media of choice for audio and video connections from the production studio to home distribution. It is already being used for many studio entrance links and distribution trunking. The digital revolution now in progress in broadcast facility hardware creates new applications for fiber, in which bulky coax will be replaced with fiber wherever serial digital links interconnect equipment.

Pugh is a senior staff engineer at Grass Valley Group's Telecom Systems Division, Grass Valley, CA.

A basic fiber-optic tutorial

A fiber-optic communications system is composed of three fundamental elements: light source, fiber media and light detector. A brief description of these elements is necessary in order to better understand the capabilities and limitations of fiber-optic systems.

Light sources

The majority of light sources used in fiber optics emit light at one of three different wavelengths: 850nm, 1,300nm and 1,550nm. These are considered to be low-loss "windows," where glass fibers carry light with minimal attenuation. All of these wavelengths are in the infrared portion of the spectrum. For reference, the human eye can see from 400nm (violet) to 700nm (deep red).

Early fiber systems operated at 850nm, but more recently, developments in fiber have driven the market to 1,300nm and 1,550nm, in order to take advantage of lower losses at these wavelengths.

The two major types of light sources used in current fiber-optic systems are LEDs and lasers. LEDs are manufactured in two forms, edge-emitting and surface-emitting. These refer to the location on the chip from which the light is emitted. Surface-emitters have essentially the same construction as LED panel indicators; they radiate a large amount of light in multiple directions. Edge-emitters have a smaller but more focused beam. Because of the geometry of the junctions, the edge-emitters have lower capacitance and allow higher modulation rates.

Semiconductor lasers are constructed in a similar manner to edge-emitting LEDs. The two basic types of lasers are Fabry-Perot (FP) and distributed feedback (DFB).

The creative environment

Just as the digital system provides a transparent pathway from camera to transmitter, so too does it provide a transparent pathway from talent or event to viewer. Equipment or technology ceases to be a barrier to getting the project done. This enhances the ability of creative talent to communicate effectively and efficiently with the viewer. The digital system permits creativity that is limited not by what machines can or cannot do, but by what the creative people can imagine.

We stated at the beginning that digital technology will redefine broadcast and post-production operations in the 1990s. Most of the pieces of the all-digital system are here. There will be new developments and refinements, but clearly, the '90s will be the digital decade.

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engineers, even from a remote location, to evaluate the on-going, on-line performance of each VTR.

A unique feature of the D-2 (composite) digital recording format is the ability to perform audio and video pre-read edits, where the tape machine is used as a playback source and a recorder simultaneously! This unusual aspect of the D-2 format is just beginning to be appreciated.

Digital signal processing is better than analog signal processing

Digital processing has been around for years. All of today's character generators, graphics systems and multi-effects generators are entirely digital in their signal creation and manipulation. Time base correctors have incorporated a lot of digital processing; and digital control circuits have been used in production switchers, routing switchers, editing systems, transmitters, etc.

Digital signal processing enjoys the common digital advantages: more reliability, more consistency and more efficiency. All that's needed to bring out the full potential of much of today's processing equipment is the elimination of the analog interface. But digital processing offers a lot more.

Color correction in the component digital domain (D-1) has proved to be the most precise and effective means of control and manipulation of color parameters. Digital routing switchers offer efficiencies never before possible in the analog realm. One example: video (with vertical interval time code) and audio can be handled as one combined signal, requiring just one crosspoint in the switcher. Another efficiency is the ability of a routing switcher to handle both D-1 component and D-2 composite signals, eliminating the need for separate routing switchers.

Digital component and composite production switchers allow all of the features of today's analog switchers, without the aggravation of instability and constant adjustment. Powerful new video effects processing and picture manipulation are possible in these switchers. Image manipulation is an integral part of the production switcher; complex layering and multi-effects are accessed by the switcher control panel and/or edit system.

Encoding and decoding of composite and component signals will be accomplished in the digital domain much more precisely and accurately. Digital DAs and delay lines, digital audio mixing and digital distribution systems are now in place to complete the all-digital studio.

Digital interconnection is better than analog signal interconnection

Direct connection among digital boxes will eliminate the need for multiple analog-to-digital and digital-to-analog converters. Each such conversion in our present analog-oriented equipment introduces distortion and artifacts.

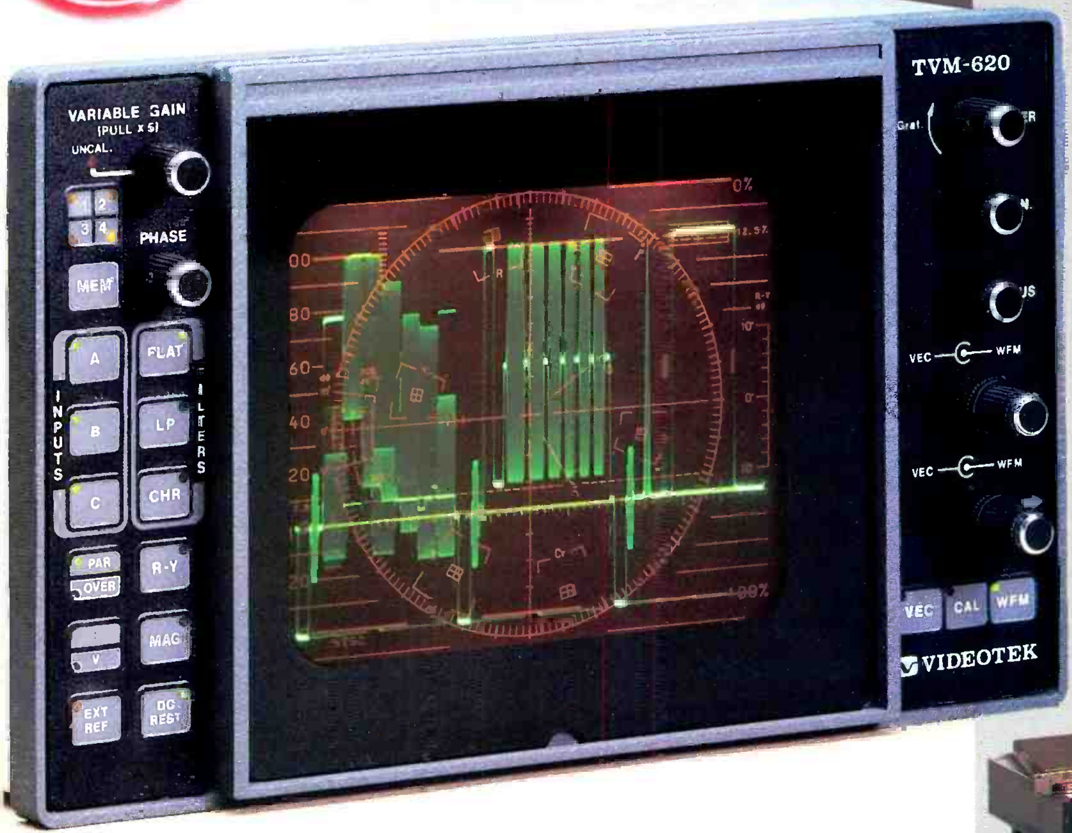
In the all-digital system, signal distribution and transmission will be in serial form. This means that digital video and four channels of digital audio will be all combined on one coax cable. Serial transmission allows the data to be sent over long distances without the usual problems encountered in analog (noise and interference, high-frequency roll-off, etc.).

Signal quality and consistency will be maintained throughout the all-digital system. Separate video and audio patching systems will be consolidated into a single digital patch. Routing switchers, with multiple levels of video and audio, can be reduced to one digital level.

And once we're all-digital, video and audio level adjustments will be eliminated from most equipment. All signals will remain at unity throughout the system. Just one more advantage of an all-digital system.

There is little question that digital technology offers major improvements over much of our analog-designed equipment. But what started out as improvements in individual devices now extends to the overall system. The digital system provides a transparent pathway from camera to transmitter. This pathway is more reliable and efficient, and requires less set-up time, less parameter monitoring and less maintenance. The digital system has lower operating costs and a longer life, both of which contribute to a greater return-on-investment.

TriplePlay



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Both types channel the emitted light into a high-Q cavity, thereby correlating the light waves into a coherent beam. The DFB type also includes a grating filter that ensures a pure output. The purity of the output is inversely proportional to the spectral width. LEDs have spectral widths on the order of 100nm, FP lasers are on the order of 10nm and DFB lasers can produce narrow spectral widths of less than 1nm containing a single line.

The narrower the spectral width, the higher the cost of producing the emitter. Prices for LEDs run in the tens of dollars, FP lasers run $200 to $800 and DFB lasers start at $5,000. Coherent reflections inside a laser's cavity can cause spurious outputs, often requiring opto-isolation, and increase the cost by several thousand dollars.

Because the velocity of light through glass varies with frequency, the broad spectral content emitted by an LED is dispersed during transmission through a fiber, causing different frequency components of light to be received at different times. This so-called "material dispersion" limits the bandwidth (and, therefore, capacity) and distance capability of fiber links driven by LEDs. Current research is examining methods of physically compensating for the frequency-dependence of light transmission in glass media. The LEDs' high reliability, stability, low-drive voltages and low cost make them the appropriate choice for many applications.

Lasers' narrower spectral width makes their higher cost worthwhile for longer distances and wider bandwidths. They also possess faster rise times (10^{-12} second) than LEDs (10^{-9} second), making lasers more suitable for higher frequency operations. On the other hand, lasers have the disadvantage of being temperature sensitive; a slight temperature change can

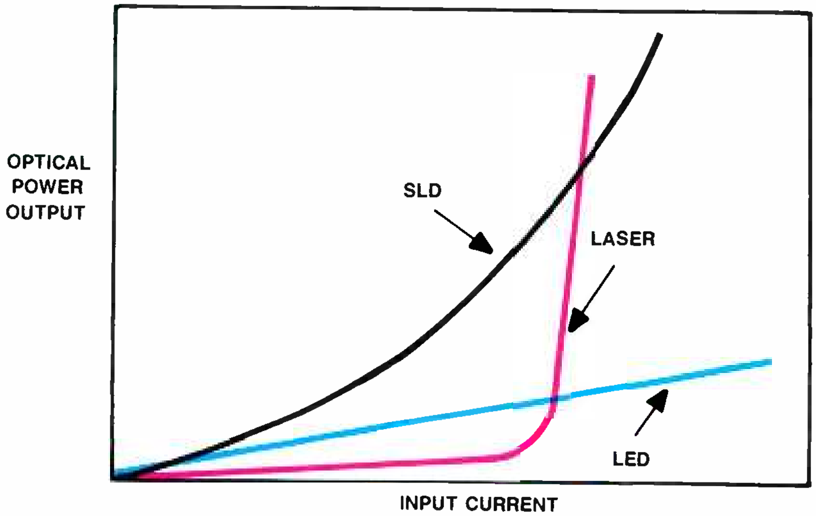

Figure 1. Transfer characteristics of the three types of fiber-optic emitters.

cause as much as 20nm drift in center wavelength. LEDs exhibit no such sensitivity.

A recent addition to this marketplace is the superluminescent diode (SLD), which falls somewhere in between the LED and the laser in performance parameters and cost.

Optical power output characteristics also vary among devices. The LED is nearly linear, the SLD is non-linear (output rising vs. input) and the laser is collimated (linear until saturation, then rising asymptotically). (See Figure 1.) Emission angles are also important, because they determine coupling efficiency with small-core fibers. Figure 2 shows the emission angles of these three output devices. Lasers again show about one order of magnitude advantage over LEDs, allowing about 10 times more power coupling efficiency with the smallest fibers, owing to its narrower dispersion angle.

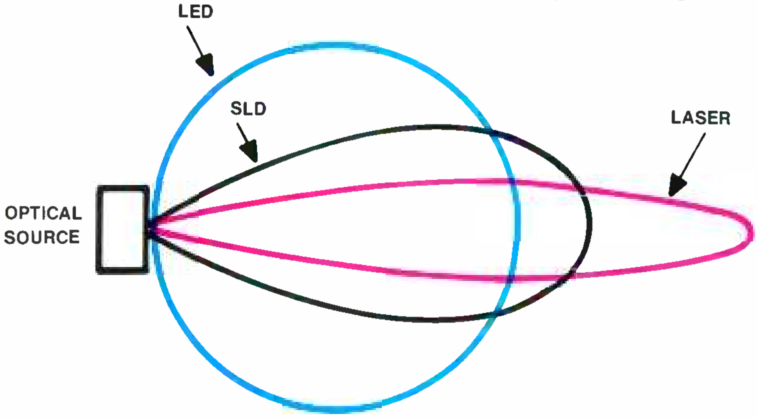

Figure 2. *Dispersion patterns of the three fiber-optic emitter types.*

Fiber media

Optical fiber is a light guide made of fused silica (glass). Some plastic fibers are in use, but they exhibit high losses and limited bandwidth, and are typically used only in special applications. The actual glass path in a fiber-optic line is only about as thick as a human hair, and weighs approximately one ounce per kilometer.

As mentioned earlier, the process of light transmission through glass is based on the phenomenon of total internal reflection. To understand this process, consider first the "refractive index" (n), which states the ratio of the speed of light through a medium (v) relative to the speed of light through a vacuum (c), in an inverse relationship.

$$n = c/v$$

The speed of light through air is just a bit slower than through a vacuum, so its refractive index is 1.0003, but generally considered 1. Lightspeed through glass, on the other hand, is about two-thirds that of a vacuum, so its refractive index is 1.5. Whenever light passes from one medium to another, rays are bent to an angle determined by the relationship of the two materials' refractive indices. Figure 3 shows some examples.

First, consider the boundary between two media, then visualize a line perpen-

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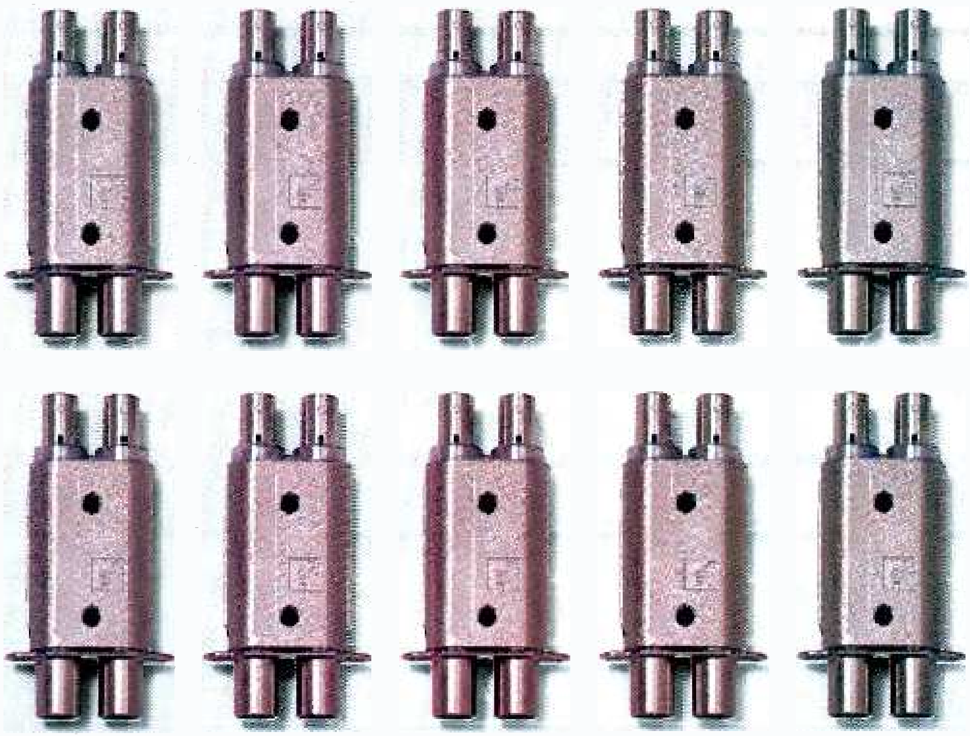
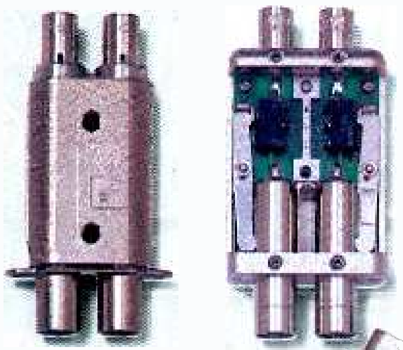
On the surface, most dual video jacks look exactly alike.





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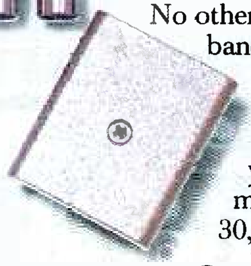

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Continued from page 54
dicular to that boundary. The light ray's angles of incidence, reflection and refraction are all measured in degrees from this normal line. If a ray passes from one medium with a refractive index of n_1 to another medium with a refractive index of n_2, and n_2 is larger than n_1 (light slows down in the second medium), the refracted wave in the second medium will be bent toward the normal. If n_2 is less than n_1 (light speeds up in the second medium), the wave will be bent away from the normal, and thus bent toward the boundary. So for any two materials, a fixed amount of bending will occur when any light ray hits the surface. The actual angle of the refracted wave still depends, of course, on the angle of incidence of the light ray. In the latter case ($n_2 < n_1$), as the angle of incidence increases, some incident angle will cause the refracted wave to be placed along the surface of the boundary, and it will not enter the second material. This is referred to as the critical angle of this media interface. As the angle of incidence becomes even more oblique, the refracted ray is actually turned back into the first medium, and total internal reflection is achieved.

Fiber-optic media uses a pure glass as a core (the more uniform and dense the medium, the slower light travels through it), with a less pure glass as its cladding. (See Figure 4.) The refractive index of the core is higher, and light is fed into the core
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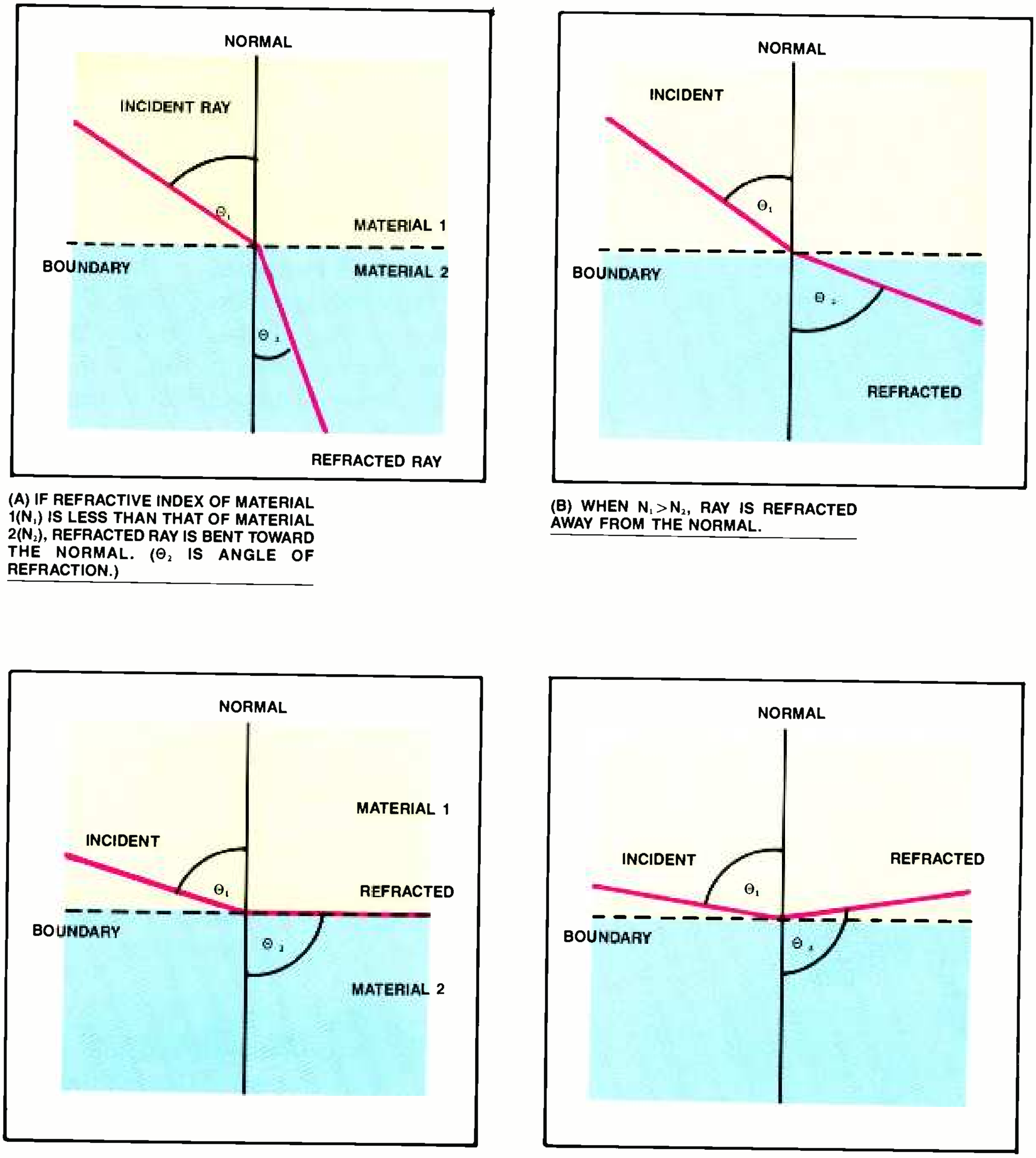

(A) IF REFRACTIVE INDEX OF MATERIAL 1(N_1) IS LESS THAN THAT OF MATERIAL 2(N_2), REFRACTED RAY IS BENT TOWARD THE NORMAL. (Θ_2 IS ANGLE OF REFRACTION.)

(B) WHEN $N_1 > N_2$, RAY IS REFRACTED AWAY FROM THE NORMAL.

(C) WHEN Θ_1 REACHES "CRITICAL ANGLE," Θ_2 = 90°, AND REFRACTED RAY TRAVELS ALONG BOUNDARY.

(D) AS Θ_1 GOES BEYOND CRITICAL ANGLE, REFRACTED RAY IS BENT BACK INTO MATERIAL 1. THIS IS "TOTAL INTERNAL REFLECTION."

Figure 3. *The physics of total internal reflection.*


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Continued from page 58

(only) with an angular dispersion so that as much as possible of the light strikes the core-to-cladding interface at an angle of incidence greater than the critical angle for that junction. Thus the bulk of the light stays inside the core and propagates along its axis.

Fibers with an abrupt change in refractive index between core and cladding are called step index fibers. Figure 5 shows how light can propagate through a step index fiber via multiple paths (multimode) or through one path (single mode). When light travels through a multimode step index fiber, some of its paths are straight down the core of the fiber, while others deviate from the fiber core and are reflected back toward the center through the principles discussed previously. This reflected light takes a longer path and arrives at the destination later. The difference in arrival time is called modal dispersion. Its spreading of signals out in time upon reception creates problems similar to those of the LEDs' low-Q emissions mentioned earlier, and thus limits the applications of these fibers accordingly.

One solution to this problem is the multimode graded index fiber, which gradually bends the light back into the fiber by using a material with a continuously decreasing refractive index relative to distance from the center. This allows the light to travel faster when further from the core, thus compensating for the longer distances that reflections follow relative to direct paths. The curved internal reflection paths that result create less dispersion.

Another approach uses a step index fiber with a narrow core, which can be made to propagate only one transverse electric wave (TE) or electromagnetic propagation path mode. Simply put, a mode here is a "possible path" for light to follow through a fiber, as determined by Maxwell's electromagnetic equations. (You can only stick to the the pure "ray model" of light so far in this examination.) This kind of fiber is referred to as a single-mode type. Its single-mode nature creates no modal dispersion, resulting in much wider bandwidth and lower loss. These are preferred for telephone company installations where high capacity and long distances between repeater amplification is required.

The more uniform and dense the medium, the slower light travels through it.

Single-mode fibers generally operate at 1,300nm wavelengths, carrying bandwidths up to several gigahertz with 0.5dB or less loss per kilometer. Multimode fibers operate at 850nm, with step index types offering bandwidth typically in the 10MHz-20MHz region and losses of 6dB/km; graded index fibers provide bandwidths up to a few hundred megahertz and 3dB/km losses. The most common fibers in use today are 62.5 and 50μm (core diameters) graded index multimode and 8μm single mode.

Bandwidth of a fiber is usually quoted in megahertz/kilometers, indicating the direct relationship of capacity to path length between repeaters.

Connectors

In many applications, fiber-optic connectors (FOCs) present the greatest loss in a optical path. Typical real world connectors cause 1dB of loss each, and with fiber attenuation often less than 1dB/km, connectors can easily dominate the loss budget. The most popular connectors are biconic

and ST types, with the former preferred for telco uses and the latter for production applications, where frequent connects and disconnects may be required.

Figure 6 shows these and other common FOCs. Users should be aware that installation of these connectors to a fiber is a critical and often time-consuming process.

Other losses also can occur in fiber as a result of splices (0.01dB-0.5dB), which are made either mechanically, chemically or by heating processes (welding or fusion). Microbend losses are caused by small anomalies (bumps) in the core-cladding interface. The fiber itself creates losses through scattering and absorption, and finally, coupling loss occurs between the fiber and its emitters/receptors. Total loss is referred to as fiber-optic transmission loss (FOTL), expressed in decibels/kilometers.

Light detectors

Photodetectors are made of photoemissive material, which emits electrons when illuminated by light of sufficiently short wavelength. Two basic semiconductor structures are used for the detection of light: positive intrinsic negative (PIN) and avalanche photo detector (APD). For this discussion, a switch to the particle model of light theory is required.

In an ideal PIN diode, a single electron is emitted for each photon impacting the active region. In practice, some recombination results in efficiencies on the order of 0.8 for 1,300nm systems, such that a PIN diode with an efficiency rating of 0.8 will produce 0.8a of current from an optical signal of 1W. The APD diode also acts as a current source, but is operated near the diode's reverse breakdown voltage. This results in an avalanche effect when a photon releases an electron, effectively translating a single photon into multiple electrons, and dramatically increasing the output current. Multiplication factors range from 10 to 100, depending on the material and the reverse bias. This high-conversion efficiency provides increased sensitivity, and, therefore, requires less external amplification, resulting in lower noise floors and high gain factors. However, APDs require higher power supply voltages (100V-300V), and can suffer from output level variation with temperature.

In many applications, fiber-optic connectors (FOCs) present the greatest loss in a optical path.

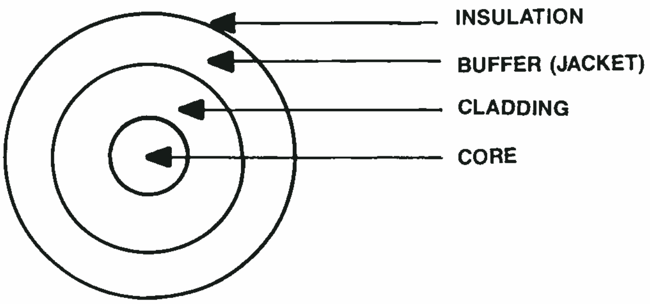

Figure 4. *Cross section of a typical fiber-optic cable.*

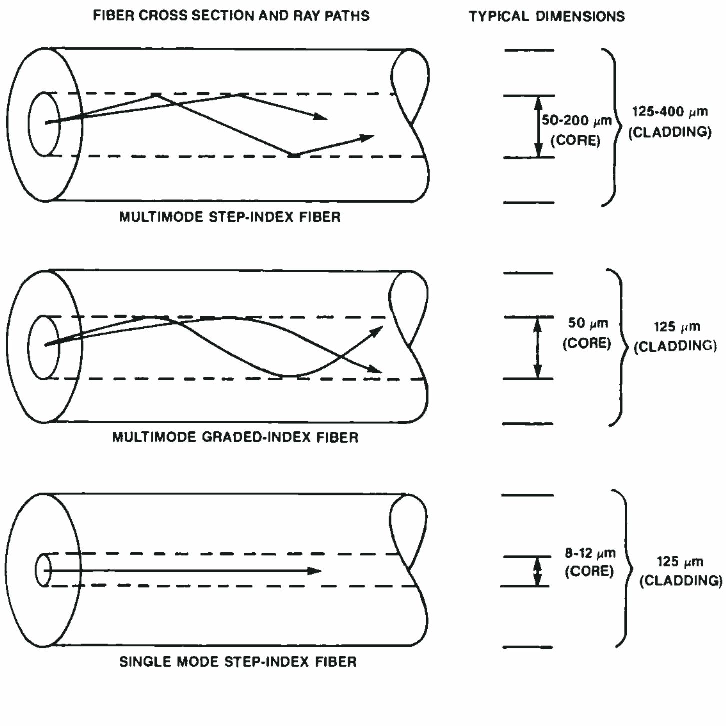

Figure 5. *Multimode step index, graded index and single-mode fibers compared.*

Modulation

LEDs and lasers can be directly modulated by changing the current through the device. Because both devices are a form of diode, strong non-linearities exist when the modulation depth is substantial. Both analog and digital modulation techniques can be applied.

Analog modulation

A straightforward approach involves direct intensity modulation of a linear waveform on a lightwave carrier (for example, amplitude modulation). The most bandwidth-efficient system at present for fiber is multichannel VSB AM video modulation. This approach requires the best DFB lasers to meet CATV linearity and signal-to-noise ratio (S/N) requirements, however. As many as 80 channels over a single fiber have been transported in this manner, but these systems are expensive, and are limited to approximately 57dB carrier-to-noise ratio (C/N).

