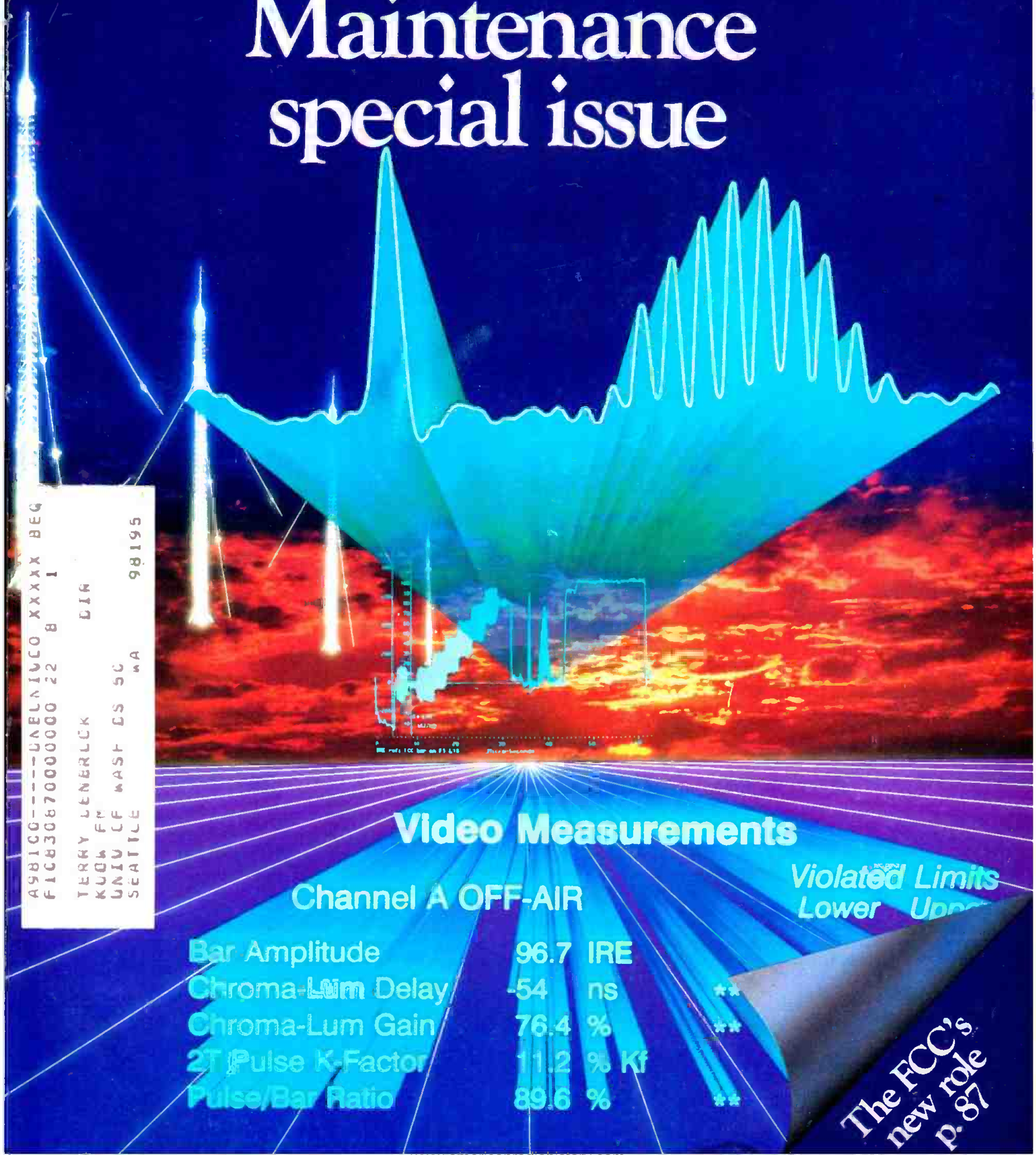
BROADCAST engineering

AN INTERTEC PUBLICATION

November 1987/$3

Maintenance special issue



The FCC's new role p. 87

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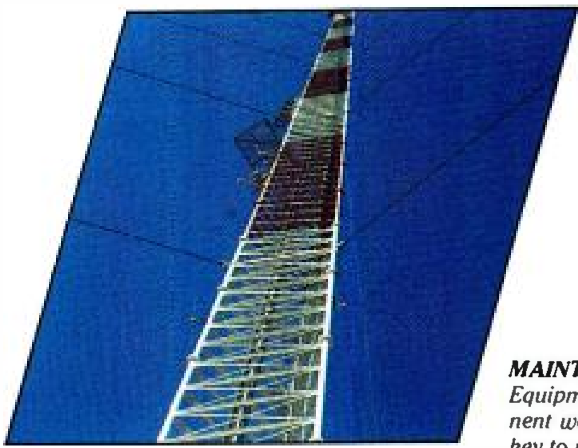

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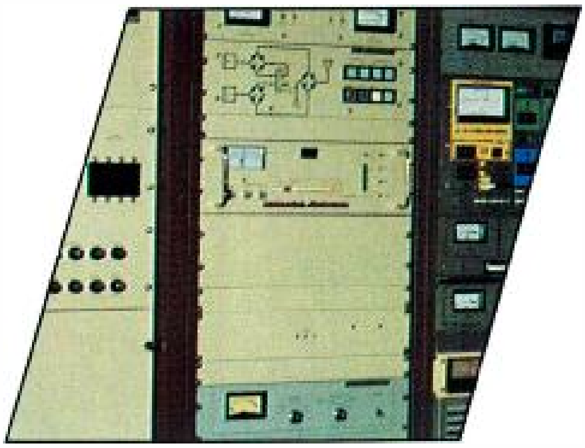

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BROADCAST ENGINEERING

MAINTENANCE SPECIAL REPORT:
Equipment failure is inevitable, whether from routine component wear or from outside forces, such as severe weather. The key to preventing problems is to know your equipment. Our 4th annual Station Maintenance Special Report *will examine areas of equipment reliability and maintainability.*

ON THE COVER
As broadcast equipment becomes more complex, the requirements for sophisticated monitoring gear for system evaluation and troubleshooting also increases. Our cover this month, features a composite waveform display showing, in part, the display screen of a VM-700 TV system analyzer. (Photo courtesy of Tektronix.)

DEPARTMENTS

NAB forms HDTV technology center

Edward O. Fritts, president, National Association of Broadcasters, has announced the formation of the Broadcast Technology Center to bring high-definition television to reality for terrestrial broadcasters.

The announcement was made at the Association of Maximum Service Telecasters' Special Conference on HDTV. The center will be under NAB Technologies, the association's subsidiary formed earlier this year. Thomas Keller, NAB senior vice president, Science and Technology Department, will head the center.

Ben Crutchfield, the department's HDTV project director will work with Keller and other additional staff, which will include engineers and support personnel.