For broadcast-quality and super-trunking systems, frequency modulation

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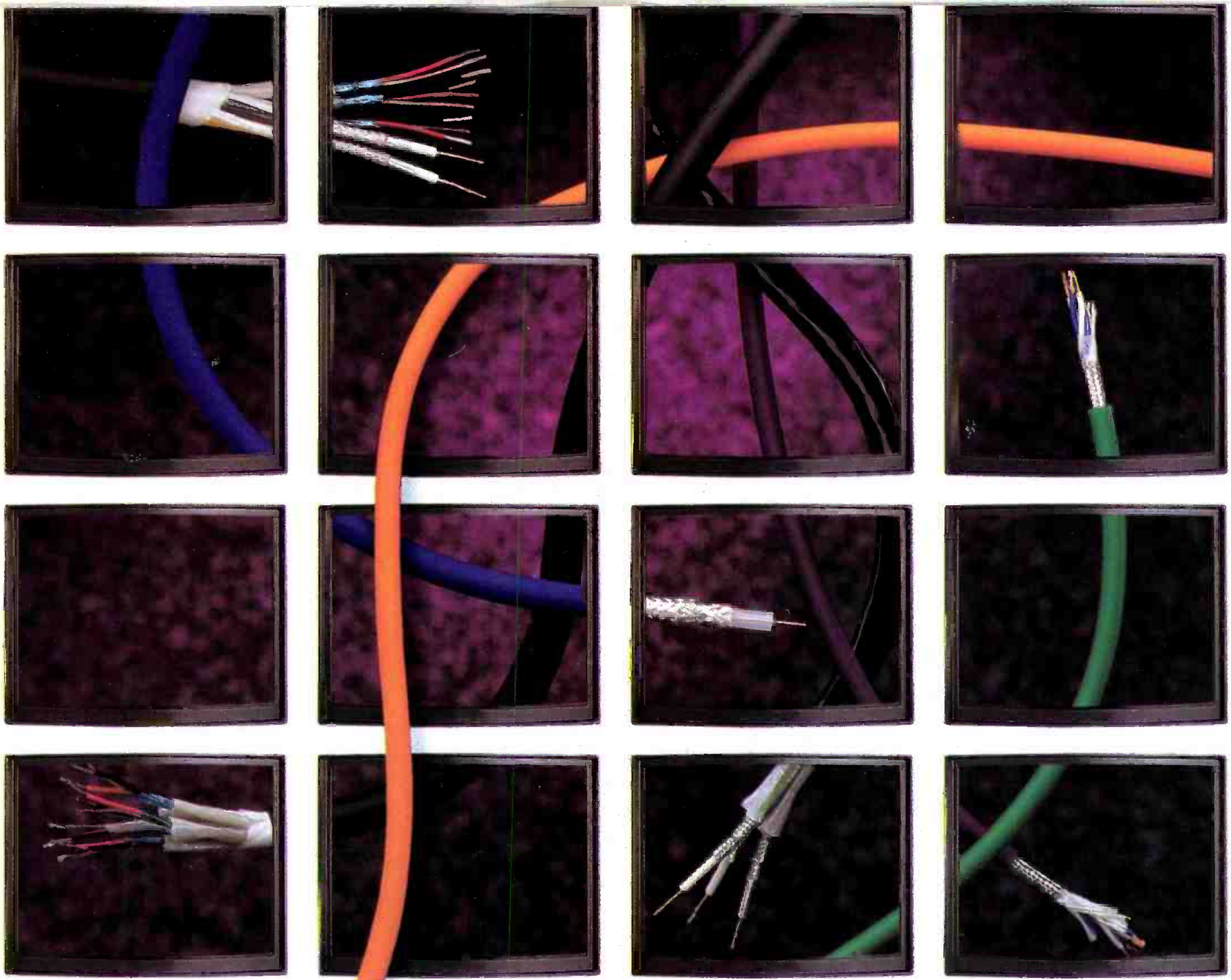

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Continued from page 64

(FM) often is employed. FM provides extremely good linearity, adjacent channel immunity and better S/N. Current single-channel systems exceed RS-250B short-haul specifications over tens of kilometers. In CATV, super-trunking 16 channels per fiber is common. Although not as straightforward as the AM process, use of FM solves the inherent problem in AM of linearity; no light source exhibits a truly linear transfer characteristic between the electrical and optical domains. As such, AM systems must be operated over relatively narrow intensity ranges, or with complex compensation circuitry, as well as concern for temperature-sensitive conversion-efficiency changes, none of which are factors with FM.

Digital modulation

Almost all digital fiber systems use direct modulation of the light source. In other words, the light is intensity-modulated from a low (nearly off) level to a high level. The non-linearities that hurt analog performance have little effect on the digital signal. Furthermore, the S/N requirement is much less demanding. For a bit error rate (BER) of one in one billion (10^{-9}), the S/N need only be 12dB. Better yet is the rate of improvement in BER with S/N. A 1dB improvement in S/N provides nearly three orders of magnitude improvement in BER. For these reasons, digital techniques are well matched to fiber-optic systems.

The limiting factors for a digital fiber system are bandwidth and noise. For surface-emitting LED light sources the practical limit is 250Mb/s, while edge emitters extend the range by several hundred megabits/second. Laser-based systems are operating in excess of 2Gb/s. The optimum setup at present seems to be the use of DFB lasers on single-mode fiber. This combination can provide 2+Gb/s over 30km of fiber with low BER.

Digital techniques are well matched to fiber-optic systems.

The noise generated by the laser or LED usually sets the BER limit for a given bandwidth. The receiver shot noise combined with thermal noise limit the sensitivity that can be achieved. Because all three primary noise sources are functions of bandwidth, the wider the bandwidth, the lower the maximum sensitivity for a given BER. For example, a particular PIN-based receiver operating at 500Mb/s can achieve a sensitivity of −19dBm at a BER of 1 in 10^{12}. This same receiver could only achieve a sensitivity of −16dBm at 1Gb/s, because of the doubling of bandwidth.

Practical system configurations

Systems today are generally split between LED systems operating on multimode fiber below 200Mb/s and laser systems operating on single-mode fiber at data rates above 150Mb/s.

LED systems are used primarily for lower-cost systems. The use of multimode fiber allows lower-cost connectors, and launches more light. The local area network standard, fiber-distributed data interface (FDDI), is representative with a fiber rate of 125 megabaud, 1,300nm LED sources and 62.5μm fiber. These links are good to 2km between nodes. This technology can be pushed to 250 megabaud operation.

Systems requiring longer distances or higher data rates require laser light sources. Most high data rate systems use

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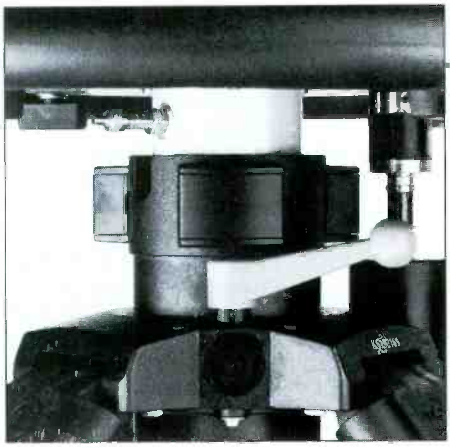

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1,300nm lasers with single-mode fiber. Almost all long distance telecommunications

Fiber will be essential to error-free connections at digital HDTV rates.

links fall into this category. The bandwidth advantages of this combination of fiber and light source suggest this will be the configuration of the future.

Fiber and video today

Fiber offers almost unlimited bandwidth, low weight and complete freedom from EMI interference (nor does it generate EMI). However, as mentioned earlier, limitations exist in terms of linearity and S/N that have dictated how analog video is transported by fiber.

Most studio-quality video carried over fiber today is analog composite video carried by pulse frequency modulation (PFM) systems. These digital transmission systems are used for entrance links over fiber owned by telephone companies. Digital pulses do not require a linear channel to be transmitted, thus even the non-linear effects of lasers used for long-distance applications have little effect on signal quality.

Digital video and fiber

Composite digital video, such as D-2, requires a serial data rate of 143Mb/s for NTSC and 177Mb/s for PAL. In the fiber world these are relatively low data rate signals that can use either LED or laser systems. Even component D-1's 270Mb/s is not challenging to digital fiber links. Component HDTV will require nearly 1,200Mb/s, which can be carried with current laser systems.

Cost dictates which digital links will use fiber first. Long-distance links require fiber for data integrity; they are the first candidates. The distance at which fiber becomes economical depends highly on the data rate and the environment. At digital HDTV rates of 1,200Mb/s, 100 feet is a long distance for coax. Current spikes on the coax can cause errors for periods of 100µs, which translates to 120,000 bit errors. Fiber will be essential to error-free connections at digital HDTV rates. Even at D-2 rates, the simplicity of fiber connections for grounding of equipment and interbuilding connections may make the cost of fiber transmitters and receivers attractive.

Long-haul circuits using telco DS3 protocol (44.736Mb/s) are now in use on fiber for compressed digital NTSC transmission. Recent and continuing advances in data compression will make even the lower-capacity fiber links extremely useful to broadcasters. Meanwhile, work continues in Japan on a 10Gb/s fiber link, which will run 100km between repeaters.

Digital audio and fiber

With these capacities, digital audio is certainly no problem for fiber. The AES/EBU standard interface only requires a 3Mb/s transmission rate (for a stereo signal). Fiber's primary benefit here is in multichannel short- and long-haul paths. Again, telco circuits (DS1 and DS2) via fiber are useful and flexible for a wide variety of audio bandwidths, plus data and control channels. They are useful and cost-effective wherever mono or bidirectional audio/data paths of any type are required between two facilities (STLs, remote sites and multiple studios). Recently, several audio "snake" systems (used for connecting multiple stage microphones to one or more audio mixing consoles) have been implemented with multiplexed digital audio on fiber. Remote-site setup and striking will be eased by the replacement of a large, heavy and electromagnetically vulnerable multipair copper cable (carrying many analog mic-level signals) with a light and robust single cable. In the audio studio, the multichannel audio digital interface (MADI) format, a serial interface carrying up to 56 digital audio channels, uses fiber for paths greater than 50m for its 100Mb/s data.

Current applications

The use of fiber is widespread among telephone companies, and these paths are used routinely now for local and long-haul broadcast video and audio program circuits, often without the customer's awareness. Many private and state telecommunication networks have been established using fiber for all or part of these systems' paths. The term fiber news gathering (FNG) has been coined for the use of a fiber network between frequently-used remote sites and broadcast stations in Washington, DC, in which a customer-managed switcher at a downtown C&P

Several audio "snake" systems have been implemented with multiplexed digital audio on fiber.

Telephone facility provides cost-effective feeding of analog video news material to all participants. Extensive use of fiber has become commonplace at major remote sites, such as this past summer's Economic Summit in Houston and the Goodwill Games in Seattle.

Next on the horizon is switching in the optical domain. Optical busing and distribution has always been a problem, but recently a fiber-optic switch using gallium arsenide technology has been developed, and shows some promise.

Continued on page 74

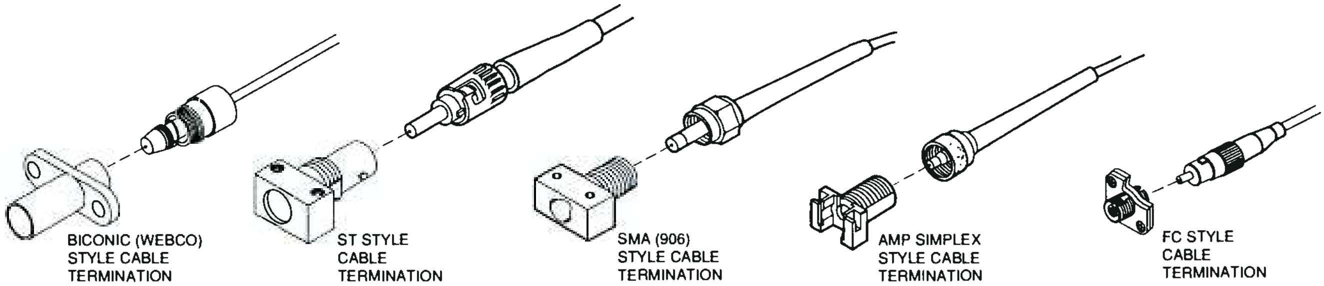

Figure 6. *A variety of fiber-optic connectors in common use.*

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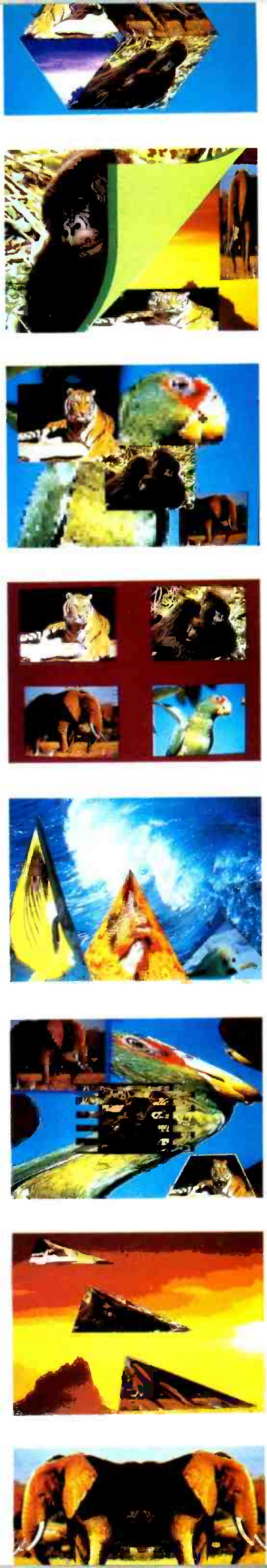

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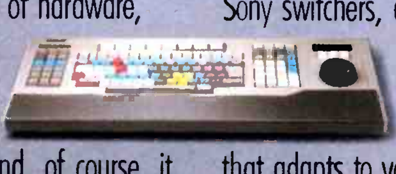

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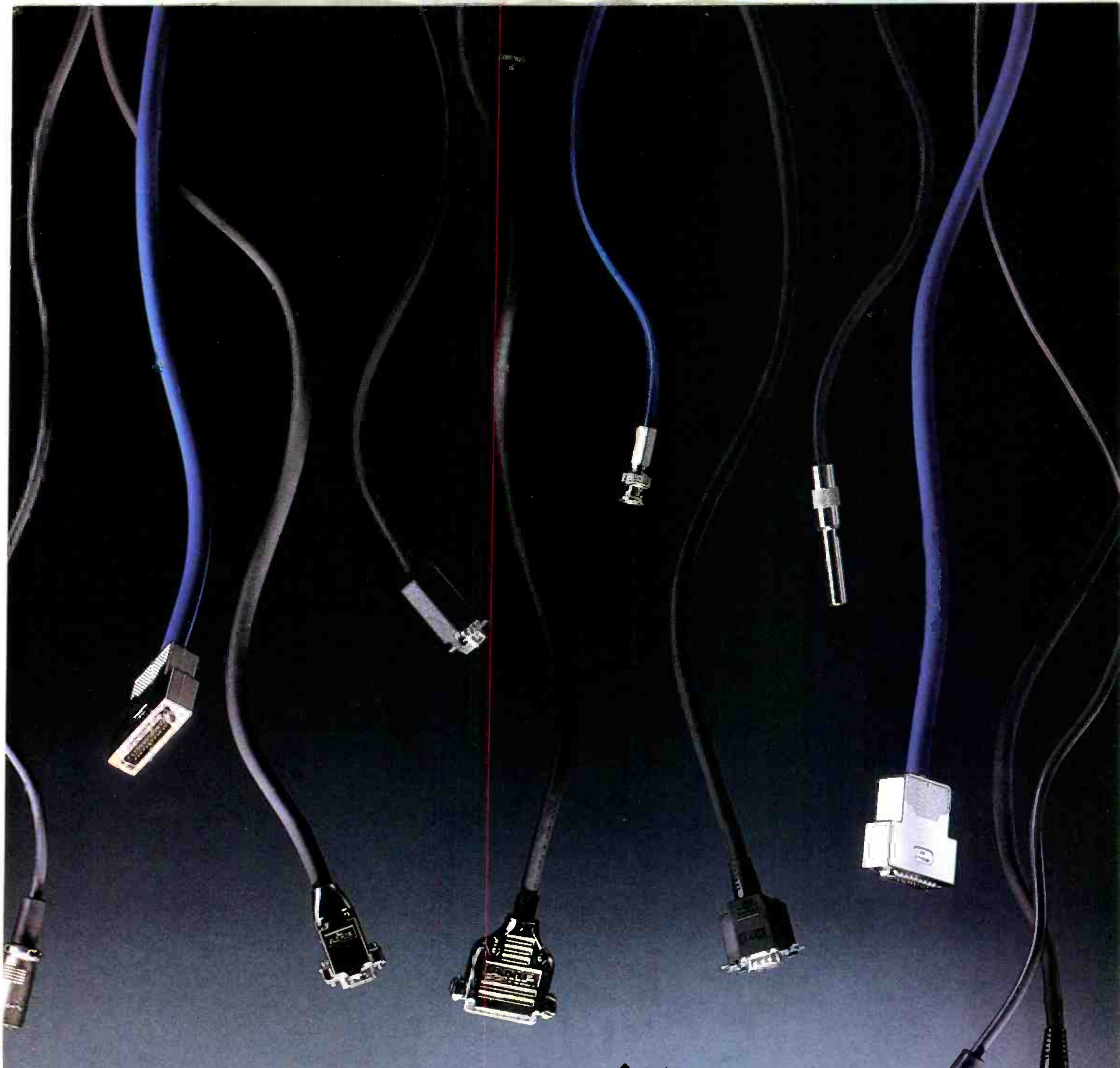

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Continued from page 70

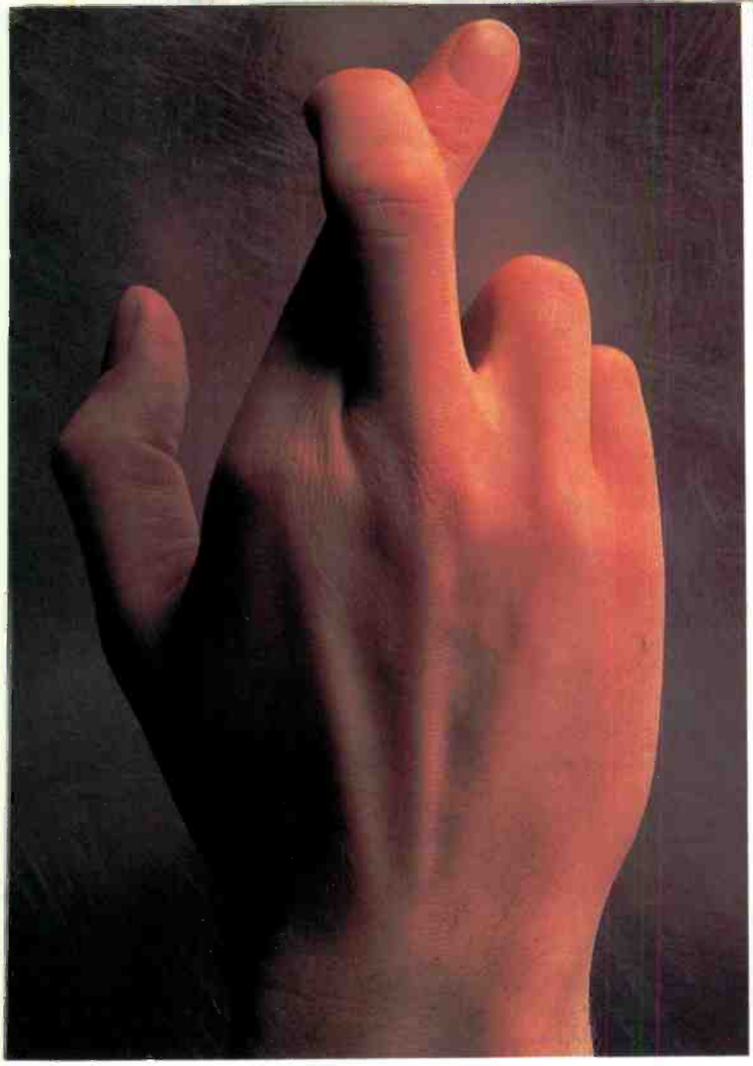
Fiber-optic links provide the broadcast industry with a media ideally suited to requirements of digital signals, so there is little doubt we will see their usage increase. In addition to its other advantages, the inherent versatility of optical fiber with respect to changing formats and data rates will allow cabling plants to remain in place through many generations of digital standards. This future staying power will offset initially higher costs and conversion expense.

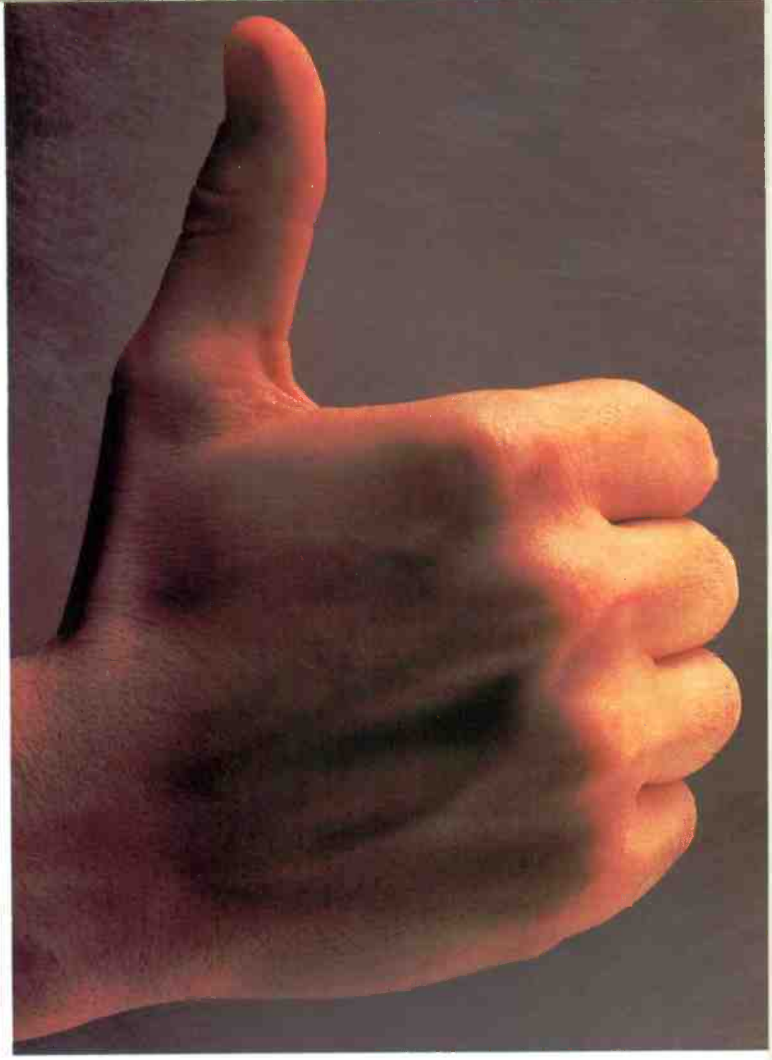
With the advent of digital audio and component, high-definition and digital TV transmissions, along with growth in the number of offerings to consumers, continually wider bandwidths will be required. As Lewis Carroll's unwittingly prophetic Alice remarked in *Through the Looking Glass*, "You have to run as fast as you can to stay in the same place," a familiar feeling indeed to many in the broadcast world. Fiber-optic transmission should give them all a big head start.

Fiber-optic measurement and testing

By Skip Pizzi, technical editor

Once a fiber link is established, its performance must be assessed on an ongoing basis. In addition to standard end-to-end link measurements made on audio and video signal quality, measurements made on the fiber-optic link itself — in the optical domain — require a new breed of test equipment. Fortunately, not much can go wrong with a properly engineered fiber link; about the only tests that need to be made are for continuity and loss. When digital methods are used, audio and video program signal quality really will not be affected in any incremental way by the performance of the fiber link itself; program output will either be present or not. (For analog video on fiber, standard video link quality tests are still useful, but typical performance is excellent and quite consistent.) A no-output condition can be caused, of course, by lack of continuity, but also by





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excessive loss, such that an optical receptor does not see sufficient light power to generate electrical current.

Loss is the primary criterion of performance in fiber. Loss measurements are critical, because they determine all the basic link-design parameters in a given application. They are complicated by the fact that optical power is wavelength dependent. The optical wavelength used (850nm, 1,300nm or 1,550nm) will affect the actual loss encountered in a given length of a given type of fiber. Derived from this loss data are the link-engineering benchmarks of carrier modulation bandwidth and distance between repeaters. Loss in a fiber-optic circuit can be caused by a wide variety of culprits along the path. (See "Fiber Optics in the Broadcast Industry," pg. 50.) Accurate measurement and attribution of all losses in a fiber-optic link is vital to proper system installation and operation.

Tests for continuity can literally be as simple as holding a flashlight or high-intensity lamp to one end and looking into the other. A dull reddish point of light should appear at the receive-end when looking straight on-axis into the fiber in a dark or dimly lit room. (The light source should be aligned with its axis of maximum output firing straight into the fiber, as well.)

A more elegant method of simple testing uses an optical power meter. This device is the optical equivalent of a voltmeter, measuring optical power in dBm on a digital numeric display. (All measurement in the optical domain uses dB units, with a dBm scale referenced, as always, to 1mW. The milliwatt reference in this case is an optical--light--power measurement, however.)

Basic styles of optical power meters are designed for use on one optical wavelength. More sophisticated models are switchable to all commonly used wavelengths and may include other convenient metering features.

Optical power meters can be used to determine total system loss, which, as you might expect, is a simple comparison of optical input power and output power. Calibrated meters are used on each end, and their readings compared. If the loss figure is within specification, that's all there is to it.

If not, finding the source of the loss or discontinuity is the next step. An optical fault finder or optical time domain reflectometer (OTDR) is used for this step. As with RF-type reflectometers, these devices send a light pulse down the fiber, and measure the characteristics of the reflected light that returns. The simpler and more portable of the two devices is the optical fault finder, typically a battery-powered, microprocessor-based measurement tool that examines the reflected light for losses and reflections.

First, a baseline reflected light level caused by the fiber-optic cable's normal "backscatter" is measured. This is typically a low-level signal, and requires an extremely sensitive detector section in the fault finder. (As with all fiber-optic test gear, coupling loss to the device's optical detector must also be low, and optimized to the type and size of cable under test.) Next, the device measures discrete reflections caused by mechanical splices and connections, and in-

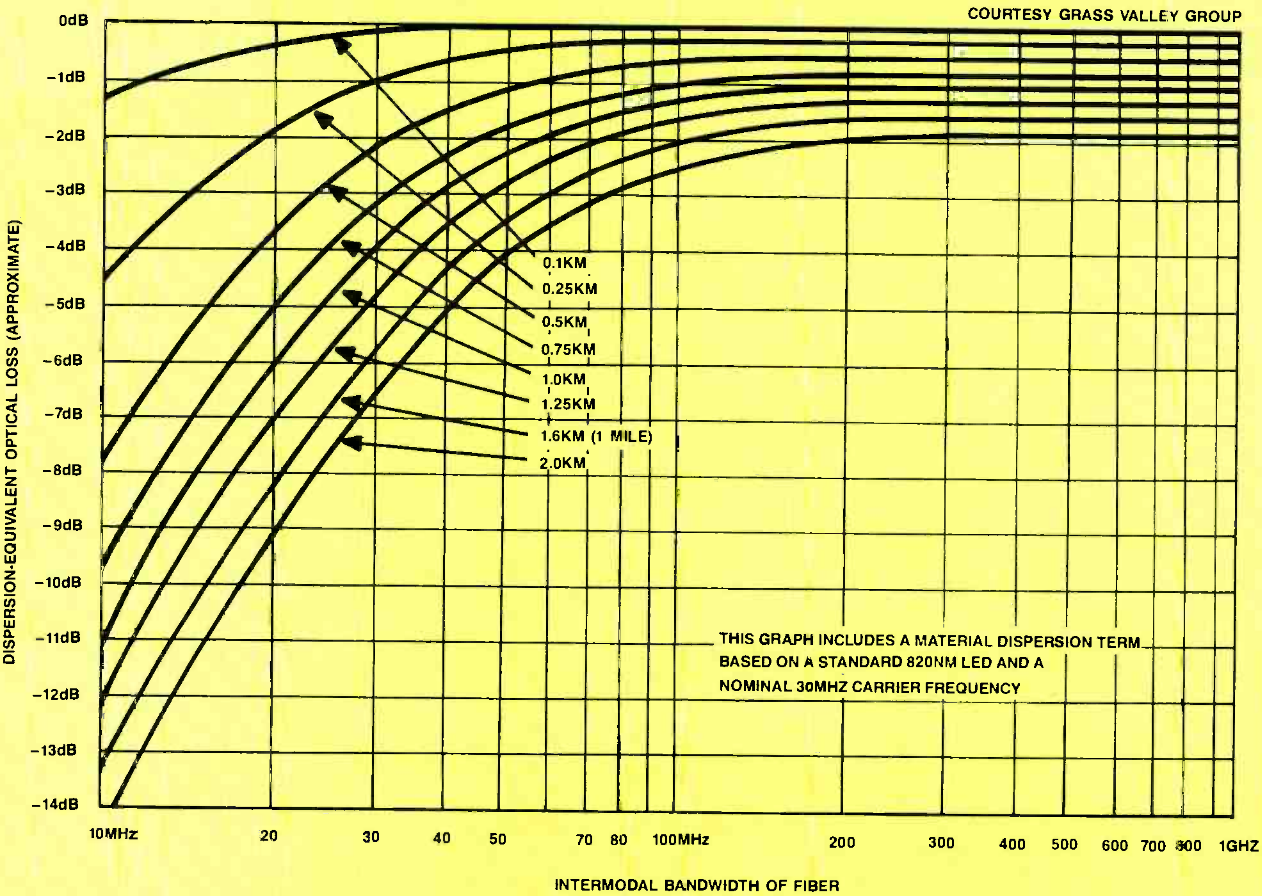

Figure 1. *A typical dispersion loss table, showing the interrelation of path length and bandwidth.*

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dividual losses caused by fusion splices or crimps in the cable. A complete break in the cable will typically create a reflection and a loss. The fault finder measures the value and location of these events (in meters or feet from the end under test), and presents them in an alphanumeric display.

An OTDR is typically a larger, less portable, 120VAC-powered box with a specialized oscilloscope display, measuring the same things that an optical fault finder does, and more. On an OTDR, a waveform is presented on the CRT screen, plotting loss in decibels on the vertical axis vs. linear distance (meter or feet) on the horizontal. In this way, a graphic display of events along the cable is given, and each connector, splice or anomaly can be seen, measured and located. The overall length of the cable can also be calculated, as can the attenuation loss of the fiber cable, measured in decibels/kilometers, the latter derived according to the following formula:

$$L_{fop} = \frac{10 \log P_1 / P_2}{D}$$

where L_{fop} = fiber-optic loss (dB/km)
P_1 = optical power at transmit end (mW)
P_2 = optical power at receive end (mW)
D = length of cable (km)

Modal compensation is employed on laboratory tests of multimode fibers to simulate the modal filtering effects of real world longer cable runs, at a given optical wavelength and carrier frequency. The loss per kilometer figure described previously can be multiplied times the number of kilometers in an actual cable run, then added to the "component" losses from connectors, splices and coupling, to obtain the total equivalent path loss of a fiber-optic link, in decibels. These calculations are compared to the requirements of the transmission and reception equipment (in terms of output levels and input sensitivities), whereupon the link's components and length are adjusted such that combined losses do not exceed the capabilities of the terminal hardware.

If, for example, such hardware can accept a 10dB loss across the path, the sum of cable losses from dispersion (an optical wavelength- and carrier frequency-dependent value, (see Figure 1), path attenuation (per formula above x length), coupling losses on both ends, and losses from any splices, splits or connectors encountered along the way must total less than 10dB. A little headroom should be left for unexpected anomaly losses, such as those from microbends. If the losses add up to more than the 10dB that this hypothetical system allows, then component losses must be reduced (by using lower-loss units or eliminating splits or splices, if possible) or a different type of cable should be selected. For example, if multimode step index is being considered, graded index or single-mode should be plugged into the calculations. Or, if possible, the use of a longer optical wavelength on the same cable should be tried. Failing this, of course, the use of repeaters will be necessary. A budgetary factor gets plugged in here at some point as well, because all the possible choices and compromises available will involve differing expenditures.

Speaking of dollars, optical test equipment costs can also be considerable. A full-blown OTDR for measuring multimode fiber generally runs about $15,000 and up to $30,000 for single-mode units. Optical fault finders start around $5,000. Prices for optical power meters range from $1,000 to $10,000, depending on wavelength agility and other features.

In the initial design of fiber-optic systems, more detailed testing is involved, which measures the time domain performance of the cable and its optical-to-electrical (O-to-E) transducers. A "pulse-spreading" measurement is used here to determine the eventual performance of a cable or device system in terms of bandwidth and distance, as shown in Figure 2. A short optical pulse is sent in, and the resulting pulse shape at the receive end of a known length of cable is analyzed, in effect measuring the optical impulse response of the path. Fast-Fourier transforms of this time domain data are performed on the input and output pulses, and the resulting frequency domain data compared, thus quantifying the path's attenuation vs. frequency and phase vs. frequency. These responses can then be used to determine a particular path's suitability for a given application, based on the bandwidth and distances required.

In more practical applications, OTDRs were extremely useful in troubleshooting the first transatlantic fiber-optic cable, which kept developing mysterious discontinuities after being laid. The cause turned out to be shark bites, but what was attracting the sharks to the cable was not immediately evident. After some examination, it was determined that the high-voltage coaxial power conductors in the the center of the fiber bundle (for powering the in-line repeat amplifiers) created an electrical field similar to some of the sharks' natural prey. The solution was to sheath the cable with a tough but lightweight insulation that sharks could not penetrate. The insula-

tion was only required for the depths occupied by sharks. The middle (and by far the longest) section of the transoceanic run did not require it, because it lay on the ocean floor, well below shark-depth.

Similarly hostile environments will be encountered as fiber-to-the-home progresses. Installations have already begun with "fiber-to-the-pedestal" for residential telephone service, using multipair copper from each 4-home pedestal to individual homes. The transition to using fiber all the way into the customer's premises is a simple step from this, and that application is expected to become popular soon for high-definition cable TV distribution. Flexible optical test gear will be a must in this marketplace.

Although the typical user of a fiber-optic link may only require an optical power meter for troubleshooting and routine maintenance measurements, an installer of fiber-optic cables will require an optical fault finder, and a fiber-optic system designer will want a full-blown OTDR. Where the broadcast engineer fits into this matrix will vary greatly over the next few years, as the industry moves increasingly away from copper and toward fiber for permanent links, temporary remote lines and even ENG uses. It may be time to clear some space on the bench for a new box.

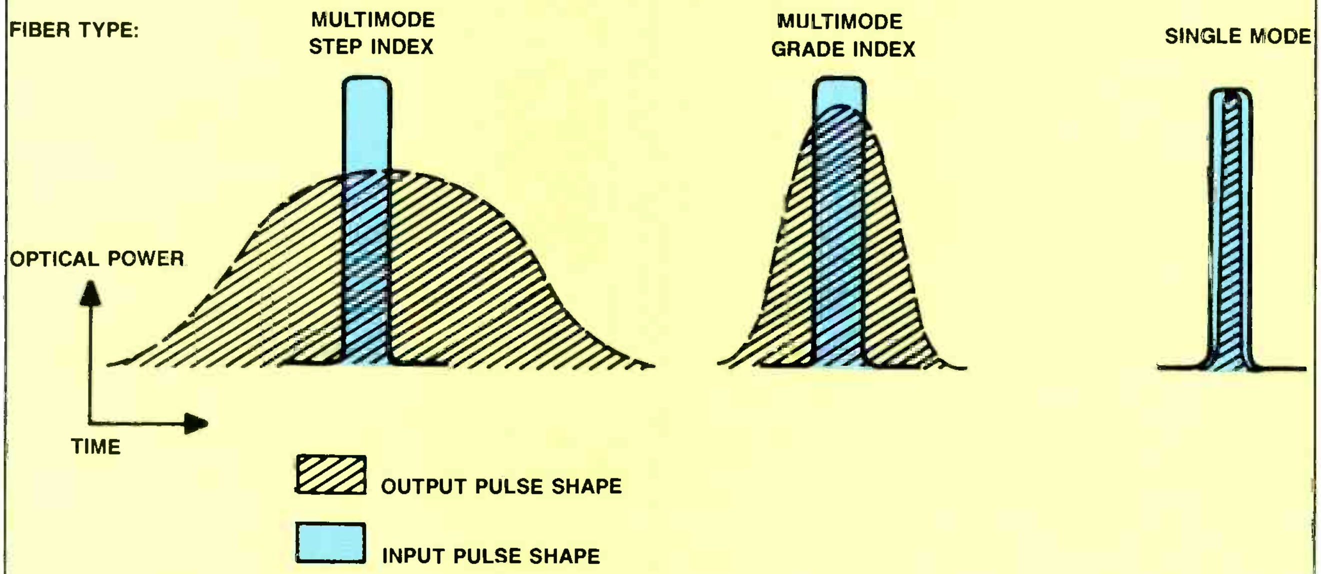

Figure 2. *"Pulse-spreading" phenomena in the three types of fibers.*

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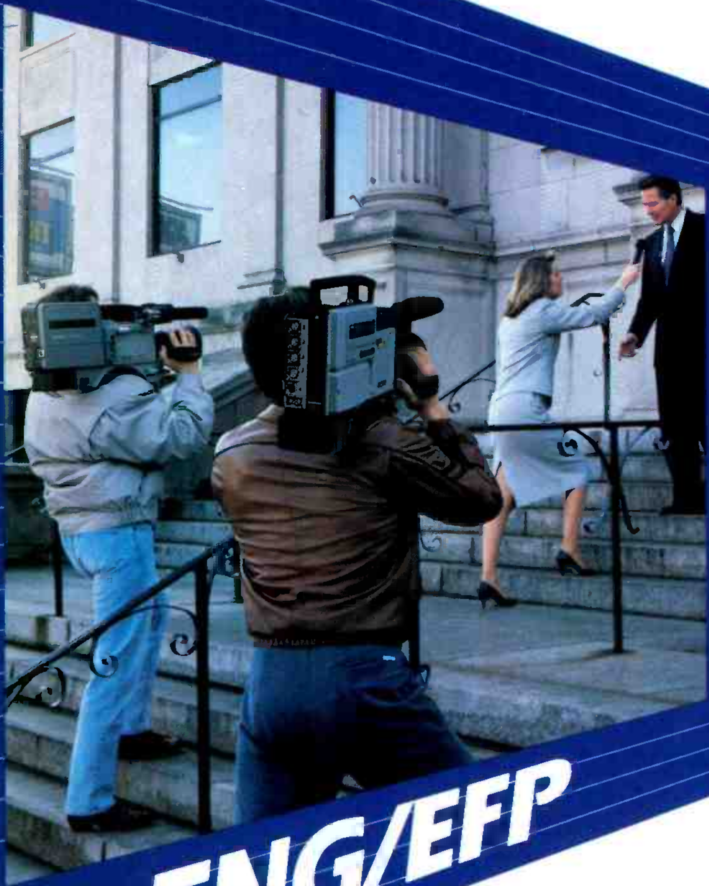

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Understanding and using VCAs

Master VCA basics and gain remote-control alternatives.

By Ron Dow and Dan Parks

Voltage-controlled amplifiers (VCAs) have become common building blocks in the design of professional audio equipment. Therefore, broadcast engineers and other audio professionals need to develop a more detailed understanding of VCA technology. For a thorough evaluation of various available VCAs, refer to Ben Duncan's recent work.[1]

Audio 101: Fundamentals of VCAs

VCAs allow automatic or remote control of volume in audio systems. Most applications call for attenuation, although some instances might require gain, such as in automated consoles.

A VCA in its simplest form contains an audio input and output and a control port. (See Figure 1.) A voltage (or current) applied to the control input will provide a gain change. The heart of a VCA is its gain core, which is based on closely matched NPN and/or PNP transistors. Because bipolar transistors are current-amplifying devices, they operate best in current mode. Therefore, to access the gain core, voltage-to-current conversion must occur at the input, and current-to-voltage conversion must occur at the output.

Two classes of bias are possible for the gain core. In *Class A*, the standing bias current is equal to the maximum signal the gain core can pass without clipping. In *Class AB*, the quiescent, or idle, bias current in the core is some small fraction of its maximum signal range.

For similar size gain-core transistors, Class AB offers greater dynamic range and lower control feedthrough. Class A has the inherent advantage of lower overall distortion than Class AB, which is evident over gain and attenuation. With some VCA topologies it is possible to externally select the gain-core bias, or even dynamically change it, depending on the program material. This is generally referred to as *sliding bias* operation.

Dow is director of design engineering, SSM Audio Products, at Precision Monolithics (PMI), Santa Clara, CA. Parks is marketing manager for the audio line at PMI.

VCA applications

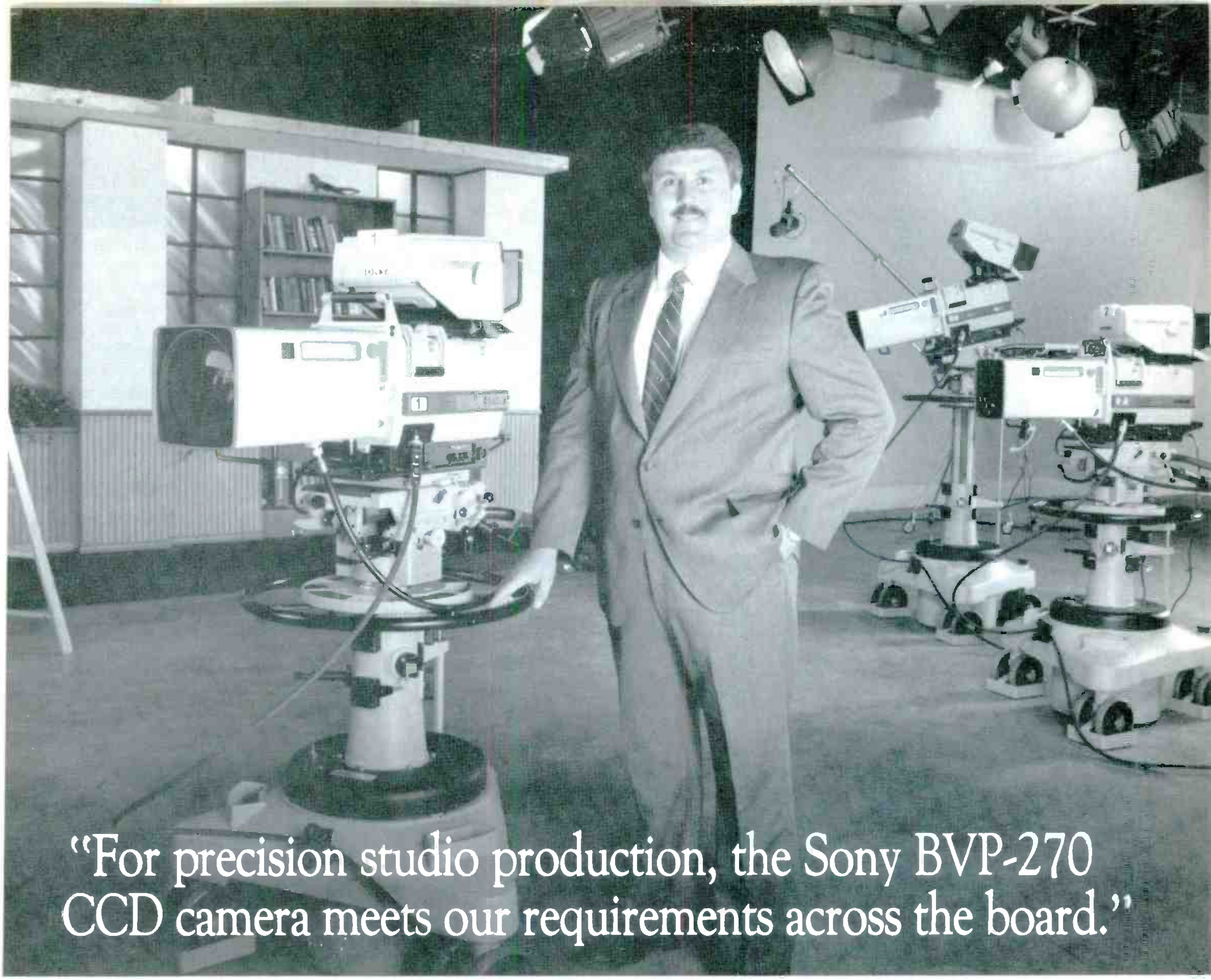
VCA has become a familiar acronym in professional audio equipment, and is starting to be touted as a feature in consumer audio systems. Voltage control of gain lends itself to use in audio mix consoles and dynamic range processors. Console automation, once reserved for the most-expensive systems, has worked its way to midrange, and, in some cases, to low-end mixers. VCAs are one of the techniques used in fader automation.

The other primary use of VCAs is in dynamic range processors. These systems can increase or decrease the effective dynamic range of an audio signal, depending on the particular requirement. Almost all dynamic processors use some type of level detector to control the VCA. Compressor/limiters prevent clipping by attenuating an audio signal when it exceeds a user-selectable threshold. Noise gates attenuate completely when no audio signal is present. Other types of dynamic range processors include noise-reduction systems, duckers, automatic noise levelers, psychoacoustic enhancers, de-essers and automatic microphone mixers.

Additional applications include voltage control of equalization, panning and other potentiometer functions.

A historical retrospective

In order to understand VCA technology, some historical background information would be useful. The first commercially available integrated circuit (IC) products were made by RCA in the late



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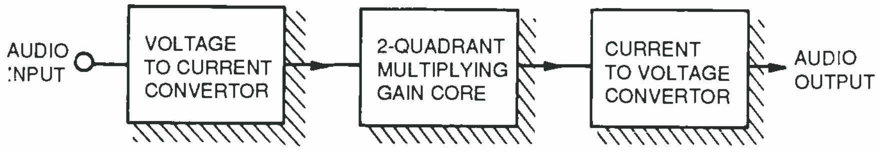

Figure 1. The basic block diagram of a voltage-controlled amplifier. In its simplest form, a VCA contains an audio input and output and a control port.

1960s. Referred to as operational transconductance amplifiers (OTAs), the principal products in this series were the 3060, 3080 and 3280. These were current-controlled parts. Although audio and control specifications made significant improvement as the series progressed, they were never adequate for professional audio. However, they were used by pioneering American electronic musical instrument manufacturers of the time, such as Moog, Arp, Emu, Oberheim and Sequential Circuits. In an OTA, the gain (transconductance) of a simple bipolar differential transistor pair is controlled by a current-controlled current source. (See Figure 2.)

More precise control of gain resulted from the work of Barrie Gilbert in 1968, who developed several circuits using log-anti-log or translinear techniques. Although his 4-quadrant multiplier[2] was not generally useful for audio gain control — because of control characteristics and signal feedthrough problems — a condensed version, the 2-quadrant multiplier, permitted significant improvements over OTAs. (See Figures 3 and 4.)

What's more, an exponential or decibel-per-volt control could easily be added to the circuit. Two whole families of IC products were developed along these lines by Solid State Micro Technology (now the SSM Audio Products Group of Precision Monolithics)[3] and Curtis Electro Music (CEM) for electronic musical instrument applications. Also during this period, the National LM13600 and Signetics 570[4] compandor series were introduced, using OTA technology. Although Signetics developed the 570 series for noise reduction in telecommunications, these units found their way into audio products, such as wireless microphones and signal delay units.

The modern professional audio VCA descended from the work of David Blackmer, then of dbx[5]. Introduced in the early 1970s, the original dbx VCAs were Class AB gain-core designs offered in module form. They opened the way for fader automation in mixing consoles. (See Figure 5.)

Figure 6 shows an alternative with some embellishments. It was developed by Paul Buff, then of Allison Research (now Valley International). The EGC-101 also was a module, but it had a Class A gain-core bias. A lower-cost module, the TA-101, was later introduced by Valley. Around this time, Robin Bransby of Audio Kinetics pioneered the development of a sliding bias technique.

These modular products were expensive, bulky and had drift problems because of internal thermal gradients that could adversely affect performance. A push was on to develop professional quality IC VCAs. IC technology can assure tight transistor matching, reduce thermal gradients, significantly lower cost and improve relia-

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bility. In 1980, three products appeared: the dbx 2150 series, which used a Class AB approach; the Class A SSM 2013 from Solid State Micro Technology; and the 1537A, developed by David Baskind and Harvey Rubens (now VCA Associates)[6,7], also a Class A design.

In early 1983, a joint development was undertaken between SSM and Doug Frey of Lehigh University. Frey had developed a generalized VCA circuit topology that could control many commonly used audio functions, such as panning, equalization, pre-amplification and gain. This type of circuit was called the operational voltage-controlled element (OVCE).[8,9,10] Most earlier professional audio VCAs were single-ended current-in, current-out devices. This device could operate through a single end or differentially in voltage or current on the input(s) and output(s). (See Figure 7.) An electronic bias control permitted external selection of gain-core class or dynamic sliding biasing. This allowed the user the advantage of both classes of operation. Also, a gain-variable compensation scheme was employed that extended the effective bandwidth over gain and attenuation. This circuit was integrated and is available as the SSM-2014 from Precision Monolithics.

In 1988, SSM introduced the SSM-2120, a dual dynamic range processor IC with two VCAs and two level detectors, and its derivative, the SSM-2122 with only the VCAs pinned out.[11]

The Class A VCA 1001 was introduced by Aphex Systems in 1987 for inclusion in its dynamic range processing products, and also is available on an OEM basis for non-competing applications.

The dbx OEM VCA business was acquired by That Corporation in 1989.

Today, VCA devices are available from a number of manufacturers. (See Table 1.)

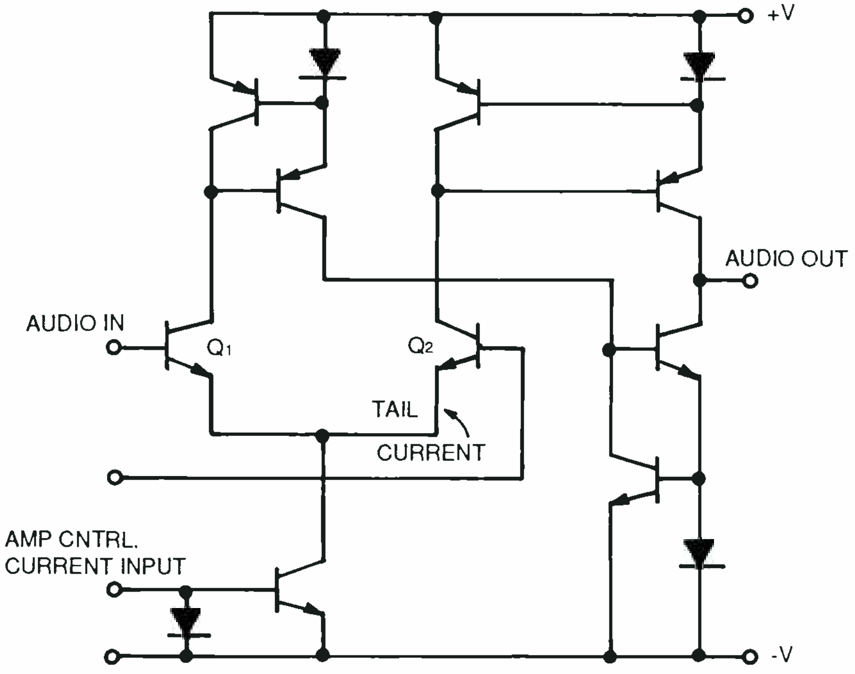

Figure 2. RCA 3080 operational transconductance amplifier (OTA).

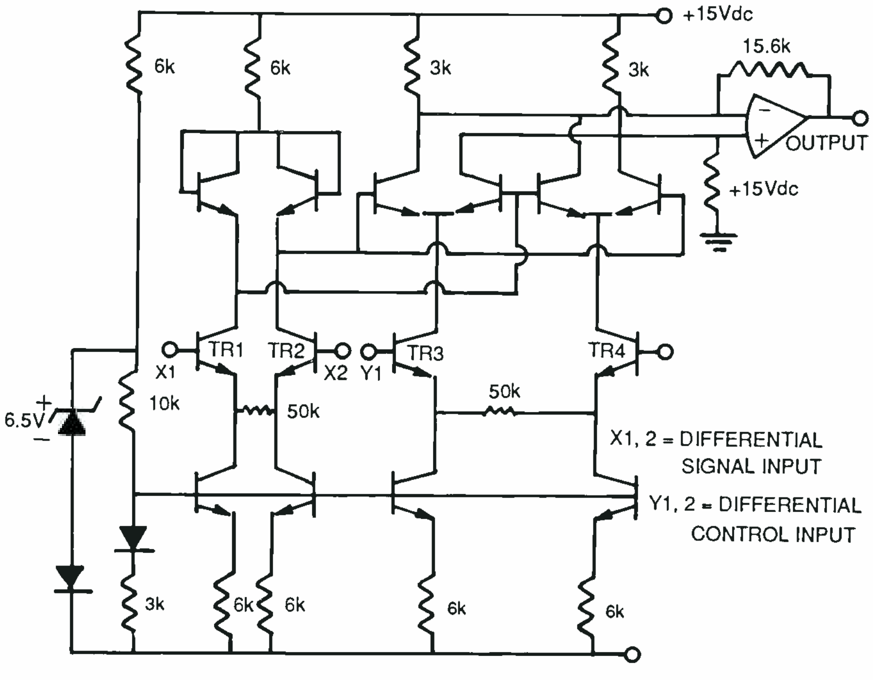

Figure 3. A 4-quadrant variable transconductance multiplier.

VCA evaluation criteria

Professional audio equipment designers and users are exercising increasing scrutiny over audio performance, and VCAs are no exception. This is not surprising, considering the sensitivity of the end-user's test and measurement system — the human ear. As with most component or system choices, however, tradeoffs have to be made among various performance attributes, as well as cost, reliability and manufacturing considerations. We are suggesting some key performance and control factors to consider in VCA evaluation and selection, but this information is by no means exhaustive. VCAs are expected to have superb audio specifications, which include:

Distortion:

Advancements in overall audio system design have resulted in ultralow distortion. In measuring VCAs, 0.01% THD is desired over all operating conditions (signal level, frequency, load condition and gain range). In addition to THD, intermodulation distortion (IMD) and transient intermodulation distortion (TID) must be considered. IMD is caused by system non-linearities and produces harmonic components not present in a complex non-sinusoidal input signal. TID, which can degrade rapidly with increasing frequency, is caused by crossover distortion and/or low slew rate. This results in a loss of audio detail during sudden or large transients.

par•a•gon \'par-e-,gän, -gen\ *n*
1 : a model of excellence or perfection, an apparently perfect person or thing

As Defined by Webster's.

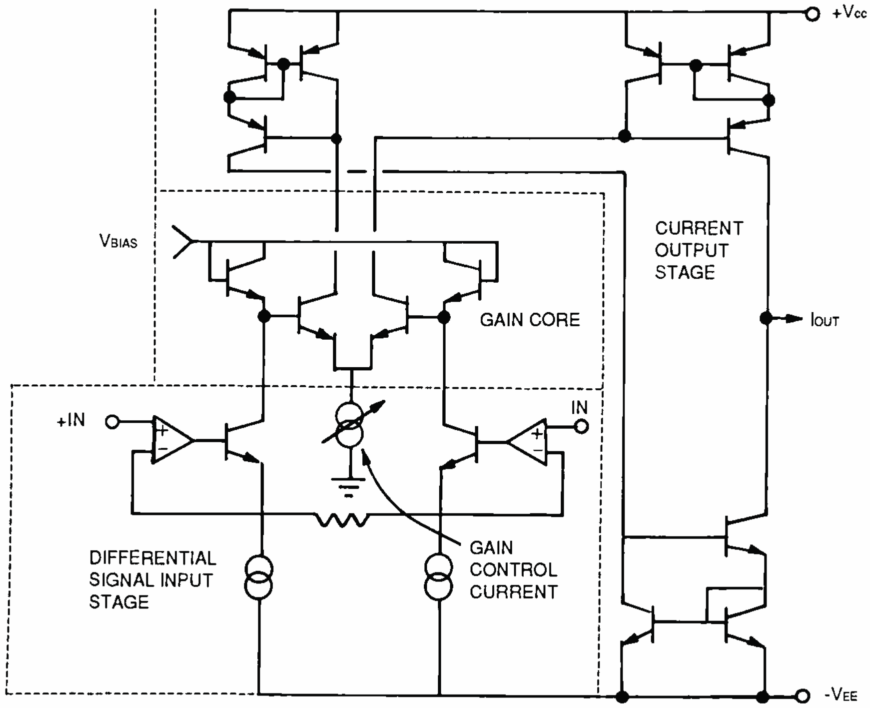

Figure 4. A 2-quadrant multiplier/VCA. This is a condensed version of the 4-quadrant unit, and offers significant improvements over OTAs.

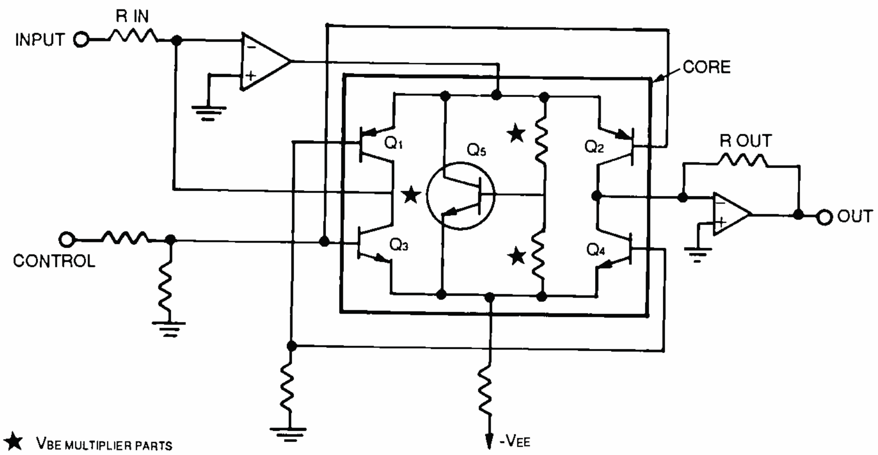

Figure 5. A dbx Class AB log-anti-log VCA. Introduced in the early 1970s, the original dbx VCAs were Class AB gain-core designs offered in module form and opened the way for fader automation in mixing consoles.

Dynamic range:

This is generally expressed as a ratio (in decibels) of the VCA's clipping level to the noise floor over the audio bandwidth. The human ear's maximum dynamic range, defined as the threshold of hearing to threshold of pain, is approximately 120dB at 1kHz. Because uncorrelated noise in a system adds as the root mean square, every component in the signal path should have a dynamic range in excess of 100dB as is possible.

Speed:

The three interrelated specifications that are often given as figures of merit for speed are bandwidth, slew rate and phase response. An audio phase flat response (no more than a degree of phase shift at 20kHz) implies a 3dB bandwidth or at least a few hundred kilohertz. Modern audio engineers get uncomfortable with a slew rate specification any less than approximately 6V per microsecond.

dc offset:

This is a concern because ac coupling may be required between amplifier gain stages that have inadequate input-referred offset, which can affect the phase integrity of low-frequency signal components. Many audio designers prefer dc coupling wherever possible. Offset also can cause annoying pops and clicks during signal switching.

In addition to audio performance, a VCA's control input and its characteristics also have stringent and sometimes subtle requirements:

1. *Gain control accuracy:* This should be no more than a few tenths of a decibel, particularly near unity gain. Also, no adjustment or selection should be required for unit-to-unit variability. Furthermore, environmental conditions, such as temperature, should not produce unacceptable gain changes.

2. *The useful gain control range:* Generally specified in decibels to a given accuracy. A somewhat related specification is off-isolation, which is the amount of input signal reaching the output when the device is at maximum attenuation. A frequency test condition is required to make this specification meaningful because it will degrade with increasing frequency.

3. *Control feedthrough:* Also called control breakthrough. This results from incomplete isolation of the control input from the signal path and manifests itself as pops or clicks during sudden gain changes.

Summary

VCAs do not have as good a dynamic range and distortion performance as the best of their rival technologies. (See the related article, "Alternative Technologies: The Other Gains in Town," page 94.) However, the gain port problems that plague their rivals, such as unit-to-unit gain variability, limited gain range and non-logarithmic control laws, are not serious problems in modern VCAs. VCAs have a precise control law over a gain range of +40dB to almost −100dB. Moreover, VCA distortion is so low that it can only be measured at signal levels near the top of its dynamic range. Sliding bias techniques that switch the VCA's gain-core operation can improve overall performance and min-

imize the concern of such tradeoffs. Further advances in IC processing can extend performance, features and cost. Finally, specialty products, such as the SSM 2300 8-channel multiplexed sample and hold, have made designing large VCA-based systems easier and less expensive. As the technology continues to develop, VCAs should make possible the automation of

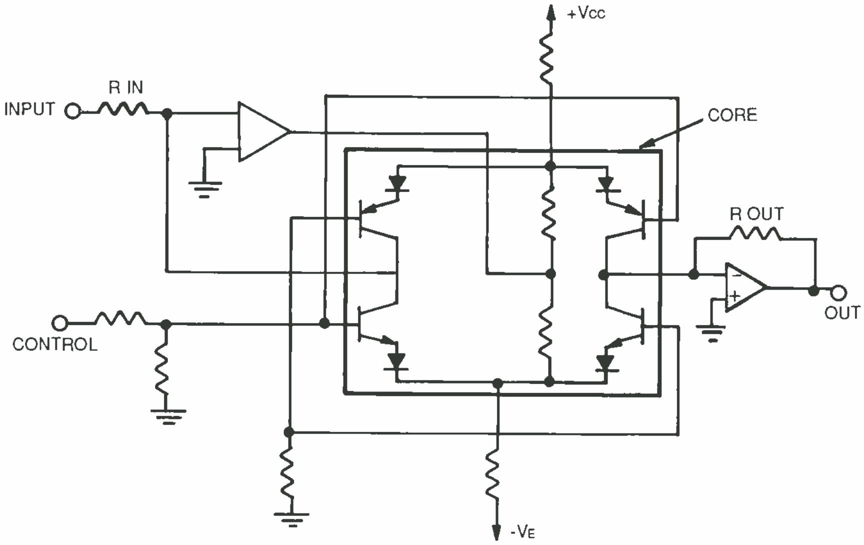

Figure 6. *A Valley Class A VCA. It is an alternative to the Class AB unit, with some embellishments.*

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more functions in large analog systems.

Suppliers of VCAs				
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THAT Corporation 15 Strathmore Road	dbx 2155 dbx 2150A	IC IC	AB AB	8-pin SIL 8-pin SIL
Natick, MA 01760 508-653-6335 Fax 508-653-5334	dbx 2151 202XL	IC Module	AB AB	8-pin SIL PCB
Valley International P.O. Box 40306 Nashville, TN 37204 615-383-4737 Fax 615-269-2441	TA-101 TA-103 ECG-101 ECG-205M	Module Module Module Module	A A A A	12-pin Brick 12-pin Brick 8-pin Brick PCB
VCA Associates 7131 Owensmouth St., B87 Canoga Park, CA 91303 818-704-9202 Fax 818-704-9310	MTA-1537A MTA-1537B MTA-1537C MTA-1537D	IC IC IC IC	A A A A	14-pin DIP/SO 14-pin DIP/SO 14-pin DIP/SO 14-pin DIP/SO
	VCA 1001	IC	A	18-pin DIP

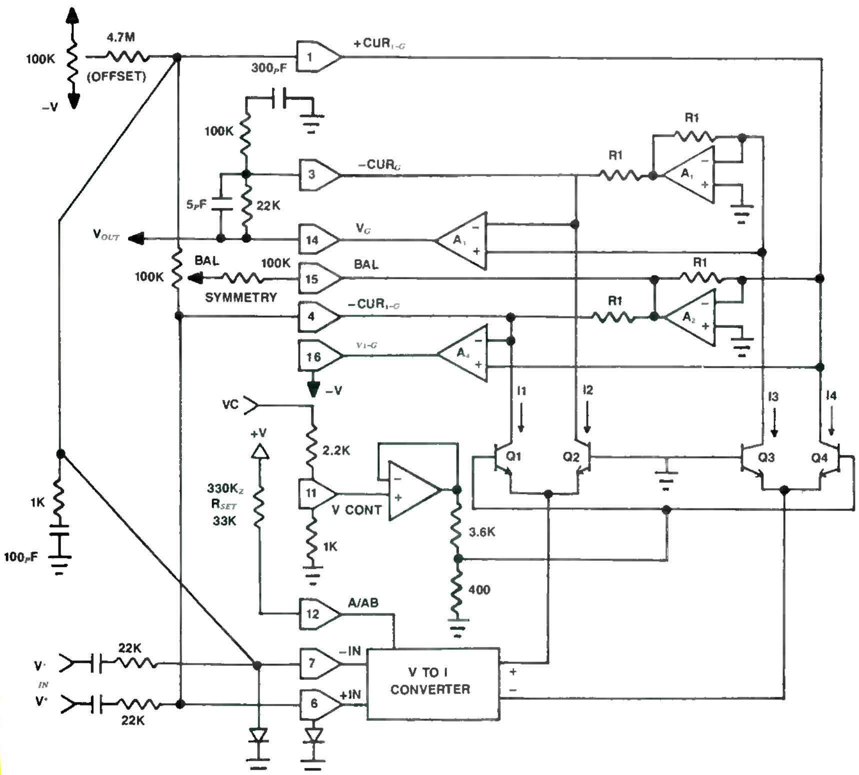

Figure 7. An SSM 2014 connected as a differential input VCA. Most earlier professional audio VCAs were single-ended, current-in, current-out devices.

Footnotes

1. Ben Duncan. "VCAs Investigated." *Studio Sound*, June, July, August 1989.
2. Barrie Gilbert. "A Precise Four-Quadrant Multiplier with Subnanosecond Response." *IEEE Journal of Solid State Circuits*, December 1968, p. 365.
3. Ron Dow and David Rossum. "A Set of Integrated Circuits for Electronic Music." *Audio Engineering Society* Preprint 1367, May 1978.
4. C. Todd. "A Monolithic Analog Compandor." *IEEE Journal of Solid State Circuits*, Volume SC-11, No. 6, December 1976.
5. David Blackmer. United States Patent No. 3,714,462. Issued Jan. 30, 1973.
6. D. Baskind and H. Rubens. "Techniques for the Realization and Applications of Voltage-Controlled Amplifiers and Attenuators." *Audio Engineering Society* Preprint 1378 (A-6), May 1978.
7. D. Baskind and H. Rubens. "The Design and Integration of a High-Performance Voltage-Controlled Attenuator." *Audio Engineering Society* Preprint 1555 (D-2), November 1979.
8. D. Frey. "The Ultimate VCA." *Audio Engineering Society Preprint* 2024, October 1983.
9. D. Frey. "An Integrated Generalized VCA Building Block." *Audio Engineering Society* Preprint 2403, October 1986.
10. D. Frey. "The Design of High-Performance Voltage-Controlled Equalizers." *Audio Engineering Society* Preprint 2527, October 1987.
11. Ron Dow. "A Stereo Monolithic Dynamic Range Processor." *Audio Engineering Society* Preprint 2696, November 1988.

Alternative technologies: The other gains in town

When it comes to remote or automatic gain control, VCAs aren't the only option. Various alternatives include some predecessors to VCAs, and others are emerging. Following is a summary of alternative gain-control techniques:

- *Electromechanical devices:* Although a seemingly archaic technology, motorized faders and potentiometers are popular in automated mix consoles and hi-fi equipment. The advantage of little audio signal degradation other than motor noise is offset by increased energy consumption and heat, reliability and cost. Nevertheless, the motorized fader is and will be a viable alternative to VCAs.

- *Photoelectric devices:* With these devices, audio characteristics can be excellent in all respects, as well as control feedthrough and off-isolation. However, other control port issues present problems for many types of systems, such as unit-to-unit variability, which may require trimming of device selection. The control transfer characteristic is highly non-linear and varies from device to device. Recalibration may be necessary over time.

When you need extra hands mixing audio, Shure's AMS can help.

Until recently, you needed outstanding hand-ear-eye coordination to mix audio in multiple-microphone broadcast situations.

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Because of this unique gating concept, an AMS microphone channel will *only* gate on when addressed from within a 120-degree "window of acceptance" centered at the front of the microphone. AMS mics *not* addressed from within this angle remain off. So the number of open microphones is kept to a minimum automatically, with no need for manual control.

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audio without the headaches of manual mixing or the time-consuming setup of so-called automatic mixers.

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• *Field-effect transistors (FETs):*
FETs are used in gain-control circuits as voltage-controlled resistors. Although the channel specifications for such circuits are not as good as for photoelectric devices, they can be acceptable. Because the FET has a square law control characteristic, producing a large control range in decibels can be difficult and requires a considerable amount of external hardware. Unit-to-unit variability of discrete FETs, which offer the best audio specifications, can be large. Gain drift over temperature and gain also presents problems.

• Digital-to-analog converters (DACs):
Because they offer a direct digital interface and good signal channel specifications, DACs are tempting candidates for gain control in consoles. The main difficulties come with the control port. Because gain control is not continuous, but occurs in finite steps, it can produce an effect called *zipper noise*, which is a large glitch introduced in the signal path on certain code transitions. Most DACs are linear rather than decibel-per-bit of code change. Decibel-per-bit DACs are available, but they are relatively expensive and have limited gain resolution and range. They also produce code noise on gain transitions.

• Digital signal processing (DSP):
DSP is regarded to be the wave of the future. It is useful for automating gain control, panning, routing and equalization. However, at the present, applications of DSP in audio are limited. Studio console designers, who are at the leading edge of audio technology, consider 16-bit technology, which yields a maximum dynamic range of 96dB, inadequate. Present analog mixing desks can have dynamic range performance in excess of 120dB. This corresponds to approximately 20 bits. Furthermore, digital encoding causes distortion to increase as signal level decreases. This is opposite of the distortion trend in analog systems that we are used to because the ear itself is such a system.

An economically viable professional digital mixing desk would have to employ at least 20-bit converters and a 24-bit internal computational architecture. Low-cost, high-resolution conversion technology, particularly ADCs, is likely to be the pacing item for commercially viable audio DSP equipment. A complication in digital audio equipment is sampling time uncertainty, or aperture jitter, which can limit the effective dynamic range to considerably less than the number of bits involved in the conversion. (Editor's note: At the October 1989 AES in New York, several 18-bit processors were introduced. What effect this will have remains to be seen. However, their stated audio performance is said to be substantially superior to current 16-bit hardware.)

Fortunately, there *is* a system: The Denon CD Cart System. The broadcast and production industry standard, already on the air at more than 1000 radio stations around the country.

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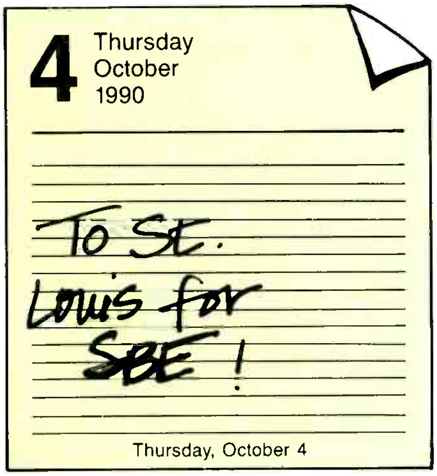

By Brad Dick, editor

It's back to St. Louis as the SBE national convention holds the 1990 show in the same city in which it started. The show is scheduled for Oct. 4-7 and promises to be even larger than last year's highly successful show in Kansas City.

Cutting-edge sessions

This year the seminars begin on Thursday and continue through Sunday morning. The 3½ days of sessions will look closely at the upcoming technological revolutions that will affect broadcast engineering. Almost every type of radio and TV broadcast subject will be addressed from ACTV to UHF.

The sessions are coordinated by John Battison and *Broadcast Engineering* magazine. Building upon last year's success, the sessions promise to be a hit with attendees. Each paper has been allocated an additional 10 minutes, so every speaker will be allowed a total of 40 minutes. The change was based on last year's attendee survey, which indicated a desire for more time for questions and discussion.

In addition to the changing technology front, many sessions are designed to help engineers cope with the demands of today's fast-paced operations. More than 20 papers will explore areas to help the engineer measure and maintain the equipment better and faster.

Ennes workshops

The Ennes workshops will be held on Wednesday, the day before the show opens. These special workshops are designed to provide hands-on training by factory instructors. This year's sessions include:

- Medium- and High-Power FM Transmitters, Continental Electronics
- Understanding and Maintaining C-Quam AM Stereo Systems, Delta Electronics
- Earth Station Technology, Andrew Corporation
- System Modeling Using AudCAD and CableDOC, Video Design Pro
- S-VHS Electronic News Gathering and Production, JVC Electronics
- RF Technology, Harris/Allied
- Satellite Communications, Mitchell Vo-Technical School
- The Don Markley RF Workshop
- Management for Engineers

Paid registrants can attend any one of the full-day or up to two of the half-day workshops.

Lots of fun

The SBE believes that engineers should be allowed to have some fun (when working away from home). To help create a festive atmosphere, several special events are planned.

Two days of spouse tours are scheduled, so be sure to bring your spouse along. Several technology tours also are planned. If you've always wanted to see that high-power operation or your company's sister station, this is the chance. Look for additional information at the registration booth.

Attendees will enjoy a wide range of gifts and prizes from tote-bags to coffee cups. Free lunch and breakfast are included with all paid registrations. The Saturday banquet will once again be the highlight of the event. After a first-class dinner, noted comedian Calvin Coolidge returns to the SBE stage to entertain. He received a standing ovation from the attendees last year, and this year promises to be no exception.

SBE National Convention and *Broadcast Engineering* Conference

Wednesday, Oct. 3:	
• 8 a.m.-9 a.m.	Hosted continental breakfast for attendees of Ennes Engineering Workshops
• 9 a.m.-5 p.m.	Ennes Engineering Workshops
• 5 p.m.	Ennes Awards Reception
Thursday, Oct. 4:	
• 8 a.m.-noon	Morning Engineering Session: State of the Broadcast Industry
• 1 p.m.-5:40 p.m.	Afternoon Engineering Session: The Regulation Front
• 6 p.m.-8 p.m.	Attendee Reception in Exhibit Hall
• 8 p.m.-10 p.m.	Night Owl Session: Audio Processing


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Friday, Oct. 5:

• 8 a.m.-10 a.m.	Morning Radio/TV Engineering Sessions
• 10 a.m.-3 p.m.	Exhibits
• 3 p.m.-5:40 p.m.	Afternoon Radio/TV Engineering Sessions
• 6 p.m.-7 p.m.	Ham Radio Reception
• 7 p.m.-9 p.m.	Night Owl Session: The Upward Engineer

Saturday, Oct. 6:

• 8 a.m.	Hosted continental breakfast
• 8 a.m.-1 p.m.	Exhibits
• Noon	Lunch with exhibitors
• 1 p.m.-5:40 p.m.	Afternoon Radio/TV Engineering Sessions
• 5:45 p.m.	SBE Reception, Banquet, Entertainment

Sunday, Oct. 7:

• 9 a.m.-10 a.m.	Frequency Coordination Update
• 10 a.m.-noon	Engineering Workshop: Preparing for a Disaster
• Noon	Close of convention

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Schedule of Engineering Sessions

Oct. 4-7, 1990
St. Louis, MO

Thursday, Oct. 4
- **Morning Session: State of the Broadcast Industry**

7:30 a.m.	No-host continental breakfast
8 a.m.	**Conference Opening and SBE Membership Meeting** • Brad Dick, SBE president • John Battison, Conference Chair *Keynote remarks to launch this year's convention.*
8:45 a.m.	**NAB Looks to the Future** • Mike Rau, NAB *A glimpse into NAB's plans for the Fifth Estate.*
9:25 a.m.	**Overview of the World of Broadcasting** • Wally Johnson, Moffett, Larson and Johnson *A former chief of the broadcast bureau looks at today's achievements in the industry.*
10:05 a.m.	**Engineering at the FCC** • Tom Stanley, FCC *The commission's work goes beyond issuing violation notices.*
10:45 a.m.	**FCC vs. FAA: Are Solutions in Sight?** • Moderator: John Chevalier Jr., Aviation Systems Associates

- Panelists:
  William Suffa, Lahm, Suffa & Cavell
  Harry F. Cole, Bechtel & Cole
  William Hassinger, FCC
  Steve Rothchild, FAA
  A panel discussion about problems between the FCC and the FAA that have broadcasters caught in the middle.

Noon — End of morning session
(Lunch break)

- **Afternoon Session: The Regulation Front**

1 p.m. — **Avoiding Pirate Radio Interference**
- Don Bishop, *Mobile Radio Technology* magazine

Pirates may capture listeners, but the FCC eventually sinks the pirates.

1:40 p.m. — **Dealing With PCBs**
- Kent Kroneman, KUED-TV, Salt Lake City

If you're going to have a hand in dealing with PCBs, wear kid gloves and do your homework.

2:20 p.m. — **Reality Check: Broadcasting Today**
- Jerry Whitaker, *Broadcast Engineering* magazine

What lies below the waves?

3 p.m. — **FM and the FCC**
- Robert Greenberg, FCC

A look at the latest happenings in the world of FM.

3:40 p.m. — **FCC Field Enforcement**
- James Dailey, FCC

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4:20 p.m.	**FCC Roundtable** • Moderator: John Battison, Conference Chair • Panelists: Keith Larson (LPTV) John Reiser (International Affairs) John Sadler (AM) Robert Greenberg (FM) Tom Stanley (Mass Media Bureau) *Your chance to pick the FCC's brains.*
5:40 p.m.	End of afternoon session

*** * * 6 p.m.-8 p.m. — Attendee Reception in Exhibit Hall * * ***
(An informal get-together with friends, exhibitors and SBE officers.)

• **Night Owl Session: Audio Processing**

8 p.m.-10 p.m.	**Audio Processing in the NRSC and Digital Age** • Moderator: Bill Ammons, CRL Systems • Panelists: Kelly Hannig, Gentner Electronics Frank Forti, Cutting Edge Charles Harbrick, QEI Sandra Woodruff, KFWB-AM *Find out how the pieces of the NRSC and digital puzzle fit together.*

Friday, Oct. 5

• **Morning Radio Session: RF Technology, Part 1**

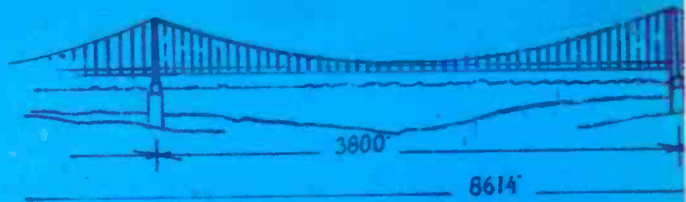
7:30 a.m.	No-host continental breakfast
8 a.m.	**Directional Antenna Assessment** • Tom Osenkowsky, consultant, Brookfield, CT *It is imperative to keep tabs on how well your DA is accomplishing its intended job of area coverage.*
8:40 a.m.	**Constructing a Tight-Budget FM Station** • John McKinley, WJMR-FM, Fredericktown, OH *How a penny-pincher puts a successful FM station on the air.*
9:20 a.m.	**Cellular Radio Towers — A New Design Consideration** • Lawrence Behr, LBA Associates, Greenville, NC *Don't forget the other towers in your pattern.*
10 a.m.	Close of session

*** * * 10 a.m.-3 p.m. — Exhibit floor open * * ***
(Free walk-around lunch with paid admission.)

• **Afternoon Radio Session: New Technology for Radio, Part 1**

3 p.m.	**Solid-State FM Transmitters** • Greg Stone, Varian/Continental Electronics *An examination of the technology and its tradeoffs.*
3:40 p.m.	**Engineering an All-Digital-Disc Audio Facility** • David M. Schwartz, Compusonics *Digital discs require first-class support.*
4:20 p.m.	**Infinite Remote-Control Expansion** • Ron Steenwyk, WKLQ-FM, Grand Rapids, MI *How to multiply your remote-control's control.*
5 p.m.	**Interfacing Digital Telephones** • Paul Anderson, Gentner Electronics *Connections that were once a snap are now potential troublemakers unless they're handled properly.*
5:40 p.m.	Close of session

BRIDGING THE GAP.



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INTELLIGENCE RUNS IN THE FAMILY

6 p.m.-7 p.m.	Ham Radio Reception

- **Morning Television Session: Advanced TV Systems**

8 a.m.	**HDTV: Coming in Wide and Clear?** • Rick Lehtinen, *Broadcast Engineering* and *Video Systems* magazines *After all this time, is HDTV really on the way?*
8:40 a.m.	**What We've Learned from ATV System Tests** • Ben Crutchfield, ATTC, *A review of advanced TV test results and what they mean to broadcasters.*
9:20 a.m.	**Applications of HDTV Technology** • Tom Bentson, NASA *Entertainment certainly isn't the only way HDTV will be used.*
10 a.m.	Close of session

*** * * 10 a.m.-3 p.m. — Exhibit floor open * * ***
(Free walk-around lunch with paid admission.)

- **Afternoon Television Session: New Technology for TV, Part 1**

3 p.m.	**Real World TV Field-Strength Measurements** • Robert J. Gorjance, Evans & Associates *TV field-intensity measurements require a different technology.*
3:40 p.m.	**Stereoscopic Viewing for TV** • Dave Holbrook, StereoGraphics *Television viewing from a different angle.*

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Balancing Act

Just because your operation is mostly NTSC doesn't mean your test and measurement needs aren't complex. Verification of your many signal sources is just as important to you as to anyone working in Beta SP or M-II.

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4:20 p.m.	**TV RF Environmental Measurements** • Dave Baron, Holaday *How to avoid getting cooked by a batwing and other helpful advice.*
5 p.m.	**Measuring Your Satellite Antenna's Performance** • J. Herbert, Andrew *Decibels mean more than meters as an antenna performance index.*
5:40 p.m.	Close of session
6 p.m.-7 p.m.	Ham Radio Reception
7 p.m.-9 p.m.	**Night Owl Session: The Upward Engineer** • Moderator: Marvin Born, WBNS-TV, Columbus, OH • Panelists: F. David Harris, NAB Tom Weems, Tektronix Dennis Behr, Wisconsin Public Television Network *A frank, informative panel discussion about setting your sights on the manager's chair.*

Saturday, Oct. 6

8 a.m.	Hosted continental breakfast with exhibitors on convention floor. Receive a free SBE coffee mug with paid admission.

*** * * 8 a.m.-1 p.m. — Exhibit floor open * * ***
(Enjoy an informal lunch of pizza and beer with exhibitors on convention floor.)

- **Afternoon Radio Session: New Technology for Radio, Part 2**

1 p.m.	**Multichannel Digital Audio Distribution** • Charles Meyer, N-Vision, Nevada City, CA *An Integrated approach to Multichannel digital audio distribution.*
1:40 p.m.	**Theory and Practice of Fiber Optics** • Ralph Evans III, Evans & Associates *Intelligent applications of fiber optics in radio depend on a clear understanding of the technology.*
2:20 p.m.	**Living With Combined Cavity-Back FM Antennas** • Fred Pantsios, Harris *A discussion of the new technique, "one antenna, many transmitters."*

• **RF Technology, Part 2**

3 p.m.	**Graphical Presentation of an FM Channel Search** • Doug Vernier, Northern Iowa University *A must for anyone who has ever wondered what an FM allocation looks like on paper.*
3:40 p.m.	**Is Your STL Antenna too High?** • Carr Stalnaker, contract engineer, Cabot, AR *Believe it or not, the sky is not the limit when it comes to your facility's STL antenna.*
4:20 p.m.	**Keeping Broadcast FM Technically Competitive** • Tom Keller, Broadcast Technology Partners *Today's FM dilemmas call for new techniques, such as diversity, Walsh decoders and FMX.*
5 p.m.	***Goodby EBS, Hello RDS*** *• Jerry Lebow, Sage Broadcasting* *Hidden digital signals can bring new profits to your station.*
5:40 p.m.	Close of session

• **Afternoon Television Session: New Developments in UHF Technology**

1 p.m.	**Klystrode Status** • Nat Ostroff, Comark, *A status report on a TV wonder that has come of age.*
1:40 p.m.	**Solid-State Transmitters for UHF-TV** • Dr. Timothy Hulick, Acrodyne Industries *An examination of the solid-state alternative to tubes.*
2:20 p.m.	**Field Performance of MSDC Transmitters** • Jim Pickard, Harris *Depressed collectors mean not-so-depressing power bills.*

• **New Technology for Television, Part 2**

3 p.m.	**New Digital Fiber-Optic Transmission Systems** • Bob Paulson, AVP Communications *Digital techniques and fiber optics are a winning combination.*
3:40 p.m.	**Something Old and Something New: TDRs** • Marshall B. Borchert, Riser-Bond Instruments *You can save your facility time and money through intelligent use of time domain reflectometers.*
4:20 p.m.	**Interfacing the RF Plant With the New UHF Transmitters** • Tom Vaughn, Micro Communications *Updating your plant may mean there's a microprocessor in your future.*
5 p.m.	**PC Automation** • Michael Rich, Media Computing, Phoenix *If personal computers can rule the world, one could keep things running at your station.*
5:40 p.m.	Close of session

*** * * 5:45 p.m. — SBE Reception/Banquet/Entertainment * * ***
(Join us in a tribute to SBE's lifetime members and enjoy the comedy of Calvin Coolidge.)

Sunday, Oct. 7

• **Morning Session: Frequency Coordination Update**

Continued on page 128

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SMPTE returns to New York

By Rick Lehtinen, technical editor

The Society of Motion Picture and Television Engineers (SMPTE) 132nd Technical Conference and Equipment Exhibit winds eastward once more, landing in New York's Jacob K. Javits Convention Center Oct. 13-17. SMPTE, with its 5-day technical program, the equipment exhibit and awards program, is one of the premier events on the engineer's calendar.

Program

This year's program chairman, Kerns Powers, consultant, has lined up more than 125 papers, half of which will be directed toward the fields of video and electronics. The theme of this year's show, "Film and Television — One World," addresses the growing convergence of both media, particularly in the HDTV and electronic editing arenas. Other sessions will cover digital television, advanced TV systems and TV post-production.

A new service offered to attendees this year is a special cross-indexed program book. In addition to alphabetical listing of exhibitors with booth numbers and descriptions of products available, the new format provides products cross-referenced by category. This should allow convention attendees to more effectively use their time on the convention floor.

Guest speakers

George Vradenburg III, CBS, will deliver the keynote address to the convention attendees on Saturday, Oct. 13. Dr. Marvin Camras, Illinois Institute of Technology, will address the awards luncheon on Saturday. The guest speaker at the Fellows Luncheon, to be held Sunday, Oct. 14, will be Harold Eady, HJE Communications.

SMPTE program schedule

Saturday, Oct. 13

Morning
- Opening session

Afternoon:
- Session A: Film Production Technology
- Session B: Digital TV Processing

Sunday, Oct. 14

Morning:
- Session A: Film Presentation Technology
- Session B: The Digital TV Studio

Afternoon:
- Session A: TV Production — Recorders and Cameras
- Session B: Digital TV Distribution

Monday, Oct. 15

Morning:
- Session A: Laboratory Technology
- Session B: TV Post-Production I

Afternoon:
- Session A: Sound Technology
- Session B: TV Post-Production II

Tuesday, Oct. 16

Morning:
- Session A: Film/Electronic Interface I
- Session B: TV Sound and Ancillary Services

Afternoon:
- Session A: Film/Electronic Interface II
- Session B: Advanced Television I

Wednesday, Oct. 17

Morning:
- Session A: High-Definition Electronic Production Standards
- Session B: Advanced Television II

Afternoon:
- Session B: Advanced Television III

Equipment exhibit

More than 130 companies have reserved booth space on the SMPTE show floor.

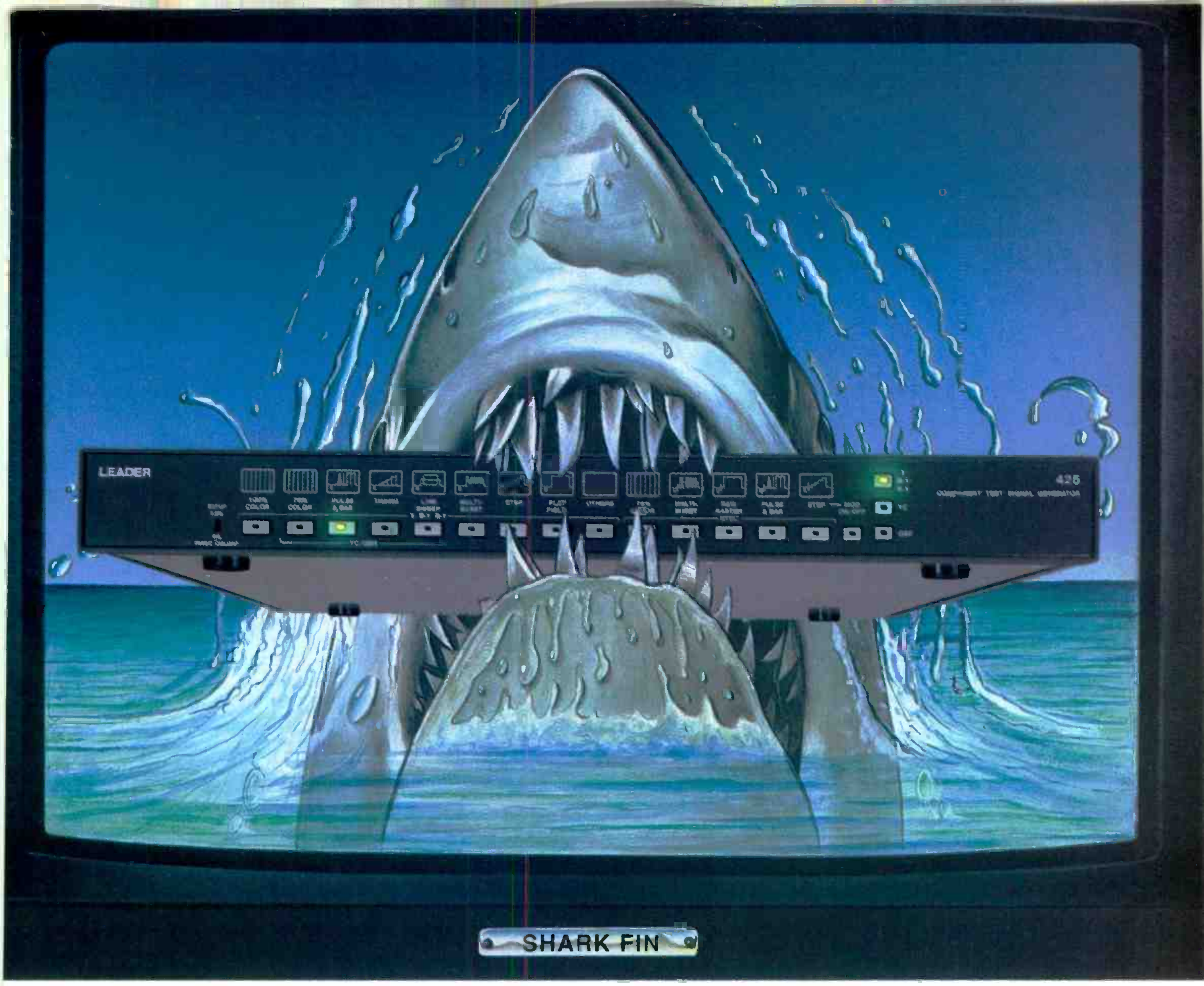
Many companies pick the Fall SMPTE, now the only one with an exhibition, as a prime opportunity to introduce new technology. Exhibition hours are as follows:

Saturday, Oct. 13
2:30 p.m. to 6 p.m.

Sunday, Oct. 14
10 a.m. to 6 p.m.

Monday, Oct. 15
10 a.m. to 7 p.m.

Tuesday, Oct. 16
10 a.m. to 5 p.m.



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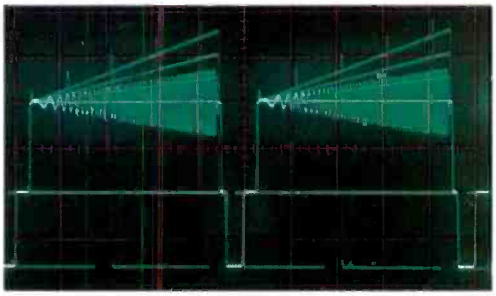
Take full advantage of component television's many capabilities with the powerful new component generator, Model 425 from Leader. First, though, we should explain what the 425 is doing in the jaws of this primitive, half-ton killing machine. The generator develops a number of test signals tailored to gauge distortion and relative timing in component systems. Among these is a new timing signal we call the "shark fin." It exposes relative timing errors over a 2 MHz bandwidth rather than at a single frequency.

The 425 generates both component and composite test signals. These include a number of test signals dedicated to component analysis (available in GBR, Y/R-Y/B-Y, and Y/Time-Compressed Chroma) as well as the more familiar test signals applied to the composite feeds. You can order the 425 in either Betacam or MII format.



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Ampex ADO 100 special effects system

By Rolland A. Desjardins

You learn several things quickly as an engineer in a smaller market station — in particular, a PBS affiliate. The money allocated to purchase new equipment must be carefully spent because it is not always plentiful. You had better be satisfied with what you buy, because you will likely have to use your choice for some years before you can replace it.

WCBB serves approximately 75% of the population of Maine, as well as parts of New Hampshire. Our area of coverage is aided through several UHF and VHF translator systems in the more mountainous areas. Although Lewiston is certainly not a major market, we take pride in our station and the quality of our on-air sound. When we began the search for a digital effects system, it was not easy determining what device would best suit our needs. But one factor — price — often made the decision for us. Many systems were just too expensive to be cost-effective.

When Ampex introduced the ADO 100 at the 1989 NAB, many features we wanted came standard. The range of effects capabilities, including 3-D and true perspective manipulations, caught our attention. By the time we were ready to place an order, another factor turned in our favor — we were able to purchase a demonstration model.

Flexible configurations

The basic package consists of an electronics signal system and the control panel with joystick and built-in display. (See Figure 1.) Although the instruction manual does not delve into the theory of LAN operation, it plainly shows how the two units are to be connected through an ethernet. In fact, diagrams show how various configurations may be interconnected. It's important to note that the basic system offers an interconnection option to operate the effects unit from the Ampex AVC Vista switcher's control panel.

The fact that we already use a Vista in our 1-inch A/B roll editing suite also contributed to deciding on the ADO 100. As soon as the software becomes available, we intend to move the regular ADO 100 control panel to the production booth and control the devices operation with the switcher control panel in the edit suite. This way, we can use the system for either production or editing.

Performance at a glance
- *2-D and 3-D configurations*
- *Component analog, composite analog and 4:2:2 component digital in 525/625 line standards*
- *Can be fully integrated into Ampex AVC Vista switcher*
- *32-bit 68020 processor, 13.5MHz/ 4:2:2 internal digital processing*
- *Digi-Matte key channel comes standard*
- *Programmable 24-effect on-line memory*
- *Internal 3.5-inch disk drive*

Included in all configurations is the Digi-Matte processor key-channel circuitry. This keying circuit manipulates the external key signal simultaneously with the source video. The result is the ability to "fly" logo keys and place live video inside switcher wipe patterns, among other possibilities.

When you have developed an effect that you will want to use again, you may select short-term storage in RAM or long-term storage on a 3.5-inch floppy disk. Each disk can contain 99 effects, each containing 100 key frames. Key frames are specific points within an effects sequence where something about the transformation occurs. For example, an image appears on the screen at point A and moves along a trajectory to point B. The two end points are key frames. At point B the image rotates around the X-axis while moving along a new trajectory until it reaches point C, another key frame. The key frames and the motions that occur between them are programmed through the

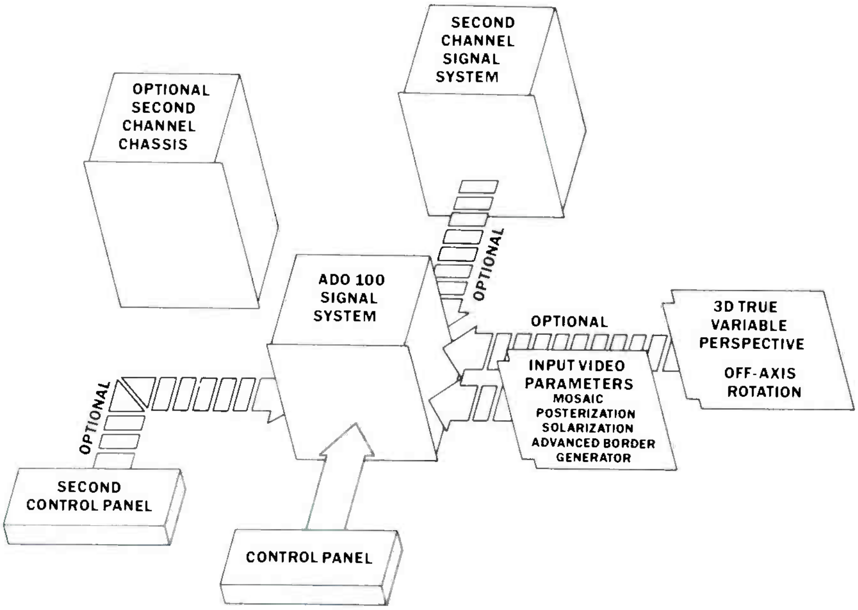

Figure 1. The ADO-100 basic system package consists of an electronics signal system and the control panel with joystick and built-in display.

Desjardins is vice president and director of engineering at WCBB-TV, Channel 10, Lewiston, ME.

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- Optional output equalization

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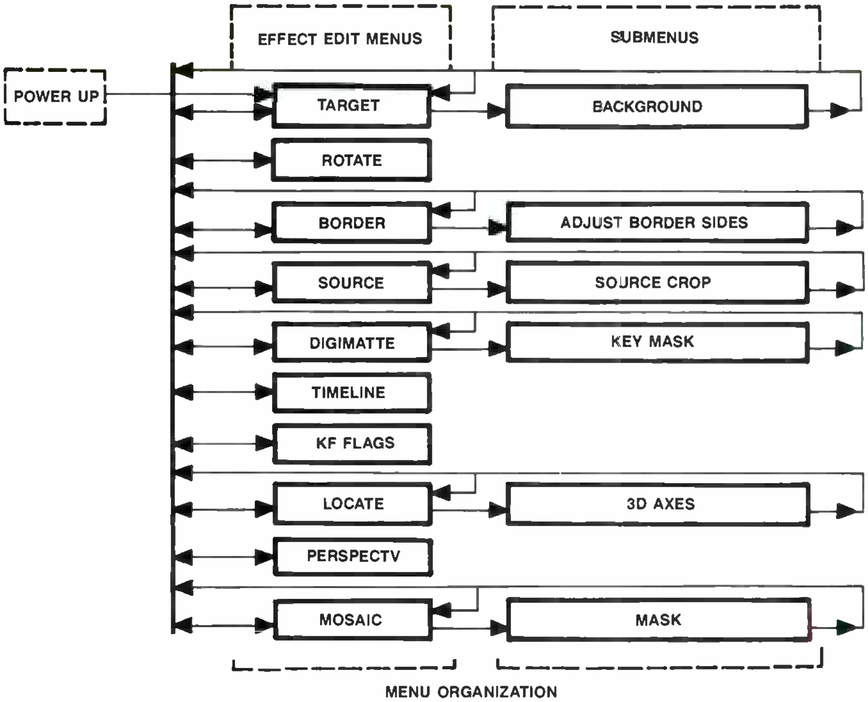


Figure 2. *Menus and secondary menus on the system's electroluminescent display guide the operators.*

use of a menu on the system's electroluminescent panel display.

Status display

There are multiple sections to the display. One section is used for selection of key-frame parameters. A second section displays information needed to make adjustments to the various parameters. The center section provides effect status, including the name you have assigned to the transformation, the operational mode and time values. A time line section indicates time-related information about the effect. The final section shows the current menu function assigned to a series of soft keys located along the bottom edge of the panel. All sections and adjustments in these areas are controlled from the soft keys, with up/down buttons positioned at the right and left edges, with a small group of dedicated switches, a keypad, a joystick and a standard fader bar. For convenience, most of the switching and adjustment devices are positioned similarly on the AVC Vista switcher panel.

To speed the progress of setting up an effect, there are 10 special effect edit menus, each of which prompts the operator for changes in parameters to achieve

the desired effect. As Figure 2 shows, there also are secondary menus involved in some choices. If the operator works through the menu sequence correctly, the effect produced should be exactly what was desired.

However, if the operator is uncertain of the desired end result, some backtracking may be necessary. Although it is possible

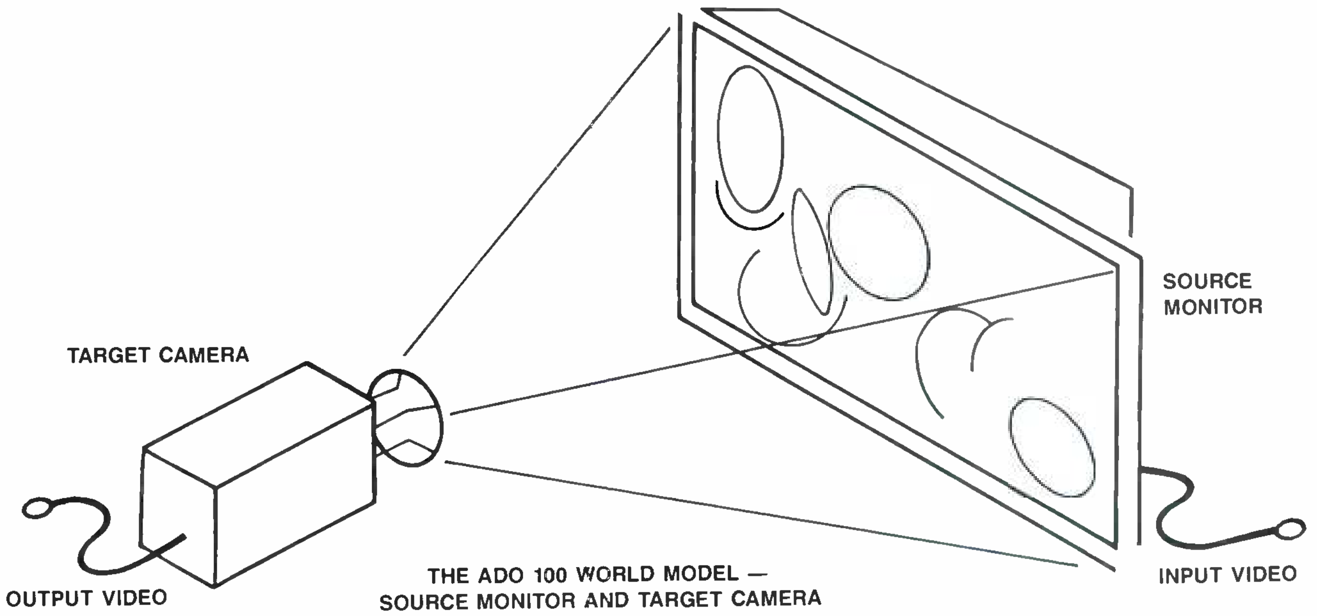


Figure 3. *The "World Model" organizes space according to reference axes X, Y and Z. Input video is mapped into the system source space. The effects transformation remaps the image into the target space, represented by the operator's output monitor.*

to enter the menu/setup sequence at almost any point, some of our operators initially expressed a feeling of getting "lost" if they didn't start at the beginning of the menu sequence. However, as they became more familiar with the system, this feeling was reduced.

Digi-Loop switcher interface

One of the possible system configurations is the direct link to the switcher through the switcher's Digi-Loop circuitry. This digital control system delegates some of the switcher's effects processing to the special effects system, thus making the effects system an integral part of the switcher and simplifying the switcher operator's tasks during production.

Some comments on how the system produces effects are worth noting, particularly in terms of the 3-D capabilities and a concept called the World Model. (See Figure 3.) Space is organized according to three reference axes, X, Y and Z. An input video image is mapped into the system source space, an infinite X-Y plane that could be considered the picture appearing on an input monitor. The effects transformation remaps the image into the target space, represented by the operator's output monitor.

To better visualize the transformations, you might think of the target space as a camera viewing the source plane. If the camera is looking perpendicularly at the source plane, there is no geometric distortion to the image.

It is possible to move the camera (target plane) and the source plane independently. Such movements can occur individually or simultaneously, depending upon the effect desired. The system's dual-input capability allows independent images to the A and B inputs to be mapped to separate source planes. Such features as Auto-Cube then can be used to create a rotating cube with different images on each face of the cube.

Simple installation/operation

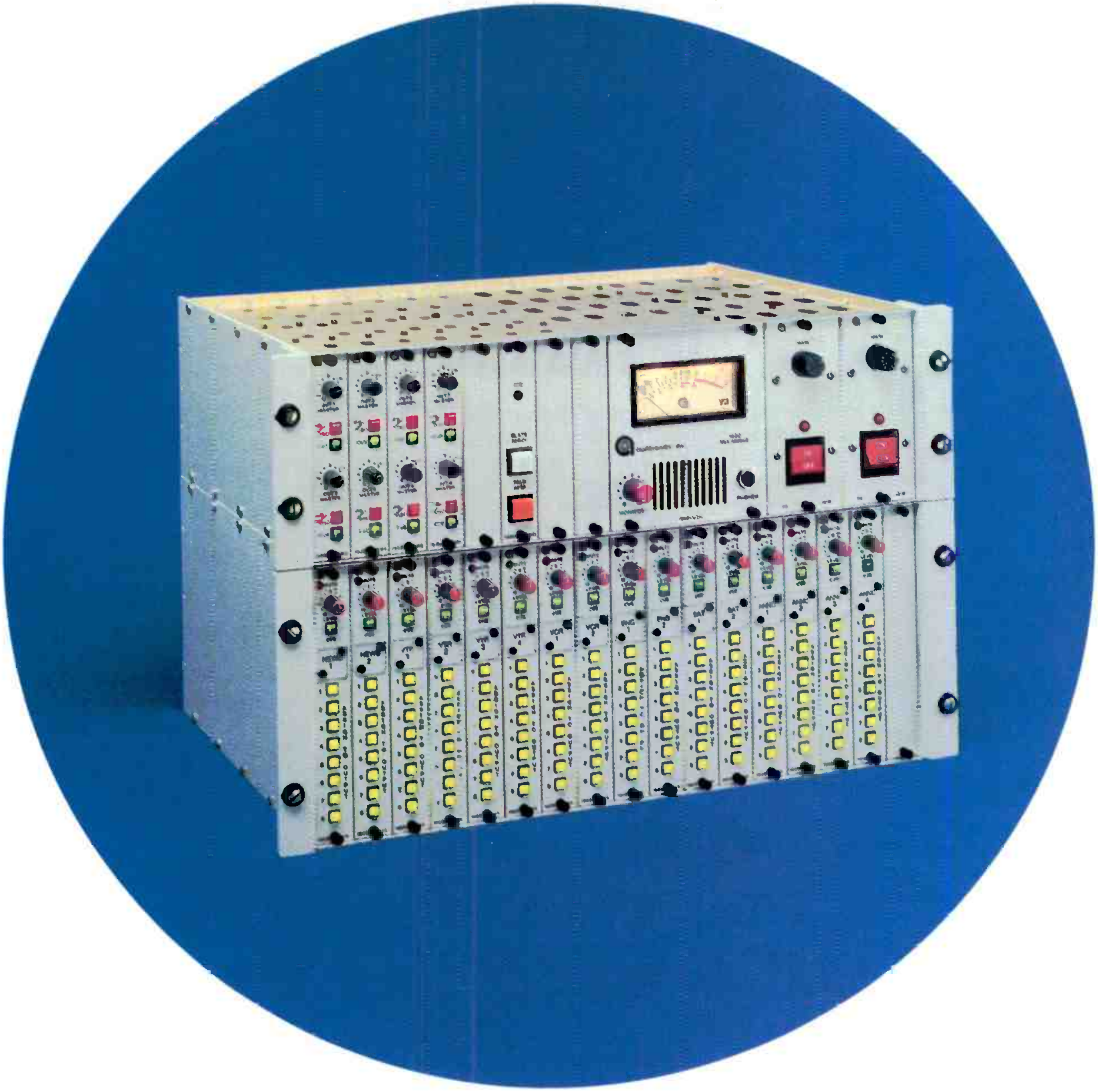
As was noted previously, we bought a demo unit. Therefore, we cannot say for certain whether the unit operated "right out of the box." We can say for certain, however, that after unpacking the equipment and installing it, the system operated almost flawlessly. At first, we experienced some minor timing problems because of the interconnect cabling from our established equipment to the new one. After locating the source of the timing errors, we have found no additional problems.

Factory training is available to help operators and technicians work with the effects system. Additionally, a videocassette that is part of a multimedia training package is included with each system. The cassette serves as an introductory session to help the station personnel begin using the equipment as soon as possible. At some point in the demonstration unit life of our system, that training package had been misplaced. However, that proved to be no great problem. Within 16 working hours after the crates had been taken off the truck, the system was installed, our crew had developed a station Christmas greeting to our viewers, and we transmitted it. That speaks highly of the ease with which the system can be learned and operated. We've been using the system for several months now and it has proved to be one purchase decision we have not regretted.

Editor's note: The field report is an exclusive **BE** feature for broadcasters. Each report is prepared by the staff of a broadcast station, production facility or consulting company.

In essence, these reports are prepared by the industry and for the industry. Manufacturer's support is limited to providing loan equipment and to aiding the author if support is requested in some area.

It is the responsibility of **Broadcast Engineering** to publish the results of any piece tested, positive or negative. No report should be considered an endorsement or disapproval by **Broadcast Engineering** magazine.



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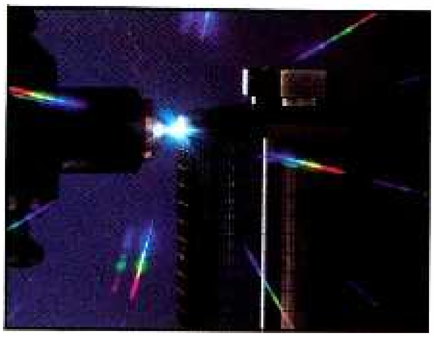

Designing a routing switcher for the 1990s

By Lyle O. Keys

In 1988, the engineers at Utah Scientific, Salt Lake City, accepted a daunting challenge to design a new routing switcher as good as the company's currrent product, but to make it 60% smaller. This article reviews some of the design philosophies chosen to achieve that goal.

Surface-mount components

To achieve the size reduction, surface-mount components had to be used. In order for users to readily obtain replacement components from multiple sources, components had to mount directly on the circuit cards, rather than on separate sub-modules, as is frequently practiced. After considerable discussion, the advantages of directly mounting components overrode the risks involved. The main concern, of course, was serviceability, but with many products already using surface-mount technology, customers either already have or would be willing to spend the small amount of money needed to buy a surface-mount workstation. Furthermore, warranty and loaner policies could ensure facilities that didn't want to perform surface-mount component replacement wouldn't have to.

The direct-mount decision was well-justified. Surface-mount component replacement is easier than working with through-hole components because there is less destruction of plated through-holes and circuit traces. Proper tools are all that are needed.

Greatly reduced crosstalk is an additional benefit of this design, because of the lower component profile and lower distributed capacity and inductance, which equate to a higher intrinsic bandwidth. Most important, the use of custom, single-source components was avoided.

System architecture

After investigating 8x8, 8x16, 16x8 and 16x16 matrix cards, it was decided that 10x10 offered the best compromise among system cost, system flexibility, physical packaging and failure modes.

As the switcher developed, the possible configurations for rack-frame architecture was dictated by the diameter of the standard BNC connector. Previous experience with high-density products indicated that BNC connectors could be spaced as close as 0.6 inches (15.24mm) without compromising serviceability. This is done by mounting a molded plastic BNC tool on the back of each frame. The 0.6-inch spacing allows 10 connectors to be mounted in a vertical row on the back of a 4-rack-unit card frame.

Using a 0.6-inch pitch for the circuit cards meant up to 28 circuit cards could fit in a standard-width card frame. Alternately, a frame could hold 22 cards plus redundant power supplies, each the width of three circuit cards.

The number of inputs that can be accommodated is determined by the size of the motherboard that interconnects the crosspoint card outputs with the output card inputs. A single input source can drive up to 10 output decades, while still meeting all system signal specifications. Video systems having more than 100 outputs require input distribution amplifiers.

The switcher design lends itself to reconfiguration in the field. This is helpful when you have outgrown your matrix. It also is a good idea for facility engineers to order systems that can handle the maximum anticipated number of inputs, but populate only as many card frames as are initially needed. In its ultimate configuration, the router design can switch 1,280 inputs by 1,280 outputs on eight separately-addressable levels.

Thermal design considerations

Component life and long-term stability are inverse functions of operating temperature, yet there's no free lunch when it comes to the signal transparency/power consumption tradeoff. Maintaining linearity under all signal conditions generally requires higher power-supply voltages and greater current consumption than might otherwise be needed. This means more power consumption, hence greater heat when added to the need to nearly triple the amount of crosspoints in a given volume to achieve the design goal. The problem becomes substantial.

This router uses a plenum chamber design borrowed from earlier designs. This plenum chamber occupies approximately 0.6 inches at the top of the frame. It has openings on the underside that act as chokes to distribute the airflow where it is needed most. An exhaust fan is mounted on the side of each card frame. Because the system relies on one fan, an alarm circuit sounds if there is too little (open fan circuit) or too much (stalled fan) current. In addition, multiple-card-frame systems share a common plenum area at the back of the stacked frames, with molded plastic dams boxing in the plenum at the top and bottom. Therefore, failure of a single fan has minimal affect on the operating temperature of its associated circuitry.

Although moving air over the components goes a long way toward maintaining hospitable operating temperatures, there is still three times the heat per unit volume. However, only a fraction is being used at any given time. With a 100-input switcher, a maximum of 10% of the crosspoints can be active at one time. Because the crosspoint cards' input amplifiers are the principal source of heat generation, one solution is to turn off all unselected input circuits. Although it's not possible to fully power down these circuits, this technique can remove approximately 25% of the heat that would otherwise be generated. (Because the audio matrices produce far less heat, this technique is applied only to the video circuitry.)

Power and control distribution

Sometimes it is better to use a freeform backplane that allows unlimited intermixing of modules. In addition to audio or video signals, each module must receive control signals and power. The plenum chamber restricts the height of the circuit cards, thereby limiting the available backplane connections. One way to get the needed wires to each card is to use an extra power and control distribution motherboard located forward of the plenum chamber. This allows sufficient pinout to all cards in the system, while still accommodating the freeform backplane design. An ancillary benefit is additional isolation of the signal circuits from the power and control circuits.

Keys is chairman of the board, Utah Scientific, Salt Lake City.

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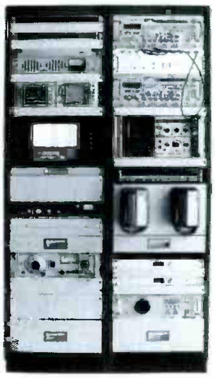

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Intradecade control distribution

One frequent limitation with large installations is limited fan-out capability in the control card output drivers. On large systems totaling 300 to 600 cards, the drivers may be strained. Other limitations are the baud rate used for card control and the difficulty of making multiple switches within a single vertical interval (salvo switching).

One solution is to add a processor to each output card to buffer the data and attend to chores such as routine refresh, power-up refresh and salvo switching. Because there are only as many output cards in a system as there are output decades, these processors also solve the fan-out problem. This allows an increased data rate between the system controller and the output cards. Also, the data rate between the system controller and the output cards is a few inches, and data rate can be increased significantly.

In operation, output cards receive "take" command data from the system controller, with each command word intended for switching during the next vertical interval or for storage in one of three memory locations. The stored commands can be used for system reconfiguration or to execute salvo switches. With the increased data rate between the output cards and crosspoint cards, all 10 buses associated with each output card can easily be switched within a single vertical interval. It is possible to reconfigure an entire switcher — every level on every bus — within a single vertical interval and then do it two more times in each of the two following vertical intervals — all with data stored on the output cards.

The output card buffer circuitry also relieves the system controller of much of its routine work. For example, routine refreshment need only be done when time permits, because the output card refreshes all 10 of its associated buses from a lithium battery-backed memory each vertical interval. This fast refreshment cycle also assures de-selection of all outputs of a crosspoint card as it is being inserted into the card frame, thereby facilitating system servicing without disruption.

A negative benefit of the output card buffer circuitry is that it makes it possible for a single component failure to take out an entire output decade. The solution is to equip each output card with fully redundant control circuits, plus an automatic switchover and alarm.

Signal circuitry

Modern video switchers, where each input on the crosspoint cards can be accessed by 8, 10 or 16 outputs, present special design problems. Crosspoint-loading phenomena can seriously compromise performance specifications, particularly timing spread and frequency response. In early designs where diodes were used in the crosspoints, these phenomena could be quite pronounced. In subsequent designs where the crosspoint input element was a transistor, this loading effect was reduced.

In order to keep frequency response essentially flat to 30MHz (HDTV), further improvement was needed. After much experimentation, a strip-line bus driven through a source-terminating resistor produced the needed characteristics. With this design, the path-length effect is reduced to less than 0.1° and the frequency response variation is negligible up to 30MHz, and only becomes significant at around 100MHz, where with the variations with crosspoint loading is still less than 1dB.

Another problem that plagues designers of large, wideband routers is the significant variation in frequency response that occurs because different crosspoint cards within the same output decade are located at varying distances from their associated output card. This design addressed the problem by using a 6-layer motherboard with closely controlled stripline impedances, uniform path lengths and terminations at either end.

These changes allowed the final design to achieve the desired frequency-response performance and delay spread specifications under all conditions of crosspoint loading and for all signal paths for systems of any size currently contemplated.

Conclusion

This design effort was an educational experience. Getting acquainted with surface-mount technology was the major hurdle. There were many interesting learning experiences in heat transfer and in dealing with circuits whose intrinsic bandwidth is more than 100MHz (they tend to oscillate). We hope that experience gained developing a switcher with acceptable frequency response through the anticipated frequencies for HDTV, can be transferred into future products involving high bit rates, such as serial digital video.

Continued from page 112

9 a.m.

Frequency Coordination
- Paul Lentz, SBE Frequency Coordinator Chairman
- Richard Rudman, KFWB, Los Angeles
- Gerry Dalton, KKDA, Grand Prairie, TX,

If you're not part of the solution, you're part of the problem. Are you coordinating or interfering?

- **Engineering Workshop: Preparing for a Disaster**

10 a.m.

Lessons Learned From the San Francisco Earthquake
- Peter Hammar, Hammar Communications

The big shake-up brought broadcasters face to face with the uncertainties of true crisis-mode operation.

10:40 a.m.

How We Handled Hurricane Hugo
- David Bird, WTAT-TV, Charleston, SC

Broadcasters joined forces against Mother Nature's fury and undoubtedly saved countless lives.

11:20 a.m.

EBS at Work
- Bill Ruck, KFOG/KNBR, San Francisco

How EBS fared during the San Francisco earthquake.

Noon

Close of 1990 Convention
- John Battison, conference chair

Goodbye and good luck until next year.

SBE Update

Society initiates strategic planning

By Bob Van Buhler

The society has initiated a strategic planning process that will create a formal plan to carry it through the 1990s. The process is based on the recent membership survey, additional input from the board of directors, the 1989 Past President's report and a focus group, which will help identify trends and issues facing the society.

SBE's new executive director, Steven Ingram (CAE), will assist the officers and directors in the strategic planning process. Ingram is certified by the American Society of Association Executives as a Certified Association Executive (CAE). The title is only available through the completion of a program of study, testing and professional development. Ingram considers it especially timely to begin the planning process now, because of SBE's current financial stability. Using the membership survey will allow the society to better determine the direction and priorities as defined by the membership. President Brad Dick said his goal was to complete the strategic planning process in time for the April 1991 board meeting.

Annual elections approach

In addition to incumbent president Brad Dick, a second SBE member has announced his intention to run for president via a press release. Andy Butler, vice chairman of the Baltimore chapter, plans to oppose Dick in this year's annual election.

The society's four officers serve 1-year terms. Because of a revision in the bylaws, directors went from 2-year terms to 3- year terms, creating off years when no director terms expire. This is the first year of such a situation. Employees of the national office are traditionally assisted in counting the votes by members of the Indianapolis chapter. Ballots must be returned to the national office by Monday, Oct. 1, to be included in the vote tabulations.

Workshops to precede convention

Technical papers have been selected for the 1990 SBE national convention and *Broadcast Engineering* Conference. At the suggestion of surveyed attendees, the presenters have been allocated an additional 10 minutes per paper, increasing the time per speaker to 40 minutes.

Once again, the popular Ennes Workshops will precede the official start of the convention. The following workshops are scheduled:

- RF Technology, Harris/Allied
- Understanding and Maintaining C-Quam AM Stereo Systems, Delta Electronics
- Medium and High Power FM Transmitters, Continental Electronics
- S-VHS Electronic News Gathering and Production, JVC Electronics
- Earth Station Technology, Andrew Corporation
- System Modeling Using AudCAD and CableDOC, Video Design Pro
- Satellite Communications, Mitchell Vo-Technical School
- The Don Markley RF workshop
- Management for Engineers

Paid registrants can attend any one of the full-day or up to two of the half-day workshops. Space is available on a first-come, first-served basis.

The regular 3½ days of seminars will address many areas crucial to the future of broadcast engineering. Sessions will examine the following: the state of the broadcast industry, the regulatory front, radio technology, advanced TV systems, and a look at new TV technologies in graphics, transmitters, terminal equipment and fiber optics. The SBE national convention will be held Oct. 4-7, in St. Louis. Contact the society for more information at 317-842-1103.

Female professional engineer certified

A frequently overlooked fact is that SBE's membership contains many talented and accomplished female engineers. Mary Brush of the certification committee recently reported that the committee had certified the society's first female professional broadcast engineer. Deborah S. Proctor, general manager and technical director of WCPE-FM. Wake Forest, NC, advanced to the 20-year title in March. Proctor earned her First-Class FCC license at age 15, and at 17 was performing regular maintenance on an RCA TTU-60/B UHF TV transmitter.

Before her certification as a Professional Broadcast Engineer, she held SBE certification as a Senior Broadcast Engineer by examination in AM/FM and television. Her next goal is to achieve registration as a registered professional engineer in North Carolina.

Professional licensing discussed

Congressman Edward J. Markey, chairman of the House Subcommittee on Telecommunications and Finance, and Matthew J. Rinaldo, the ranking Republican committee member, have requested that the General Accounting Office research and report upon state involvement in the licensing of radio and telecommunications engineers and technicians. The issue became important after the FCC eliminated the licensing of most telecommunications equipment operators.

The report documented attempts by six states to enforce statutes on licensing professional engineers against individuals working in the telecommunications business. In all cases, the report notes, the parties involved either offered engineering services to the general public or represented themselves to the public as "engineers."

The GAO identifies the issues of the long-standing professional licensing issue as whether the practice of engineering, as defined in state statutes, is involved when one practices telecommunications (or broadcast engineering), and whether individuals who offer engineering services can represent themselves to the general public as "engineers" without achieving state registration.

The report drew no conclusions, but only relayed the opinions of the involved organizations. These included the SBE's position that some concern exists and that the legitimate titles, "broadcast engineer" and "chief engineer" are appropriate designations for those who repair, maintain and operate the equipment of FCC-regulated facilities.

Van Buhler is manager of engineering at KNIX-AM/KCWW-FM, Phoenix.

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—Robert Strutzel, WGN-TV

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—Jim Martin, WOAY-TV

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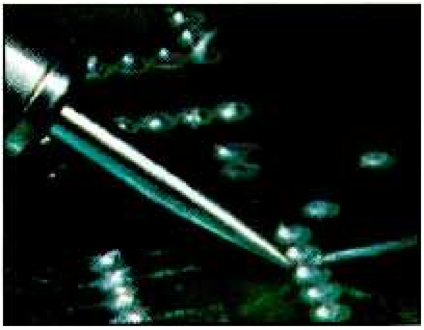

Remotely piloted ENG helicopter

By Juan Rivera

How would you like to have an ENG helicopter you can fit in your car? I've been experimenting with one for the past year. It's 6-feet long, radio-controlled and has a 2GHz live color TV downlink.

Although some may argue with me, field trials have demonstrated that a whirlybird can pull in shots from locations that are either too confined or too dangerous to get any other way.

Magic copter

The helicopter is a kit manufactured by Schluter, a West German company, and is a marvel of precision components and space-age composite materials, and is almost identical in construction to its full-size cousins. It is called a Magic and is the largest kit available currently. The helicopter is six feet long, weighs approximately 12 pounds and is powered by a 2hp motor and can fly at speeds approaching 70 mph. Just as with full-size helicopters, the Magic's biggest asset is its ability to maneuver and hover with great precision. The helicopter can carry a 3-pound payload with ease, and is steady when configured for maximum stability. It has proven to be a great camera platform.

To appreciate the level of sophistication in current radio-controlled (R/C) equipment, consider this: the helicopter's R/C receiver is a 7-channel proportional pulse-code modulation (PCM) dual-conversion FM superheterodyne with ceramic and crystal filtering, dual AGCs and internal voltage regulation. It is packaged in a case slightly larger than a match box and weighs 45 grams.

The transmitter also is impressive. For each proportional channel, it transmits a 10-bit digital word that defines that channel's binary value. Ten binary bits equal 1,024 possible positions of each servo. With this resolution, controls can be positioned to within approximately one thousandth of an inch. An added advantage of using PCM is that it allows the application of digital error checking and correction techniques.

Here's how the error checking works. The R/C transmitter downloads preset fail-safe settings to the receiver for all channels at regular intervals. These values are then stored in the receiver's microproces-

Rivera is a commercially rated airplane and helicopter pilot, and an engineer in the KTVU-TV news department.

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PICKUP: CHARGE COUPLED DEVICE
RESOLUTION: 250,000 PIXELS
LENS: F = 15MM, F1.6
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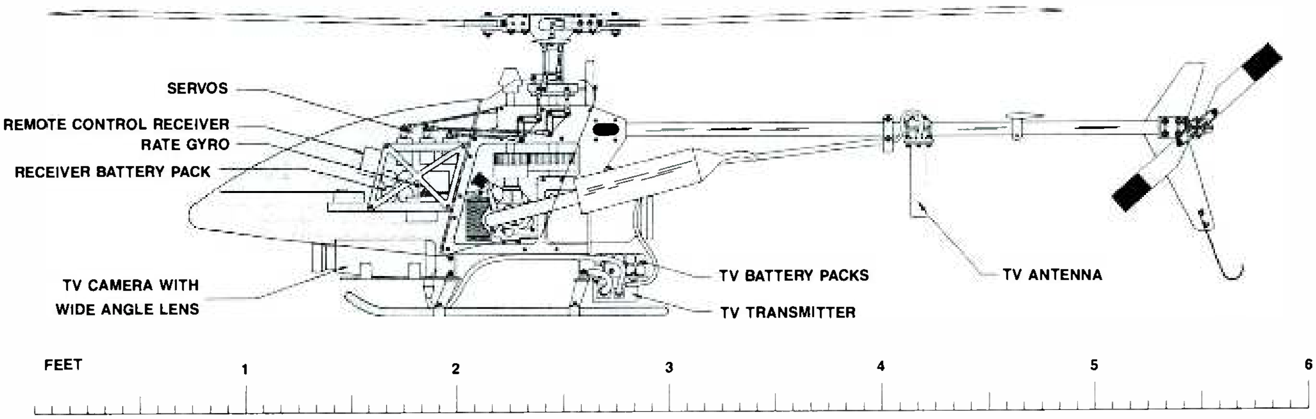

Figure 1. The helicopter weighs less than 15 pounds, yet can carry a camera, batteries and microwave equipment for ENG work.

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sor. The receiver constantly compares incoming data with previous data. Any gross change indicates an error condition. Should this happen, the servos will either maintain their last valid settings or move to their fail-safe positions, depending on

Video of the KTVU-TV studios from approximately 100 feet. Video was downlinked to an ENG van and recorded for later transfer to a photographic slide.

how the R/C system has been configured. This feature allows the helicopter to fly through areas of low signal strength or interference.

Whump, whump, whump...

Helicopters don't fly — they beat the air into submission. As the pitch of a helicopter's main rotor blades is increased, lift increases, but so does drag. Therefore, more power is needed, and the throttle must be advanced. Increasing power also increases torque, and the torque reaction will tend to yaw the helicopter in a direction opposite that of main rotor rotation.

To compensate, pilots of full-sized helicopters must increase the pitch of the tail rotor blades. Because both hands are already busy, they do this with their feet. Radio-controlled helicopter pilots can't use their feet. To keep from running out of fingers, the main rotor pitch, throttle and tail rotor pitch channels are electronically mixed. When the main rotor pitch is changed, the throttle and the tail rotor pitch are automatically adjusted according to mixing curves that are entered during initial setup and stored in the R/C transmitter's memory.

In addition, a rate gyro is used for added stability. When the helicopter yaws, the gyro feeds an error signal to the tail rotor channel. This error signal is mixed with the normal control input and immediately adjusts the tail rotor pitch to counteract the yaw and help keep the helicopter pointed in the intended direction.

The mechanical components are equally advanced. The main rotor and the tail rotor assemblies have 18 precision ball bearings. Because there is no pilot on board, manufacturers are free to bypass years of testing and put the latest technology to use immediately. As a result, many R/C helicopters are more advanced than full-size ones. Most are completely aerobatic and can even hover inverted.

The video system

The helicopter is equipped with an industrial CCD camera with a fixed wide-angle lens that weighs one pound. The camera has an auto iris, can handle an extremely wide range of illumination and has a resolution of 250,000 active pixels. (For actual on-air use, I would replace this camera with a higher-quality one. Mounting it on a tilt/pan head controlled by an operator in the truck would be a further refinement.)

For the transmitter, I wanted something that weighed less than one pound. I discovered a manufacturer who loaned me a 12-ounce 250mW transmitter that fit in the palm of my hand. If you've watched any NASCAR race or the last Indy-500, you've seen these little units transmitting live video from the race cars. The manufacturer also supplied a companion colinear antenna with an omni gain of 2dB.

To complete the ENG package and keep the total weight below three pounds, I use small NiCad batteries to power the system. This provides approximately 30 minutes of power. Because I can use a spare channel on the R/C system to turn the ENG equipment on and off in flight, 30 minutes is adequate. The batteries that run the R/C system are good for approximately one hour. Because they are absolutely essential for control, the additional half hour of capacity is an important safety feature.

2GHz tests

A series of 2GHz tests was done at KTVU-TV. The station's ENG relay truck was used for receiving. Initially, a set of golden rod antennas was used as the receive antenna. They proved to be susceptible to multipath reflections, unfortunately. Because of their construction, the golden rods are sensitive to RF from the sides as well as the back, which makes them a poor receive antenna. The test area was adjacent to the station's parking lot. The parked cars, and perhaps the building itself, were the culprits. Once the rods were replaced with a truncated 4-foot dish, the multipath problem was reduced.

However, as good as the dish was, the main lobe may have been too narrow for this application. I'd been working alone and prepositioning the dish in the general area I intended to fly, but it had a beamwidth of only a few degrees, and I'm sure I was flying out of the main lobe. A simple horn would probably be the optimum receive antenna. A horn would be broad enough to not require constant tracking of the helicopter, but still have the high side lobe attenuation and front-to-back ratio that is important in this application. Because the helicopter transmits with an omni antenna, it's going to spray RF everywhere. The receive antenna's job is to acquire the direct path and attenuate all the reflections as much as possible. High gain isn't necessary in this application.

Once the RF link was tamed I was able to see a video impairment that had been masked in the earlier tests. Vibration was causing the picture to look slightly out of focus. A frame-by-frame examination

Side view of RPV ENG helicopter shows the camera beneath the cabin, the 2GHz transmitter located below the fuel tank and the omnidirectional ENG antenna on the boom near the tail rotor.

Rear view of helicopter shows the NiCad batteries (beneath the transmitter).

showed that some frames were sharp and others were not. The cause was motor vibration. Of the various kinds of vibration, high-frequency vibration from the motor is the most difficult to reduce. This is a result of the motor being bolted directly to the helicopter's frame. This was a major cause of the image problem.

At the present, the camera is mounted on a layer of foam rubber and held in place with electrical tape. There is room for improvement. In the meantime, readjusting the foam and adding some stiffening to keep the camera from bouncing improved the video quality noticeably.

A new helicopter has been introduced that isolates the motor with a toothed kevlar drive belt system. The manufacturer claims that this, along with four elastomeric vibration-absorbing motor mounts, virtually eliminates high-frequency vibration.

The 12-ounce, 250mW 2GHz transmitter. A series of small NiCad batteries provide approximately 30 minutes of power.

It floats

The system works. It's not perfect, but with further refinement I think the helicopter could produce a respectable picture. Of course, there are limitations. It's difficult to hover with the tail facing the wind because the helicopter wants to weathervane. It also gets bounced around in gusty winds, and you might have to settle for a freeze frame in those conditions.

It's also next to impossible to fly with the sun in your eyes or to fly at night. The helicopter is not a toy and can be dangerous if not taken seriously. It should only be flown when it is absolutely safe and all conditions are in your favor.

Wallet damage

The helicopter kit with a motor, gyro and a good R/C system costs approximately $2,000. The ENG transmitter and antenna will add another $5,000. The camera I use costs about $700. A better camera might cost $2,000. Also, plan on another $500 for spare parts, battery chargers and special tools.

Learning to fly

Once the machine is properly adjusted, learning to hover, at least for short periods, should take only a few weeks. After that, it's just a matter of practice. It's more difficult to fly an R/C helicopter than a full-size one, and full-size helicopters are much harder to fly than airplanes. So don't get discouraged. Count on at least six months of regular flying to reach any proficiency.

A school in Florida can help speed the learning process. It can take beginning flyers and have them well on their way within one week at a cost of $845 including room and board. Another option would be to enlist the services of someone who is already a skilled pilot.

So what does it take to duplicate what I've done? Trying something like this without expert help might be possible, but difficult. I am lucky to live close to an excellent pilot and gifted machinist, who also is the West Coast's largest Schluter dealer, specializing in R/C helicopters. Most important, he has a complete assortment of spare parts. After I assembled the helicopter kit, we spent several hours checking and adjusting my work. (This process has been repeated several times over the course of this project). This step is important. There is no room for sloppy workmanship or improper adjustments with a helicopter, large or small. Learning to fly a helicopter that is not correctly set up can be almost impossible.

Conclusion

The helicopter can do camera moves no one has ever thought of trying before. For example, during one flight I eased the helicopter over the hood of the ENG truck for a shot through the front windshield, then I backed it up and slid it slowly sideways along the side of the truck. Next, I moved the helicopter straight up past the golden rods and over the top of the mast. Then I slowly pivoted it, flew it forward and had it climb over some tall pine trees and hover, grabbing a shot of the KTVU-TV studios. Finally, I descended the helicopter down the side of the tree, backed it up through a 3-foot hole between the lower tree branches and a shrub, and set the helicopter down beside the truck.

Should the need for high speed or aerobatics arise, the helicopter has successfully been looped and rolled with the ENG package on board. The sky is truly the limit as far as shooting possibilities go.

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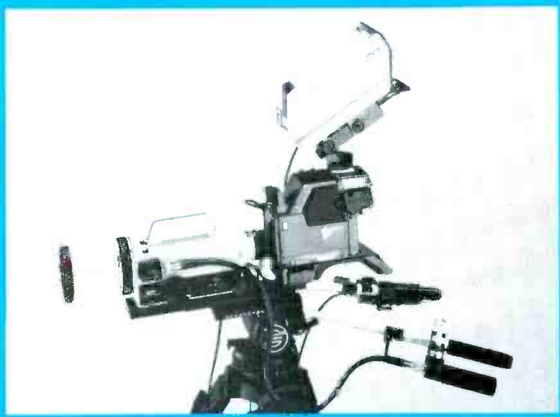

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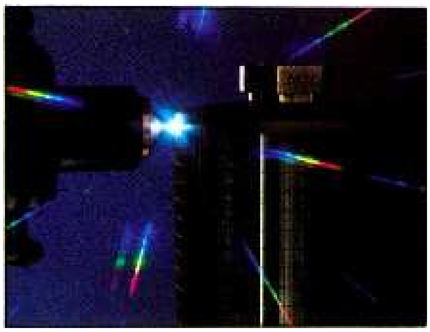

Eliminating transmission line wear

By Harry McKee and Bruce Carlson

In a broadcast application, the inner conductor joints of a rigid coaxial transmission line can degrade electrically and mechanically with time. The temperature of transmission line conductors varies with the transmitter power level and with the ambient temperature surrounding the line. Of the two conductors in the line, the inner one runs substantially hotter, because it is smaller and enclosed by the outer one.

Of the two conductors in the line, the inner one runs substantially hotter.

Therefore, the inner conductor will encounter thermal expansion and contraction at a different rate than the outer conductor. The inner conductor length will vary in a cyclic nature with the transmitter power level, or to an even greater extent if the transmitter is shut down at night and powered back up in the morning. For a conventional rigid transmission line, this variation in length between conductors is taken up by the inner conductor sliding back and forth on the inner connector or "bullet."

McKee is vice president, broadcast products at Andrew in Orland Park, IL. Carlson is transmission line engineer for Andrew.

The sliding action can cause metallic shavings to contaminate the interior of the line and allow a flashover to occur. This wear can also cause increased contact resistance, creating more power loss and possible local hot spots.

A solution to this problem involves the use of a short bellows section in each inner conductor to absorb expansion and contraction, and allow the ends of the inner conductors to remain fixed in position on the inner connectors. Such a configuration is used in MACXLine® products manufactured by Andrew.

Engineering analysis

A typical $6^1/_8$-inch rigid line with a 75Ω characteristic impedance is constructed as shown in Figure 1. The inner conductor is supported periodically with Teflon® insulators. The total line resistance is given by the equation:

$$R_L = \frac{(2.61 \times 10^{-7})(f^{1/2})(1/r_o + /r_i)}{2\pi}$$

Where:
R_L = Resistance in ohms per length
f = Frequency of operation
r_o = Inside radius of outer conductor
r_i = Outside radius of inner conductor

The total power loss of the transmission line is given by the square of the current times the total resistance ($I^2 \times R$). This resistance can be separated into inner and outer conductor contributions:

$$R_{inner} = \frac{(2.61 \times 10^{-7})(f^{1/2})}{2\pi} \times \frac{1}{r_i}$$

$$R_{outer} = \frac{(2.61 \times 10^{-7})(f^{1/2})}{2\pi} \times \frac{1}{r_o}$$

You can see that the power loss is inversely proportional to the radius of the conductor (the smaller the radius of the conductor, the larger R becomes and the

Power loss is inversely proportional to the radius of the conductor.

larger the loss). An example calculation for an average input power of 60kW (where I^2 is approximately 800 A^2 for a 75Ω line) and operating frequency of 549MHz (UHF channel 27) shows:

RADIUS	*RESISTANCE*	*POWER LOSS*
r_i = 0.856″	13.64mΩ/ft	10.92W/ft
r_o = 2.991″	3.91mΩ/ft	3.12W/ft

The calculation indicates that the power loss in the inner conductor is more than three times greater than that of the outer conductor, implying that the inner conductor will run much hotter. This is important because the average power rating of a line is limited by the maximum temperature of the inner conductor that can assure long-term stability of the dielectric support material. (Peak power is limited by electric field strength, such that a voltage breakdown between the inner and outer conductors does not occur.) At VHF, FM and UHF frequencies, rigid line is average power (i.e., temperature) limited.

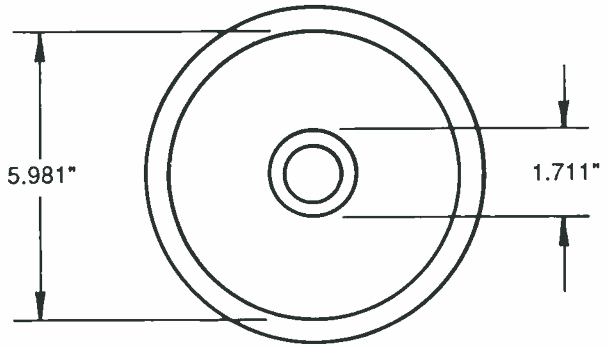

Figure 1. *Typical cross section of copper tubes used in $6^1/_8$-inch, 75Ω rigid line.*

Thermal analysis

A thermal analysis of a rigid line can be performed to determine the actual temperatures of the inner and outer conductors, taking into consideration dimensions,

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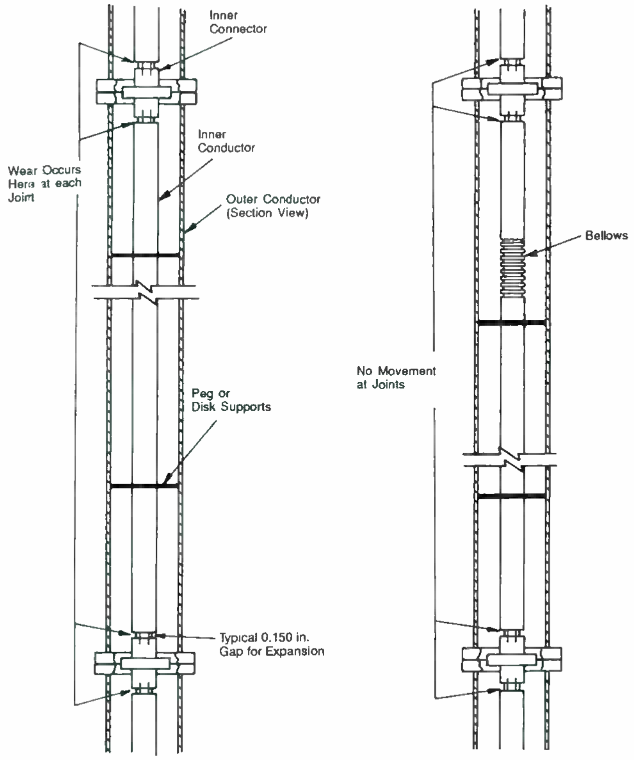

Figure 2. *Comparison of normal rigid line (at left) and bellows line (right).*

material characteristics, frequency of operation, line current, temperatures, pressures and other coefficients. The results of an analysis are presented in Table 1 for a channel 27 application (549MHz) operating at average input powers of 60kW and 50kW, at ambient temperatures of 104°F, 68°F and 32°F. The table shows dissipation and heat flow from inner to outer conductor via convection and radiation. Heat transfer by conduction is negligible because of the small amount of dielectric material in direct contact with the conductors.

From Table 1 you learn that the temperature gradient between the inner and outer conductor running 60kW average input power is about 74°F. Because the thermal expansion coefficient of copper is 9.8×10^{-6}/°F, this differential will cause the inner conductor of a typical 20-foot section of line to expand with respect to the outer conductor by 0.174 inches. In ordinary rigid line, the only place for this expansion to be absorbed is at the contact surface between the inner connector and inner conductor. (See Figure 2.) The bellows line approach, also shown in Figure 2, is designed to eliminate this constant movement caused by the expansion/contraction cycle.

Comparative testing

Two 6 1/8-inch, 75Ω rigid line sections were fabricated; one, a standard rigid line and the other with a bellows incorporated in the inner conductor. Each sample was attached to an expansion/contraction test fixture and life-cycled to an equivalent of 10 years (3,650 cycles) and 20 years (7,300 cycles). The test fixture consisted of a short line section and brass insert, which houses a cam and crankshaft assembly and operates in a piston-style configuration.

This fixture was bolted to one end of the rigid line section under test with the brass insert fastened to the inner conductor. A gap of 0.150 inches was left between the inner connector ridge and the copper inner conductor as normally allowed for differential expansion and contraction in actual service. The shaft was rotated and the cycles were monitored by a counter. The inner conductor was moved 0.090 inches with respect to the outer to simu-

Frequency (MHz)	549	549	549	549
Input Average Power (KW)	60	60	60	50
Temperature				
Ambient (°F)	104.0	68.0	32.0	104.0
Inner Conductor (°F)	199.9	166.3	132.1	185.9
Outer Conductor (°F)	126.9	92.5	57.9	123.3
Power Dissipation				
Inner Conductor (Watts/Meter)	40.6	39.5	38.2	33.5
Outer Conductor (Watts/Meter)	10.9	10.5	10.1	9.0
Heat Flow				
Convection, Inner-Outer (Watts/Meter)	27.3	28.1	28.7	22.5
Radiation, Inner-Outer (Watts/Meter)	13.3	11.4	9.5	10.9
Convection, Outer-Ambient (Watts/Meter)	18.9	21.0	23.3	15.2
Radiation, Outer-Ambient (Watts/Meter)	32.6	28.9	25.1	27.2

Table 1. Thermal analysis for channel 27.

***Figure 3.** A look inside a horizontal outer conductor section, at metal shavings resulting from 10 years of simulated cyclic contraction/expansion (3,650 cycles) in a standard rigid transmission line.*

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late one half of the relative growth and shrinkage in the line analyzed previously. This setup was used to simulate years of service under daily on-off cycling with one year equal to 365 cycles.

After an equivalent of 10 years (3,650 cycles), the standard rigid line generated a considerable amount of metal shavings from the silver-plated inner connector and the inner conductor. The line was tested in the horizontal position so the outer conductor could catch the shavings that are visible in Figure 3.

This movement of the inner conductor on the inner connector resulted in deep (0.003") and long (0.100"—0.200") gouges in the bullet connector where the silver plating was completely removed and brass was visible. (See Figure 4.) The gouges ran in the axial direction and were located periodically around the circumference. After an additional 3,650 cycles (a total of 20 years of cycling), more metal shavings were generated, but most of the damage had already been done.

This test was repeated on a bellows-equipped section, and after the equivalent of 10 years (3,650 cycles) and 20 years (7,300 cycles), no metal shavings were generated. The inner connector showed no damage, because the bellows took up all the movement.

Other, more exhaustive, life cycle tests have been conducted on the bellows section with no failures after hundreds of years of simulated operation.

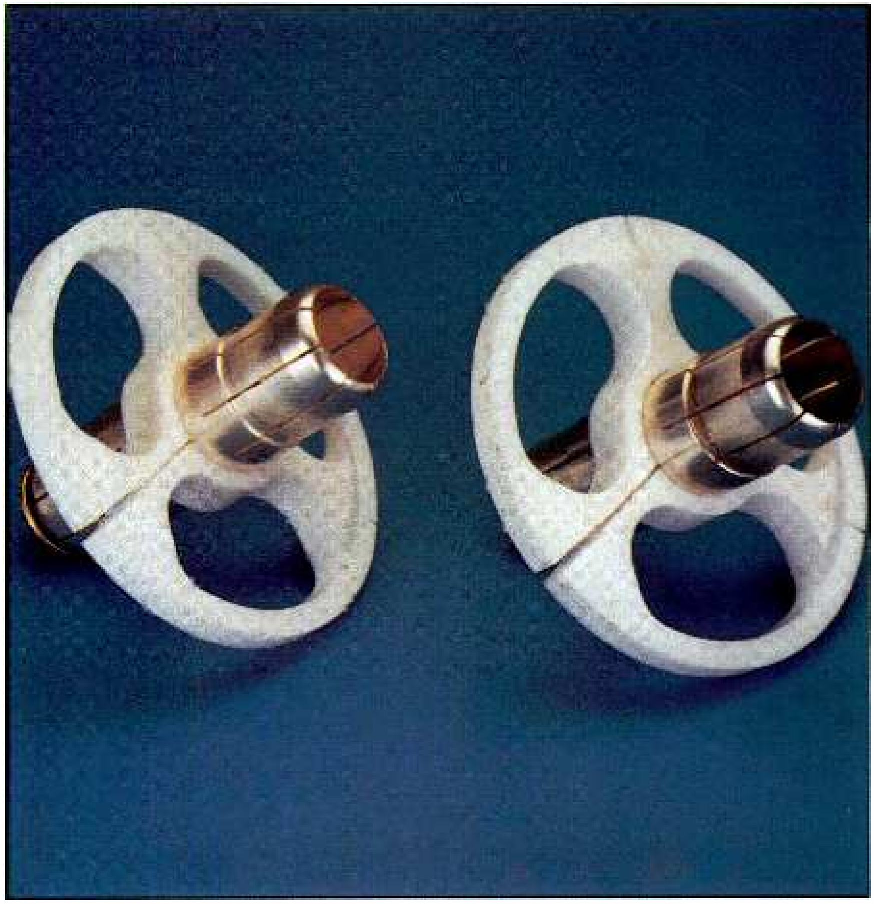

Figure 4. *Inner connectors after simulated aging of 20 years (7,300 cycles) in a bellows line at left. vs. only 10 years (3,650 cycles) in a standard rigid line at right. Note wear in silver plating at right.*

The sliding action can cause metallic shavings to contaminate the interior of the line and allow a flashover to occur.

KUVN-TV
Field test results

Channel 23, in Garland, TX, has 640 feet of 6⅛-inch, 75Ω bellows line, which was installed in 1985. The 74kW transmitter is normally shut down each night for about five hours. The average power into the transmission line is 61.4kW and the average power rating of the line is 64.3kW. A thermal analysis of this application, using an ambient temperature of 104°F, indicates that the inner and outer conductors will run 200°F and 127°F respectively. The power dissipation in the inner and outer conductor will be 41kW and 11kW respectively. For an ambient temperature

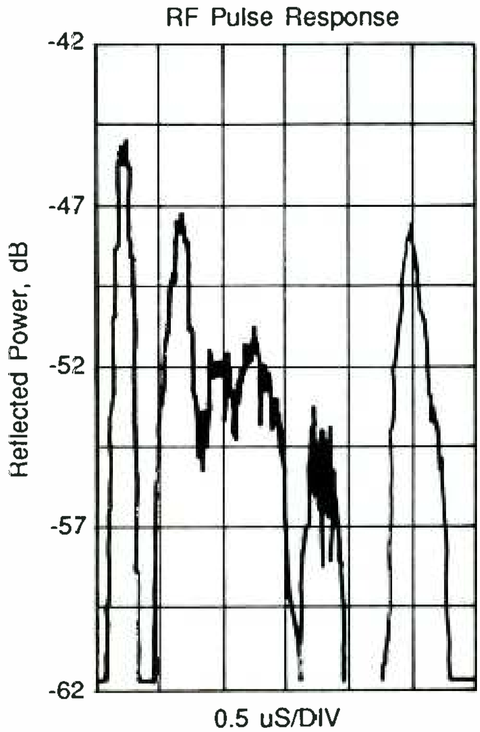

Figure 5. *VSWR results for an 800-foot bellows line at WMPV-TV, Mobile, AL.*

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of 50°F, the inner and outer conductors will be 150°F and 75°F respectively. For these two ambient temperatures, the temperature gradient between the inner and outer conductors is 73°F and 75°F respectively. This gradient causes a differential thermal expansion of 0.174 inches in each inner conductor section of the system when the transmitter is turned on.

A flange joint in the vertical run was opened and the inner connector removed. There was no sign of thermal expansion/contraction wear on the inner connector or inner conductor. All of the expansion and contraction had been absorbed in the bellows of the inner conductor sections, as simulated in the test described previously.

Regarding the RF performance of this transmission line technology, pulse test results on a recent 800-foot installation at WMPV-TV in Mobile, AL, are shown in Figure 5. Note that reflected power levels at the visual carrier frequency of 513.25MHz are below −45dB at all points in the system.

Figure 6. *Inner conductor with disk support and bellows section is shown (foreground), with its outer conductor (center rear) and inner connector (at right).*

Conclusion

In a broadcast application, the inner and outer conductors of a rigid line will expand and contract in a cyclical nature, but at different rates with respect to each other, because of the large temperature gradient between them.

When ordinary rigid lines are used, the difference in length is traditionally taken up in the inner connector to inner conductor interface. This causes a sliding motion over the electrical and mechanical contact surfaces. (Inner connectors are typically silver plated for minimum contact resistance, to facilitate current flow.) The sliding motion creates metal shavings and removes the silver plating, resulting in a situation with two potential problems:

1. The optimum contact surface is compromised by a reduction in silver plating. In the extreme case, plating is completely worn away in certain areas, increasing contact resistance. This may hamper the current path and, in turn, cause increased I^2R losses. This results in localized hot spots, which may begin to soften the dielectric material supporting the inner connector.

2. In the vertical portion of the run, the metal shavings will fall on the face of insulators below. After sufficient metallic particles have accumulated, a current path between conductors will result, causing a flashover — a problem all too familiar to many broadcasters.

With MACXLine® rigid transmission line, the bellows accommodate the inner conductor growth and shrinkage. This eliminates any of the sliding action of the inner conductor on the inner connector, and results in an optimum contact surface over the life of the line. More than 25,000 feet of this transmission line is in service at FM, VHF-TV and UHF-TV stations throughout the United States, in new and replacement installations.


ON AIR
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News
Continued from page 4

membership survey, additional input from the current board of directors and the 1989 Past President's report. In addition, a focus group will be appointed to discuss the key issues facing broadcast engineers in this decade."

Dick noted that his planning process began with the 1990 member survey, "which assures that every SBE member has the opportunity to influence the society's future direction. Although other's have talked about strategic planning, those plans prevent our members having any input. My goal was to involve the entire SBE membership in the planning process. Now, we've been able to bring every member to the table and offer them the opportunity to help set our agenda. The result will be a well-conceived, accurate and successful long-term strategic plan for SBE."

Stephen L. Ingram, CAE, executive director of SBE will assist the officers and directors in the development of the strategic plan.

The target date for completion of the strategic plan will be April 1991.

Comark receives an Emmy for the Klystrode

Comark Communications, Colmar, PA, has received an Emmy for Outstanding Achievement in Engineering Development for its development of the Klystrode UHF transmitter.

Merrald Shrader and Don Preist of Varian/Eimac also received an Emmy for the development of the Klystrode UHF power amplifier tube. Ray Kiesel, Andy Whiteside and Alvin See of Comark received Emmy Certificates for their contributions as part of the development team.

The Comark transmitter was recognized for several revolutionary broadcasting advancements. It provides a 50% to 75% reduction in UHF transmitter power consumption, and eliminates the use of vapor or liquid cooling systems as well as the broadcast use of full-time multiplex service.

Photokina '90

This year's "World's Fair of Imaging Systems" is scheduled for Oct. 3-9, in Cologne, West Germany. The event will feature a collection of photographic equipment through video production and TV broadcast equipment. There will be 1,400 exhibitors from 35 countries. The Cologne Messe venue will also host HiFi Cologne during the same period with approximately 200 manufacturers of audio products.

Special presentations will include a "Camera Forum" organized by the WDR and ZDF German public broadcasting corporation, a lighting workshop and a spe-

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cial convention on production technology in film, radio and television. To attend Photokina '90, now in its 40th year, contact: Cologne Messe, Cologne, West Germany; telephone 49-221 821-0; fax 49-221 821-2574; telex 8873426 MUA D.

CCIR plenary assembly acts on HDTV standard

The International Radio Consultative Committee (CCIR) of the International Telecommunications Union (ITU) has approved the results of the past four year's efforts of its working party dealing with HDTV standards for studio production and international exchange of programs. The working party held its final meeting at the NAB convention in Atlanta, in March, and gave tentative approval to 23 of the parameter values that comprise a TV picture. The remaining values relate to the number of lines used to display a picture on the TV screen and the number of times per second a TV picture is taken. Those critical values will continue to be studied during the next 4-year cycle.

The CCIR Plenary Assembly is expected to approve new procedures during its meeting in Dusseldorf that will permit it to make final decisions at any time world consensus is reached, not just at the end of each 4-year cycle.

Two specific international production standards have been proposed — an 1,125-line system by Japan and a 1,250-line system by the European Community. The United States has been trying to bring the two proponents closer together in order to achieve a single worldwide standard that would be used for transfer of TV signals among all countries.

Among the values decided by all nations is a wider aspect ratio. The new standard calls for a 16"×9" wide screen display. All nations have also agreed on precise definitions of basic colors (red, blue and green) for the first time in the history of TV production.

132nd SMPTE announces technical program

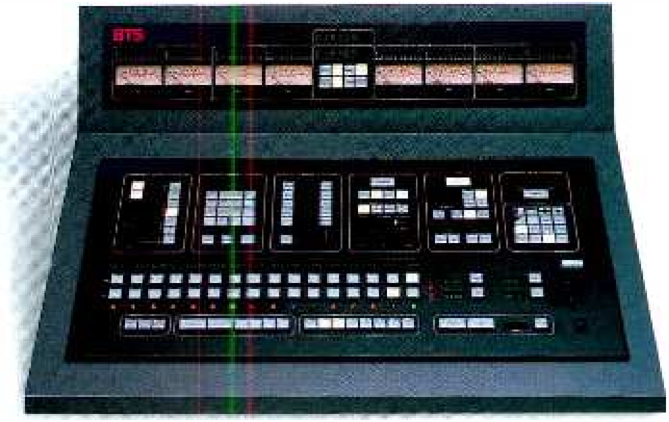
Kerns Powers, program chairman for the Society of Motion Picture and Television Engineers (SMPTE) has announced the session schedule for the 132nd technical conference and equipment exhibit. The conference will be held Oct. 13-17, at the Jacob K. Javits Convention Center in New York City.

The theme is "Film and Television — One World?" and 130 papers have been grouped into 17 sessions.

George Vradenburg III (CBS) will deliv-

Continued on page 172

How to take control of a broadcast station.



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The computer system is not only powerful, it's extremely flexible, allowing you to revise the program on a moment's notice. And there's no more reliable automation system available. Both products go through 100% computerized factory testing and have a 5-year warranty.

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New products

Dynamics processor

By Audio Animation

• **Paragon:** audio transmission processor uses digital techniques; no clipping stage; 4-band compression and limiting; adjustments for crossover, attack/release times; control interface through touch-screen VGA CRT; lockout password protection avoids unauthorized system adjustment; "sound library" of processing routines integrated for use with various types of program material.

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PC compatibles

By MicroExpress

• **ME 386-SX/SL:** desktop PC in slimline case; 5-card expansion capability with 40Mbyte hard disk; 1.2Mbyte $5\frac{1}{4}$-inch, VGA display card and VGA monochrome monitor; 1Mbyte RAM expandable to 4Mbytes; socket for 80387 co-processor; 16MHz processor; options for larger capacity hard disks, $3\frac{1}{2}$-inch floppy drive.

• **ME 486-ISA:** PC-based on 80486 processor with 128kbyte RAM cache; processor runs 25MHz with no wait states; socket for Weitek co-processor; eight expansion slots; $5\frac{1}{4}$- or $3\frac{1}{2}$-inch floppy drives; DOS, OS/2, UNIX operating systems.

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Transportable uplink service

By New England Satellite Systems

• **Leased uplink:** Ku-band service using Andrew 3.7m single-piece reflector; MCL 300 HPA, LNR exciter; 20kW Onan generator; 6.5GHz electronics; intercom, cellular telephone with IFB; fully redundant system by Wolf Coach and BAF available for use throughout the northeastern U.S.

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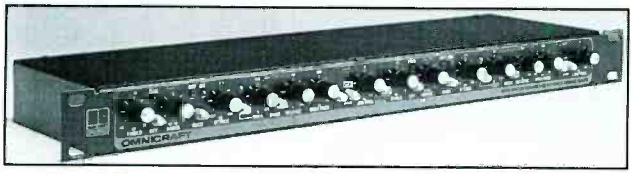

- **Omnicraft GTS:** stereo audio noise gate; balanced inputs, outputs using XLR connectors; −89dB noise rating with immeasurable distortion; optical switching devices replace voltage-controlled amplifiers; two trigger modes; variable attack, hold, release; gating possible on line or mic level signals; use for separate dual channel or ganged stereo operation.

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PC modular editing

By ASC Video

- **CASE editing system:** PC/AT compatible with software package; menu program for operations and file management; custom, color-coded keyboard, monochrome display; peripheral hardware; supports SMPTE switcher protocol; list management includes multiple bins; programmable macros, GPI ports, master and slave control.

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Satellite service

By Atlantic Satellite Communications

- **Transatlantic 2-way service:** relaying of TV signals between U.S., Europe. Sound America; conversion from and to appropriate NTSC, PAL, SECAM standards.

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Automated videodisc

By TEAC America

- **LV220-P autoturn:** videodisc player accesses both sides of the disc; does not require turning the disc over; may operate unattended as a computer peripheral or with other automated controllers; accesses one hour of full-motion video with two audio tracks, serves as a library of 108,000 still frames.
- **VA 500:** RGB video processor allows recording of wider band color information to 1.5MHz, where color-under systems limit color resolution to 0.5MHz; reduces artifacts of Y/C type recording systems; designed for LV210, LV250HC videodisc recorders.

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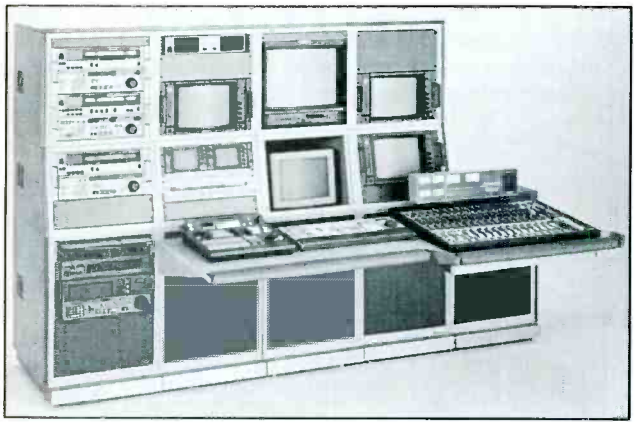
Equipment consoles
By Winsted



• **Post-production and editing:** System/85 consoles for larger electronics equipment; accommodates switchers, mixers and effects products from various manufacturers; flush mounting is possible through custom cradles; pro gray color and quick assembly frames in ready-to-assemble kits for reduced shipping charges.
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Lighting effects
By CELCO

• **PANORAMA:** lighting console; centralizes effects lighting functions into a compact control; model 60 offers 60 control channels, 150 cues, 48 sequences; digital storage interfaces, Q-Card data storage feature permits retrieval, transfer of data to another system; features "latest takes precedence" instead of "highest voltage takes precedence;" 60 Wing retrofit unit adds channels to control color changers, moving lights.
• **The Box:** replay system permits preprogrammed lighting instructions to be performed without having a lighting console present; may be used to expand a lighting console control channels.
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Light correction
By Lee Filters

• **Green filters:** six additions to fluorescent lighting correction series including positive and negative full 1/2 and 1/4 grades.
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Professional DMM

By Beckman Industrial

• **Model RMS225:** 4-digit multimeter; features 10,000-count resolution also showing true rms on 41-segment analog bar graph; auto max/min, probe hold and relative modes; self-resetting fuse avoids damage to unit if erroneously connected to excessive current.

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Special-purpose calculators

By Calculated Industries

• **FRAME MASTER PLUS:** time-code conversions and calculations with frames in 30-frame non-drop, 30-frame drop and real time (H:M:S) environments; includes 24- and 25-frame PAL and SECAM as well as non-standard, user-selected rates and feet-to-frame calculations for 16mm and 35mm film; both offer in-out duration with manual or auto-entry options and rates/costs functions to calculate time and material costs.

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Power amplifiers

By Carver

• **PM series:** six magnetic field audio power amplifiers; from 120W to 1,250W with 4Ω outputs; –120 60W/channel, –300 150W/channel in 1-RU packages; –600 300W/channel, –900 450W/channel, –1,200 600W/channel, –1,250 625W/channel are 2-RU packages; clipping eliminator circuitry, 70V direct-drive, 3-way inputs, 5-way speaker binding posts; dual-channel LED indicators display power level; detented left, right controls.

Circle (366) on Reply Card

Antenna alignment aid

By Scientific Atlanta

• **Models 7751, 7752:** beacon receivers and downconverters for C-band and Ku-band satellite reception; receiver produces a DC output voltage for use by the antenna controller to assist in accurate pointing of the antenna.

Circle (408) on Reply Card

Satellite leasing

By Communications Satellite

• **Thirty-day plan:** complementing 1-week and 3-month plans, extends special international communications requirements for news and sporting events; offers 14% savings over four 1-week lease plans.

Circle (369) on Reply Card

If you thought they were just for HDTV,

think again:

Sure, our TSG 1000 Series Television Generators support the major proposed HDTV standards. But they're good for a lot more than high definition.

The fully programmable TSG 1001 and companion SDP 1000 Signal Development Program, for example, support signal generation in NTSC, Betacam®, MII and HDTV formats. With the PC-based SDP 1000, signals can be defined in arbitrary line and field rates.

FORMAT	TSG 1001	TSG 1050	TSG 1125	TSG 1250
525/59.94/2:1	•	•		
525/59.94/1:1	•	•		
787/59.94/1:1	•			
1050/59.94/2:1	•	•		
1050/59.94/1:1	•	•		
1125/60/2:1	•		•	
625/50/2:1	•			•
625/50/1:1	•			•
1250/50/2:1	•			•
1250/50/1:1	•			•
GBR	•	•	•	•
Y, PB, PR	•	•	•	•
Analog	•	•	•	•
Parallel Digital	•	•	•	•

The TSG 1050, TSG 1125 and TSG 1250 generate signals in HDTV as well as lower line rate interlaced formats.* With an optional RAM or PROM board and the SDP 1000, signals can be generated in a wide range of line and field rates. Plus, a programmable zone plate generator is included in the TSG 1001 and is available as an option with the rest of the family.

All in all, once you get the full story from your nearest Tek representative, we think you *will* think again about looking anywhere else!

*TSG 1125 excepted.

TVG-104

Tektronix®

Circle (117) on Reply Card

Titling system upgrade

By Paltex Imaging Systems

• **Version 6 software:** for Aston 4 and Caption character generator systems; dynamic roll and crawl modes occupy single page of memory; auto page sequencing permits access to screens in any order with varying dwell times per page; effectively doubles font memory of single-channel Aston 4 titler; fast font processor increases type-face processing speed by a factor of five; batch processing for 100 display fonts.

Circle (394) on Reply Card

UHF power devices

By EEV

• **IOT7340R, IOT7360:** inductive output tubes; 40kW rated, air-cooled or 60kW water-cooled devices; for aural or visual PA stages of TV transmitters; 130% figure of merit achieved; uses external cavities for tuning from 470MHz to 810MHz; beam is electromagnetically focused with density bunching by RF-driven grid; beam power varies with depth of modulation; stepped collector voltage suppresses secondary electron emission for greater efficiency.

Circle (351) on Reply Card

Flexible editing

By United Media

• **UMI 450:** A/B roll videotape editing control; enhances capabilities of UMI 400 with serial switcher and mixer control; RS-422 plug-in for serial VTR control; parallel VTR capability optional; 250-event EDL with list management; interformat capabilities; time-code generator with jam sync; upgrade kits for 400 series models available.

Circle (416) on Reply Card

Band I antenna

By Comad Communications (SIRA)

• **Band I panel system:** constructed in a modular fashion to greater applicability in different situations; wideband power distribution system uses quadrature hybrid couplers, star power dividers; 4-panel tier typically requires 19.5m of tower space with a weight of 25 tons; two inputs with two feeder cables driven from a drum splitter for improved wideband performance; Lorenz filter combiner uses 3-pole bandpass filter to reject unwanted interaction of multiple channel signals.

Circle (368) on Reply Card

Sync processing, video switch

By QSI Systems

• **Model 5400:** sync processor cleans off-air video signals; recreates original sync, burst, blanking; automatic bypass mode enabled if the signal becomes too noisy or too low to achieve sync lock; 19-inch rack-mount package.

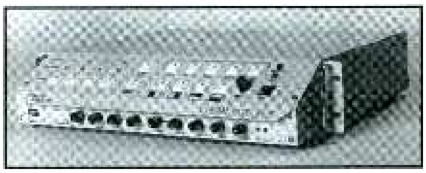
• **Model 5700:** automatic video switchover system; selects a backup source if the program signal amplitude or the noise level fall outside acceptable limits; 19-inch rack-mount system includes wired remote control and defeatable alarm output for remote signaling.

• **Model 2048:** creates messages to 255

characters for insertion into the vertical interval or in active picture area; text longer than 24 characters automatically crawls across the screen.
Circle (403) on Reply Card

Integrated production unit

By Prime Image



• **Clean Cut/FX:** combines 4-channel TBC and synchronizer, 4-input video selection from non-synchronous sources and 4-input stereo audio-follow-video switching; integral digital effects for single channel or transitions between channels; freeze, strobe, mosaic, posterization, sepia effects; S option offers four S-video inputs with S-output and transcoding between S and composite video.
Circle (421) on Reply Card

Remote control

By Moseley Associates

• **Extended I/O option:** for MRC 1620 remote-control system; expands status channel capability in groups of four; permits eight analog channels to be converted to 32 extended channels with inversion, alarm and muting functions; retrofit available for all MRC 1620 systems currently in use; latching relay option available without extended status for MRC 1600, 1620.
Circle (425) on Reply Card

Signal distribution

By TE Products

• **VAS-2000, VAS-2040 routers:** 50MHz bandwidth routing equipment; 48×64 matrix of video and audio or stereo audio in 10 rack-unit space expandable to 192×192; VAS-2040 starts at 16×64 matrix in five units, expandable to 112×192; VAS-MRC remote-control panels communicates at 200kb/s on twisted pair or coax with StudioPro automatic program control system; VAS-2200 and VAS-2240 provide 70MHz bandwidth.
• **HVAS, CVAS routing:** intelligent production distribution with 70MHz bandwidth for video and multiple level audio; 1×8 or 16×1 matrices in 1-rack unit; CVAS system handles RGB video components.
Circle (411) on Reply Card

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Circle (77) on Reply Card

Preventive maintenance

By Gibson Research

• **SpinRite II:** software package for PC systems using larger hard disk drives; improves disk access by performing a non-destructive low-level format; rejuvenates the original format to reduce data access errors that may result from a variety of format misalignments on heavily used hard disk systems; relocates data to safe storage areas of the disk only if bad sectors are detected in surface scrubbing process.

Circle (353) on Reply Card

TDR instruments

By Riser-Bond Instruments

• **1210 TDR:** universal instrument for location of cable faults; microprocessor-controlled device locates impedance discontinuities, such as shorts, opens, loose connectors, water, rodent damage; LCD display shows footage to the fault with a waveform representing the cable; ±0.01% accuracy with any metallic paired cable to 31,000 feet length.

• **2901B+:** digital time domain reflectometer; variable sensitivity, hand-held instrument locates major impedance discontinuities as well as less-severe faults; 1-button operation with ±1% accuracy to cables of 11,000 feet in length.

Circle (405) on Reply Card

Surge protection

By Tripp Lite

• **Power Pause:** single unit protects electronic equipment from power instabilities; combines surge suppressor device with a time-delay relay; AC power is restored to equipment after 5-second delay to avoid application of overvoltage; for office equipment, TVs, CD players; provides two protected 15a outlets; green indicator shows unit to be functioning properly.

Circle (415) on Reply Card

Video sync, encoder

By ICON Electronics

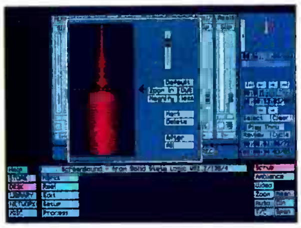
• **IEC-843:** combines RGB-to-NTSC encoder with sync generator for 1Vp-p composite or 0.7V non-composite NTSC color output; internal jumper permits Y-C S-VHS format outputs; genlock; PC lock mode for use with color graphics system provides coherent horizontal sync and subcarrier.

Circle (423) on Reply Card

ScreenSound. A fully integrated audio for video editing suite

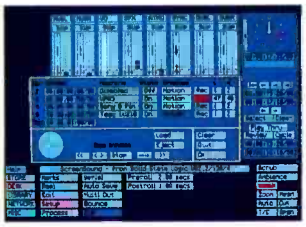
AUDIO STORE
The hard disk store of sound clips gives title and duration, in addition to powerful search and sort routines.

SCRUB EDITOR
Provides accurate edit marking and scrub of audio waveform.



OPTICAL LIBRARY
An off-line library of sound clips and effects can be compiled on a Write Once Read Many (WORM) optical disc.

MACHINE CONTROL
For control of multiple VTRs, laserdisc or film reproducers.



Post production facilities need to take advantage of the efficiency offered by today's technology. Speed and creative flexibility are essential to commercial success. Digital sound quality is no longer a luxury.

ScreenSound is a fully integrated audio for video editing suite. It combines digital audio storage and editing with machine control of multiple VTRs, Laserdisc or film reproducers. It also interfaces with Quantel's digital video editor, Harry.

Simple to learn and fast to use, a cordless pen, tablet and RGB monitor provide control of all ScreenSound functions.

Multiple sound reels enable music, dialogue and effects to be laid back to picture and synchronised to the exact video frame.

Edit, review, time offset, track slipping, cross fades and many other production techniques are available at the touch of a pen. Gain and stereo pan controls can be automated to timecode.

AES/EBU interfacing keeps digital audio transfers free of analogue distortions and losses, preserving the highest audio integrity through to the final format.

Above all, ScreenSound is a dedicated system - purpose-built to bring the advantages of hard disk sound manipulation to audio post production.

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Circle (123) on Reply Card

Specialized text, subtitling

By MRG Systems

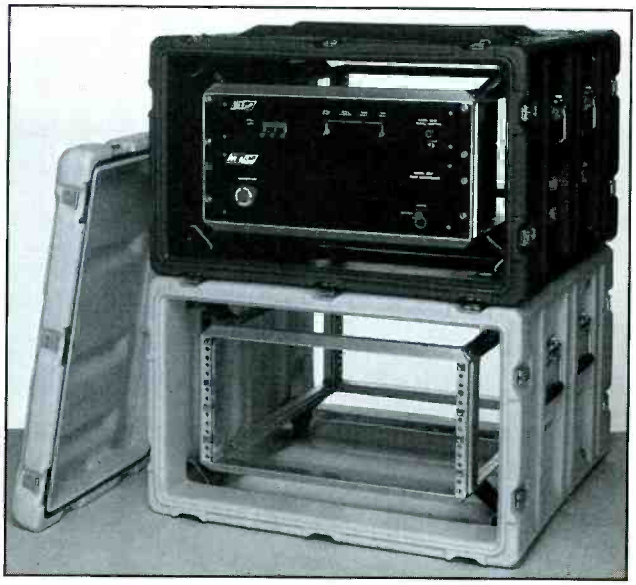
• **CT 1000:** broadcast teletext generator, inserter; 1,000-page capacity; all controls located on front panel with 32-character LCD and keypad; permits as many as seven independent datastreams for multiple magazine service; priority of a service may be changed for faster access times.

• **Subtitling system:** combines services of subtitling and opt-out; multiple language facility permits seven sets of subtitles (one set per language); subtitles are inserted by a teletext TV receiver or at a reception-retransmission center; opt-out facility controls reception of selected advertisements or text material when used with cabled distribution system by replacing incoming video with a secondary signal derived from the teletext service.

Circle (388) on Reply Card

Equipment containers

By Hardigg Industries



• **Rack-mount case:** includes 19-inch aluminum rack for equipment mounting; 2-inch sway space inside enclosure with elastomeric shock mounts; outer case of molded polyethylene; provides protection up to 25Gs from 18-inch drop.

Circle (376) on Reply Card

Graphics stylus

By IMCS

• **MousePen:** pen-like device combines miniaturized mouse for operation with IBM and compatible computers with feel of drawing stylus; shape and feel of the unit closely simulates freehand drawing of stylus; connects to same port as standard Microsoft serial or IBM PS/2 mice; package includes pop-up menu software and TelePaint program supporting VGA card; requires no special surface for operation.

Circle (382) on Reply Card

Graphics software

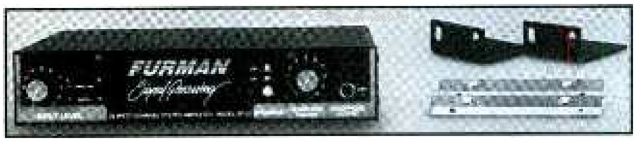
By RIX SoftWorks

• **ColoRIX:** VGA paint program; Version 1.2 directly imports TARGA 16 and exports unmapped TARGA files; also supports PCX, PCC, GEM, TIFF, IMG graphics files; generates ASCII from text within captured graphics screens; 16-color mode permits full editing in 1,024×768-pixel resolution; runs on IBM/compatible PC with 384kbyte RAM and VGA graphics.

Circle (355) on Reply Card

Stereo amplifier

By Furman Sound



• **SP-20:** half-rack unit houses dual 20W amplifier for stereo; may be switched between stereo, dual mono or bridged 40W modes; input level control, signal presence indicator and overload LED for each channel; 0.01% THD at 1kHz; protection against thermal overload and short-circuit output condition.

Circle (374) on Reply Card

Speakers, equalizer

By Altec Lansing

• **VIR Vari Intense:** horn with throat geometry to vary acoustic intensity over vertical pattern; maintains wider coverage nearer to speaker location; controls direct-to-reverb ratio for maximum intelligibility.

• **A700:** speaker system; black finished system contains 515-8G vented base horn and 909-8A compression driver on MR994 Manataray horn; -XLF low-frequency system extends bandwidth to 43Hz with two 15-inch woofers; -SK hanging accessory kit for A700 or A700XLF supports three enclosures as vertical array.

• **8553B:** dual programmable EQ system; one-third octave control, high-/low-pass filters; nine memories; System 422 digital serial communication interface.

Circle (428) on Reply Card

Still-store interface

By CEL Electronics

• **P164-DIF:** unit permits IBM AT or compatible with 100Mbyte hard disk to operate as broadcast digital still-store with 200 full-bandwidth capacity; images stored in CCIR 4:2:2 component format as fields or frames; also interfaces with P164-38 effects framestore for integrated storage with effects.

• **P165 TETRA:** bidirectional standards converter; 4-field temporal filtering produces smooth motion with 4-8 line vertical spatial filter performing line conversion; four composite inputs; four setup memories; doubles as still-store with external disk interface; direct CCIR 656-610 interface; adaptive comb filter; chroma detail enhancement and H/V retiming.

Circle (367) on Reply Card

INTRODUCING

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MRC 2

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Diverse- The MRC 2 is a true building block system. Remote terminals, control terminals and display options can be configured to your facility's specific requirements.

Accessible- 24-hour ***dial-up*** access is available over the public telephone network via the PC and modem.

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**Thanks to KCCO for use of their master page*

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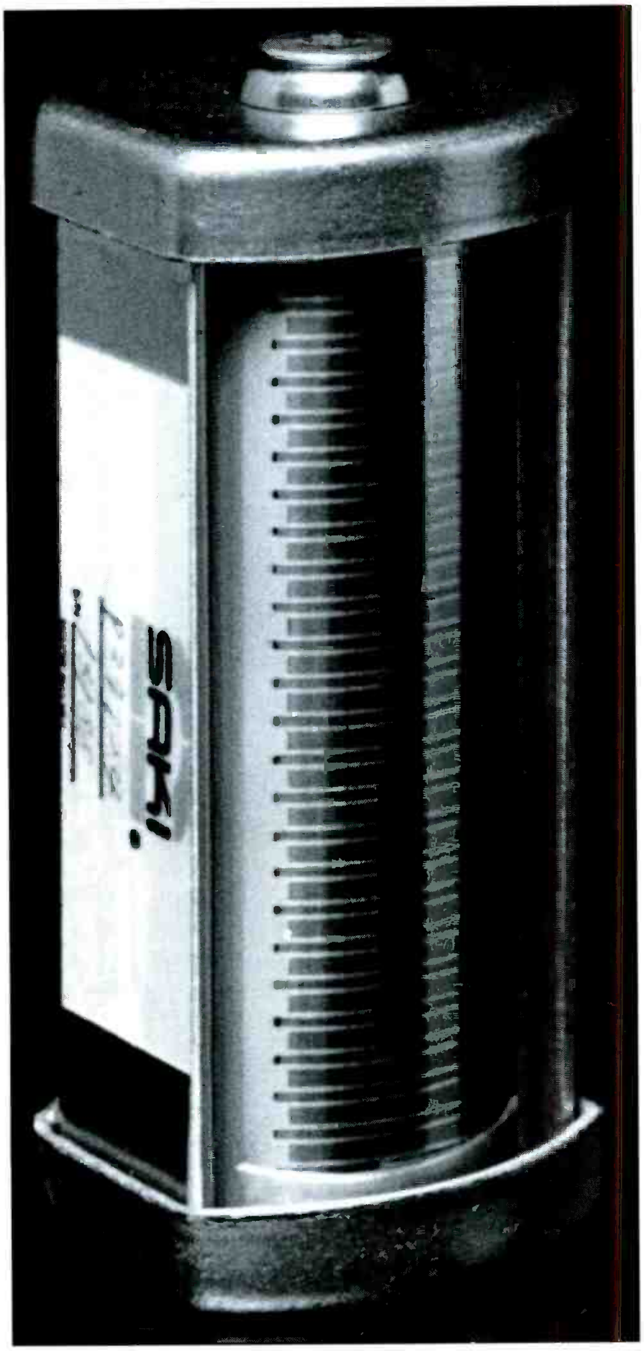
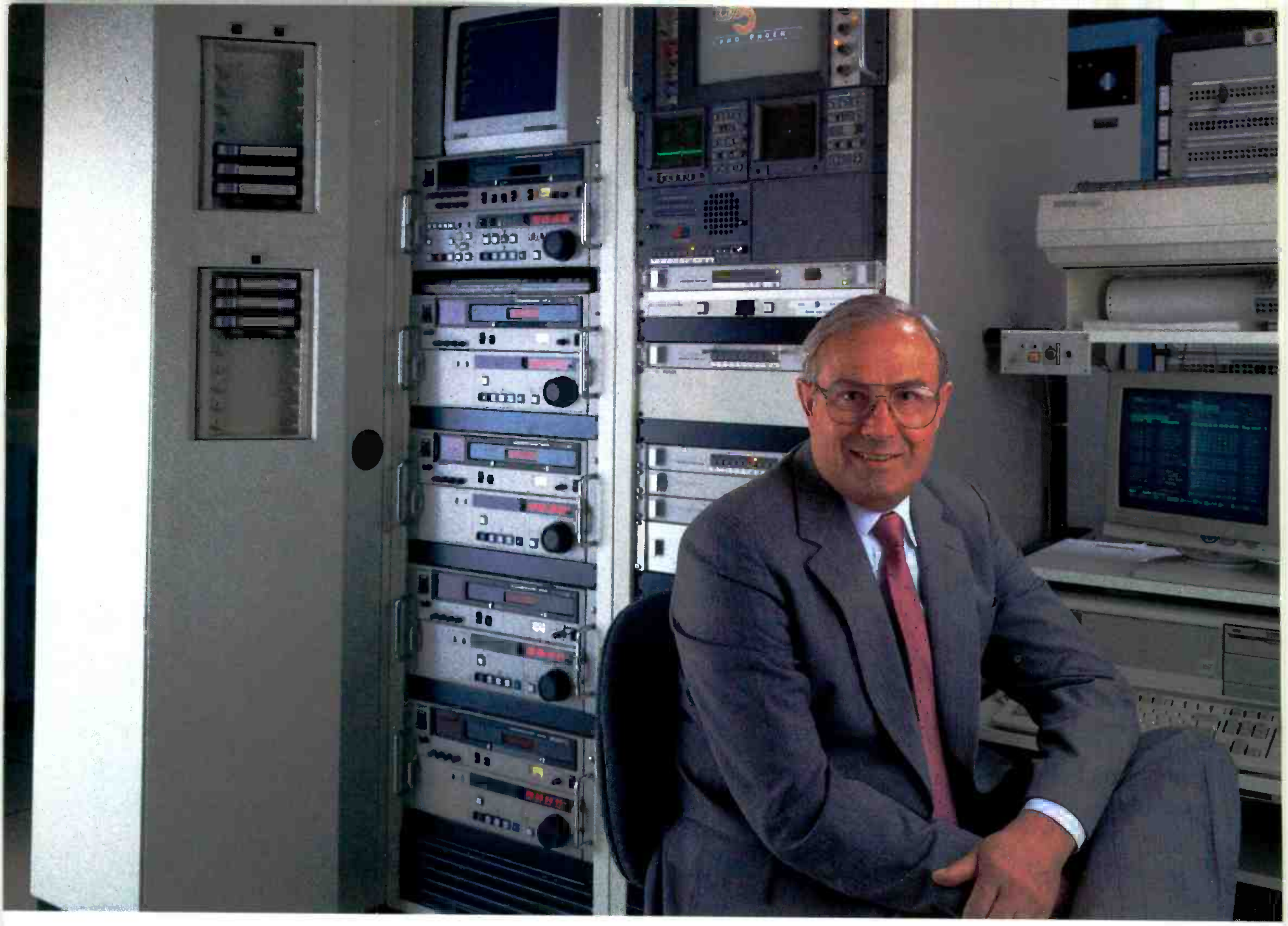
Circle (132) on Reply Card

Audio heads
By Saki Magnetics



• **Studer A-40, A-800 heads:** replaces original record and playback heads on 24-track studio recorders; complete interchangeability requires no wiring modifications; Permalloy construction; mechanical and electrical specifications meet or exceed Studer original parts.
Circle (406) on Reply Card



"For Dependability and Quality, You Can't Beat the Odetics Cart Machine..."

"Since we switched over to the Odetics TCS2000 Cart Machine, on-air discrepancies have dropped from about six per day to virtually none. And the quality has improved dramatically .

Our old machines were labor intensive. Too much time was spent daily pulling carts from storage and programming. We needed a machine that would do away with human effort...and human error.

I shopped and compared for over two years before I settled on the TCS2000. The other machines I researched didn't have the Odetics level of automation, and they were not nearly as dependable.

I've been especially impressed with the Odetics machines ability to download from our traffic computer and generate a play list. Not only does that feature save time and effort, it eliminates the error factor. And, of course, if we don't have on-air failures, we don't worry about makegoods.

The on-air appearance of the station is 100% better now. That's a big morale booster for everyone here. And the machine has certainly made my job easier. I don't miss those phone calls about our old machines problems at all hours of the night.

I didn't know a lot about Odetics before I bought their equipment, so I asked for a factory tour and demonstration. After I saw the large-scale robotics work the company was doing for the space industry as well as the broadcast business, I knew Odetics had the automation expertise I needed. In fact, I would strongly recommend that any chief engineer looking at cart machines take that factory tour. Also, I knew Odetics had already installed about 80 machines at other stations, so I called some of those chief engineers. I didn't talk to anyone who wasn't happy with the Odetics machine.

Most of the engineers I talked to emphasized the exceptional after-sale service and support Odetics provided. We found that out for ourselves when our new machine was installed. The training and support our operations people got was efficient, thorough and highly professional.

If you'd like to know about what the Odetics cart machine has done for KPHO, why not get some firsthand information? Feel free to give me a call at (602)264-1000."

Bill Strube, *Director of Engineering KPHO, Phoenix*

Odetics Broadcast

1515 South Manchester Avenue, Anaheim, California 92802-2907 Phone (800) 243-2001 or (714)774-2200

Circle (134) on Reply Card

Video with dimensions

By StereoGraphics

• **Stereo 3-D system:** combines a stereo 3-D camera by Kietami Electronics with viewing products from StereoGraphics; signals may be recorded and replayed on video monitors, large screen projectors as well as through cable and broadcast channels; uses CrystalEyes wireless active glasses; ZScreen, LCD panel with display controller and passive polarizing glasses; camera system operates at 525-line, 120Hz vertical scan frequency.

Circle (356) on Reply Card

Facilities security

By Thorn Automated Systems

• **Firequest Plus:** intelligent fire alarm system; enhanced with loop control module to interface with addressable monitor and control equipment; a 2-wire or 4-wire circuit handles 99 analog fire sensors, 50 addressable monitor modules, 49 addressable control modules and 10 fault isolator modules; allows creation of sensor groups and zones, as well as sensing for smoke.

Circle (414) on Reply Card

Uplink IDs

By Wegener Communications

• **Model 1680 ATIS:** automatic transmitter ID system, meets FCC April '90 ruling requiring video uplinks to transmit an identification signal; unit modulates 7.1MHz subcarrier with ATIS data to resolve interference problems; uses Morse code at 30-second intervals; compatible with series 1600 mainframes.

Circle (427) on Reply Card

Audio cable products

By Whirlwind Music Distributors

• **Accusonic:** 1- and 2-conductor audio cable using pure copper stranding with high-density braided shields; Accusonic+1 combines single conductor cable with MK series high-Z mic cables; Accusonic+2 uses a 2-conductor cable for MK series low-Z mic wiring.

• **Line balancer/splitter:** 1-channel low-impedance isolation, splitter and line-level balancing device; incorporates TRSP-6000 transformer for response of 20Hz-20Kz with levels from −10dB to +26dB.

• **Micpower:** phantom power supply for +12V to +18Vdc; two 9V batteries offer 50 hours operation for most electret condenser mics.

• **MIDI cable tester:** checks 5-, 3-conductor MIDI cabling; 9VDC battery operation with LED indicating cable condition.

Circle (417) on Reply Card

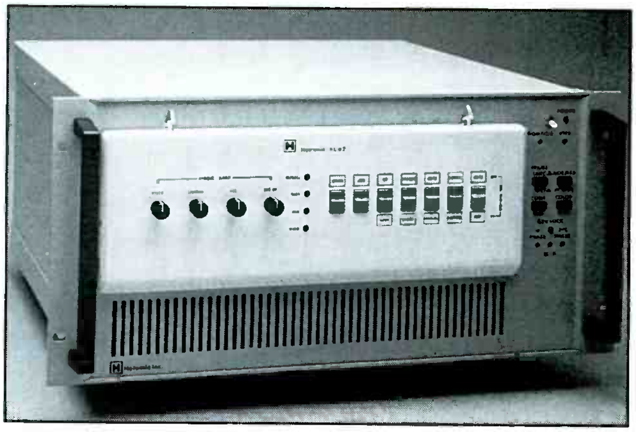
Time lapse VCR

By Javelin Electronics

• **JR-4500:** 4-head heliquad recorder in NTSC or PAL standards permits noiseless playback; 24-hour NTSC mode includes fully usable audio (18-hour PAL mode); maximum record duration of 480 hours or 20 days in NTSC using special field advance mode (720 hours or 30 days in PAL).

Circle (384) on Reply Card

Synchronizer, delay system
By Hotronic



• **AL82-40:** wideband frame synchronizer, combined with video and stereo delay; approximately 6-second profanity delay capability; 16-bit digital audio system corrects for audio delay on satellite feeds; 40-frame capture permits slow-motion effects; playback from memory at $^1/_4\times$, $^1/_8\times$ or $^1/_{16}\times$ normal rates as well as stepped frame or field playback; $4\times F_{SC}$ sampling to 8-bit architecture.
Circle (380) on Reply Card

Enhanced efficiency
By Harrison Systems

• **UHF transmitter upgrades:** modifies existing transmitting systems to use Klystrode or MSDC klystrons; results determined by technology best suited for each station. Typical 110kW transmitter annual operating cost can be reduced by $100,000.
Circle (377) on Reply Card

Next month...

BROADCAST MANAGEMENT FOR 1990:

• **Tenth Annual Salary Survey: Dividing the Pie**
A comprehensive report on the salary and compensation levels in the broadcast industry. Our 1990 report analyzes TV and radio salaries by title. The report also provides a profile of those who work in the broadcast industry. A related article lists training courses available to engineers entering the broadcast business.

• **Five Keys to Success in Broadcast Engineering**
Today's broadcast engineers face challenges from all directions. The skills that made them successful only a few years ago are insufficient today. The modern technical managers must be skilled in much more than the technical arena. This article outlines five areas in which today's engineers must excel in order to be successful.

• **Developing an Engineering Budget**
Preparing an engineering budget is a difficult, but important task. Developing a budget involves forecasting an unknown future, based upon the fuzzy present. This article presents some tips on how to accomplish the job.

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Continued from page 150
er the Keynote Address on Saturday morning. Dr. Marvin Camras (Illinois Institute of Technology) is the guest speaker for the Honors and Awards Luncheon on Saturday. Harold Eady (HJE Communications) is the guest speaker for the Fellows Luncheon on Sunday.

AHDAS inducts members

The Academy of High-Definition Television Arts & Sciences (AHDAS) has inducted 950 new members. The AHDAS, the high-definition television equivalent of the National Academy of Television Arts & Sciences, is a non-profit corporation serving the advancement of communications through HDTV. It was founded by Syd Cassyd, founder of the Emmy Bestowing National Academy of Television Publishing; Sam Bush editor of the HDTV newsletter; and Robert Munoz, president of Advanced Television Enterprises.

NAB has task force study DAB

The NAB Radio Board has named eight of its members to a special task force to study the potential land-based uses of digital audio broadcasting (DAB), a radio technology that can deliver CD-quality sound over the air.

DAB can be delivered over the airwaves at a less expensive transmission cost to broadcasters and produces a high-fidelity sound. A primary focus of the task force will be to study the economic effect of a potential DAB terrestrial service on the nation's 12,000 radio stations.

The Radio Board prefers a land-based or terrestrial DAB service over current proposals that would create a national satellite system for distributing DAB sound.

CableLabs and MIT research digital compression

CableLabs has established a research fund with MIT to support MIT in its study and development of digital video compression. Work also will be done examining exploratory approaches and any related advancements in digital video compression that might benefit the cable industry.

The CableLabs digital video compression work will be performed at the Advanced Television Research Program at the MIT Research Laboratory for Electronics (RLE). The program is headed by Jae Lim. The fund will pay for research, related support and the acquisition of certain proprietary rights.

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Contact Renée Hambleton, at (913) 888-4664, for information on frequency and pre-payment discounts. To place your classified ad send your order and materials to Broadcast Engineering, Classified Ad Mgr., P.O. Box 12901, Overland Park, KS 66212.

HELP WANTED

STUDIO MAINTENANCE ENGINEER

WTEN/WCDC-TV the ABC affiliate in Albany NY is searching for an experienced studio maintenance engineer to join our excellent technical staff. Three years studio maintenance background is preferred troubleshooting to a component level; Sony 1" and 1/2" VTR's, Sony camcorders and Grass Valley switchers. Competitive salary and benefits (health insurance, paid vacations, holidays and 401k).

Send Resumes to WTEN-TV,
341 Northern Blvd., Albany, NY 12204,
Attn: Skeeter Lansing, Chief Engineer. EOE.

HELP WANTED

CNN

TELEVISION ENGINEERS

Turner Broadcasting System, the leading News, Sports and Entertainment system in satellite communications, has career opportunities for engineers with broadcast maintenance experience. These positions demand an extensive background in television engineering and at least two years of training in electronics technology. Turner Broadcasting System offers an excellent benefit and compensation program. Send resumes to:

Mr. Jim Brown, Engineering
Turner Broadcasting System, Inc.
One CNN Center
P. O. Box 105366
Atlanta, Georgia 30348-5366
404-827-1638

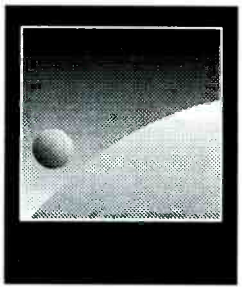
TBS is an equal opportunity employer.

TECHNICAL SUPPORT ENGINEERS

SONY, the recognized leader in Broadcast and Professional technologies, is currently seeking qualified Technical Support Engineers throughout the U.S. In addition, SONY will be expanding its **Cypress, California** customer service operations to meet the growing Southern California market. As a result of this expansion, SONY has several positions available for Technical Support Engineers to join their Cypress Customer Service team.

We seek those rare individuals who can combine technical expertise with above average communication skills and a dedication to the customer. The ideal candidates will have experience in the repair, maintenance and servicing of Broadcast and Professional Video Products with knowledge of digital recording, digital video effects, CCD cameras, or opto-electronics a plus. An appropriate technical education (BSEE/AA) or equivalent experience desirable.

SONY offers you the challenge of working for an industry leader and the opportunity to develop your technical skills on state-of-the-art equipment. In addition, we have an excellent salary and benefits package. For immediate consideration, please send your resume, indicating geographic preferences, to SONY CORPORATION OF AMERICA, Professional Staffing, Dept. BE1, 677 River Oaks Parkway, San Jose, CA 95134. We are proud to be an EEO/AA employer M/F/H/V. Also, we maintain a drug free workplace and perform pre-employment substance abuse testing.



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HELP WANTED

ASSOCIATE DIRECTOR, WASHINGTON OPERATIONS. Major market news bureau seeks Associate Director to assist in broadcast production facilities and personnel. Minimum 5 years experience. Operations/Production, as well as technical training, required. BS degree in engineering or equivalent preferred. Knowledge of business or finance beneficial. Send resume and salary requirements to: Broadcast Engineering, P.O. Box 12901, Dept. 717, Overland Park, KS 66212. 09-90-1t

ATTENTION: HIRING! GOVERNMENT JOBS—YOUR AREA! Many immediate openings without waiting list or test! $17,840-$69,485. Call (1) 602-838-8885, Ext. R-13464. 09-90-1t

FACULTY-TECHNICAL INSTITUTE: BROOKLYN; to supervise production operations of TV/Radio Department; to teach editing (½", ¾", 1 inch) and electronic graphics (Chyron & AVA) at graduate school level. Bachelors in TV production and one year TV engineering experience required. 5 day, 35 hour week, $31,272, per annum. Send letter or resume in duplicate to ST#134, Room 501, One Main Street, Brooklyn, New York 11201. 09-90-1t

SYSTEM ENGINEER needed for analog component post production facility. Knowledge of D-1 helpful. Must possess strong interpersonal and troubleshooting skills. All replies confidential. Send resume to Chief Engineer, Framerunner, Inc., 1995 Bway., New York, NY 10023. 09-90-1t

BROADCAST TELEVISION ENGINEER: Oral Roberts Evangelistic Association's Television Production Department is currently seeking an individual with the following qualifications. •5 years experience in maintaining broadcast video switchers. •One inch and betacam video tape machine experience. •Video tape editor experience. •Terrestial microwave and satellite uplink experience preferred. •Ability to troubleshoot to component level. Comprehensive benefit package available. Please send resume to OREA, Attn: Personnel Department, P.O. Box 2187, Tulsa, OK 74171, E.O.E. 09-90-1t

AM/FM RADIO STATIONS require (1) Maintenance Engineer with good RF and studio maintenance skills. FCC General Class or SBE Certification required. Please send resume with salary history to: Beverley Osborne, Personnel, Inner City Broadcasting Corp., 801 Second Avenue, New York, NY 10017. 09-90-1t

ASSISTANT CHIEF ENGINEER with five years experience on UHF-TV transmitters and studio equipment, located in the beautiful Northwest, EOE. Send resume to Manager, KTBW TV-20, 1909 So. 341st Pl., Federal Way, WA 98003. FAX 206-874-7432. 09-90-2t

CHIEF ENGINEER for Top 40 FM and DA AM in Fort Wayne, Indiana. Must have extensive analytical troubleshooting and repair skills for all types of radio broadcast equipment. Position will require leadership abilities and interaction with other staff members on a daily basis. This is a first-class Radio Group operation with quality people and top notch equipment. Send resume and salary history to Director of Engineering, Federated Media, P.O. Box 2500, Elkhart, IN 46515. 09-90-2t

BOSTON BASED production/broadcast operation, continuing to expand, is looking to fill a newly created position: **TECHNICAL OPERATIONS SUPERVISOR.** This position would answer to the Operations Manager and oversee the daily operational activities of areas such as post production, video operation, tape room, and control room, maintaining standards set by a small team of technical specialists and the Chief Engineer. Successful people-management experience is a priority, we strongly emphasize a supportive management style. Also a must is extensive operational/technical experience with state-of-the-art equipment. Must be well versed in advanced technological production techniques and able to communicate this through training and advising. Send responses to: Broadcast Engineering, Dept. 718, P.O. Box 12901, Overland Park, KS 66212. 09-90-1t

BOSTON BASED production/broadcast operation, continuing to expand, is looking to fill a newly created position: **SATELLITE COORDINATOR/OPERATOR.** This Engineering Department position would be responsible for the ordering, coordinating, and billing of daily international news and programming feeds. Position also includes assisting in the technical operation of satellite transmit and receive facilities. Must be skilled in booking procedures for both domestic and international feeds, with an emphasis on the international. Some technical operations experience would be helpful, but is not required, provided there is a desire to learn. Send responses to: Broadcast Engineering, Dept. 718, P.O. Box 12901, Overland Park, KS 66212. 09-90-1t

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POSITION ANNOUNCEMENT

■ ENGINEER TV-RADIO (SALARY: $42,938- $45,842)

Responsible for the maintenance of color TV Studio and small format (1/2", 3/4") color equipment and a campus-wide RF distribution system. Responsible for maintenance of TVRO Satellite System. The applicant will maintain a Class A FM station, do yearly proof of performance testing (as well as design new TV and radio systems). Responsible for the repair of other media equipment, maintenance of additional college electronic equipment. Ability to work with a diverse student/faculty/administration population. Some evening and weekend work is required.

QUALIFICATIONS Demonstrated ability and several years appropriate experience in maintenance of all aspects of radio, audio and TV equipment. Comprehensive knowledge of FM radio station and engineering functions. Bachelor's degree with either SBE Certification or FCC General Class License. Masters Degree in Engineering or a related field preferred, with either SBE Certification or FCC General Class License. Competitive salary and excellent benefits.

Send cover letter, resume, names, addresses and telephone numbers of three references **postmarked by October 15, 1990** to

Harold Bellinger, Affirmative Action Office

Nassau Community College

Garden City, NY 11530 - 6793

AFFIRMATIVE ACTION/EQUAL OPPORTUNITY EMPLOYER

VIDEO ENGINEER

The Savannah College of Art and Design seeks applicants for a full time Video Engineer in an expanding fully equipped Video Department, beginning October, 1990. The College offers BFA & MFA degrees in Video Production for the Corporate/Educational & Industrial markets. Applicants must have experience in equipment repair and maintenance, system and studio design, and the ability to relate to non technical personnel. Salary is based on experience. Send cover letter, resume, and references to:

Robert G. Nulph
Chairman Video Department, SCAD
P. O. Box 3146,
Savannah, GA 31402 EOE/AA

CHIEF ENGINEER—Alabama Network Affiliate seeks "hands-on" Chief Engineer. Experience with VHF transmitters, ENG microwave systems, and one-inch/beta tape formats is required. Must function as a team player in aggressive news environment. Equal Opportunity Employer. Qualified applicants apply to Broadcast Engineering, Dept. 716, P.O. Box 12901, Overland Park, KS 66212. 09-90-1t

DUE TO EXPANSION of facilities, Atlantic Video is looking for qualified Maintenance Engineers to fill several openings. Qualifications should include Associate Degree and/or 3 years experience with broadcast equipment. Computer networking literacy a plus. Please send resumes to Willy Halla, 650 Massachusetts Ave., N.W., Washington 20001. 09-90-1t

STUDIO MAINTENANCE ENGINEER

Connecticut Public Broadcasting is seeking an experienced studio maintenance engineer to join our engineering department in Stamford, CT. Applicant should possess a thorough knowledge of broadcast equipment including, but not limited to: Sony 1", ¾", ½" video tape equipment, Chyron character generator, Abekas DVE, GVG 200 switcher, RCA TK-47 cameras, and Ampex AVC-33 switcher. Requirements include a solid electronics background and at least five years experience in studio maintenance. Qualified applicants should send resume to:

Don Lamy C.E.
Connecticut Public Broadcasting
250 Harbor Drive
Stamford, CT 06904 EOE

CENTRAL INTELLIGENCE AGENCY

Broadcast Engineers

The Central Intelligence Agency is seeking Broadcast Engineers experienced and skilled in the design, construction and maintenance of AM/FM/SW broadcast stations. Knowledge of TV systems is desirable. Applicants should be self-motivated, hands-on types and must be willing to travel internationally. Minimum requirements include a BSEE and 5 years experience as an Engineer in the broadcast field. Senior SBE certification is also desirable.

Positions require U.S. citizenship. Must also successfully complete medical and security processing including a polygraph interview. To apply, send resume to: Personnel Representative (DJ21), P.O. Box 1925, Washington, D.C. 20013. We will respond within 30 days to those judged to be of further interest. The CIA is an Equal Opportunity Employer.

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HELP WANTED

SOUTH CAROLINA EDUCATIONAL TV NETWORK

is searching for an experienced **Technical Project Manager** to assist in the planning, design, and implementation of TV and Radio engineering projects with specific emphasis on satellite and fiber optic systems. Requires extensive experience in and knowledge of: transmitters, microwaves, antennas, and satellite systems; studios, recording, editing, video and pulse distribution systems; and accepted technical standards. Requires degree in engineering and four years related experience or 8 years of design experience. Salary range $32,895 to $49,342. This new position will assist in providing technical support for the production of Educational TV Programs for statewide and national distribution and will have a rare opportunity to participate in the move to a new $18,000,000 production center next year. Many employee benefits offered including paid hospitalization, dental, and life insurance plan; three weeks annual leave plus 12 State Holidays. **EEO.** Address all inquiries to:

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Educational TV Commission
Personnel Department
Post Office Drawer L
Columbia, S.C. 29250
(803) 737-3457

TRANSMITTER SUPERVISOR

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Columbia, South Carolina.

Supervisor for UHF Transmitter with four operators, includes FM and Weather transmitters and remote control of three other sites. Applicants need TV and FM transmitter operating and maintenance experience. Salary Range - $24,385-$36,577 depending on experience. All applicants must call or write for a standard application form. **(SC ETV, 2712 Millwood Ave., Columbia, SC 29205. 803-737-3457.**

CONSULTING ENGINEERING FIRM

based in San Francisco and specializing in AM-FM-TV broadcasting, CATV, and microwave systems needs competent, personable, self-assured associate. BS in engineering essential, higher degrees desirable. Systems design, FCC applications, forensic engineering, some field work and travel. P.E. registration essential but may be obtained later. Salary commensurate with qualifications and experience. Enjoy the benefits of a small specialized professional firm with an established nationwide practice. All replies confidential. Send resume to Hammett & Edison, Inc., Box 280068, San Francisco, California, 94128.

TV MAINTENANCE ENGINEER

needed for a national Christian studio post production satellite uplink facility. Three years component level maintenance experience. Ampex, AVC, ADO, VPR-3, Beta, Scientific Atlanta Uplink. Positions available in San Diego and Dallas. Competitive salary and benefits (Paid vacations, holidays, incentive programs, medical & dental insurance) with an exciting organization. Send resume to: Personnel Dept., Word of Faith, P.O. Box 819099, Dallas, TX 75381-9099

CORPORATE VIDEO ENGINEER: EG&G Energy Measurements, Inc., a prime contractor to the U.S. Department of Energy in Las Vegas, Nevada, has an immediate opening in the video production area for a Video Engineer to design, fabricate, and install various types of complex broadcast video and audio systems as well as other specialized imaging systems and interfaces. Desired qualifications include a BS in Electrical Engineering, four years' experience, and a general class radiotelephone license. Send resume to: EG&G Energy Measurements, Inc., Pat Ullom/32-90, P.O. Box 1912, Las Vegas, NV 89125. EOE. 09-90-1t

TELEVISION MAINTENANCE ENGINEER. For Camrac Studios in Reno, Nevada. Experience required for 3-tube & chip cameras, switchers, 1", BETA-SP, ¾ & ½ inch duplicators, graphics, ADO, stereo audio, multi-track, terminal equipment and general maintenance. Computer experience an asset. Join our team for clean air, blue skies, skiing at Lake Tahoe with good benefits and career opportunity. Salary commensurate with experience. Send resumé & cover letter to Jim Mitchell, 1775 Kuenzli Lane, Reno, NV 89502. 09-90-1t

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KTVA-TV IS SEEKING A TECHNICAL DIRECTOR/MASTER CONTROL OPERATOR. Individual must be an experienced technical director and also be able to perform some master control and light production duties. Send resumés to Chief Engineer, KTVA, 1007 W. 32nd Ave., Anchorage, AK 99503. EOE. No phone calls please. 08-90-2t

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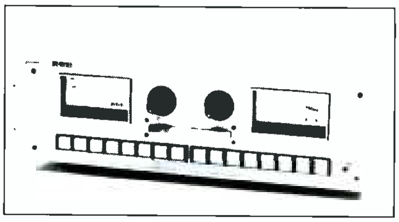

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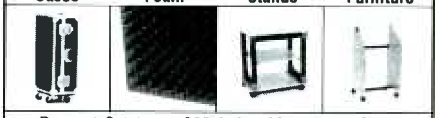

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04-90-6t

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09-90-3t

For Classified information Call Renée Hambleton (913) 888-4664

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