The center will be housed in new facilities, which will include a laboratory and the necessary electronic and computer equipment.

Some of the funding will come from the $700,000 already allocated by the NAB for HDTV research. The remainder will come from broadcasters through direct investment, as limited partners, and through earmarked contributions to the NAB for the center's activities. A major industry campaign to provide sufficient financing with an expected budget of approximately $2 million per year, will be mounted soon.

SMPTE releases study on film rate

A Society of Motion Picture and Television Engineers (SMPTE) study group formed in 1985 to examine a change in the motion-picture frame rate from 24- to 30-frames per second has submitted a report to the society's standards committee. The group was organized under the society's standards committee.

The report, which includes the results of a number of tests and demonstrations, concludes that a 30-frame-per-second rate standard would bring far more advantages than disadvantages to the motion-picture and TV industries.

The 30-frame-per-second rate refers to the number of images photographed by a motion-picture camera and imprinted on a strip of film and is compatible with both the NTSC and the proposed 1,125-line/60-field HDTV standards. Filming at 30-frames per second also would enhance theatrical presentation. Many TV commercials and virtually all music videos are photographed at that rate.

Concentrating its attention on how 30-frame-per-second filming could benefit theatrical presentation, the group established test criteria and generated a series of demonstration films. Three test results were reflected in the report.

The group compared movies photographed at 30-frames per second with

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BROADCAST engineering

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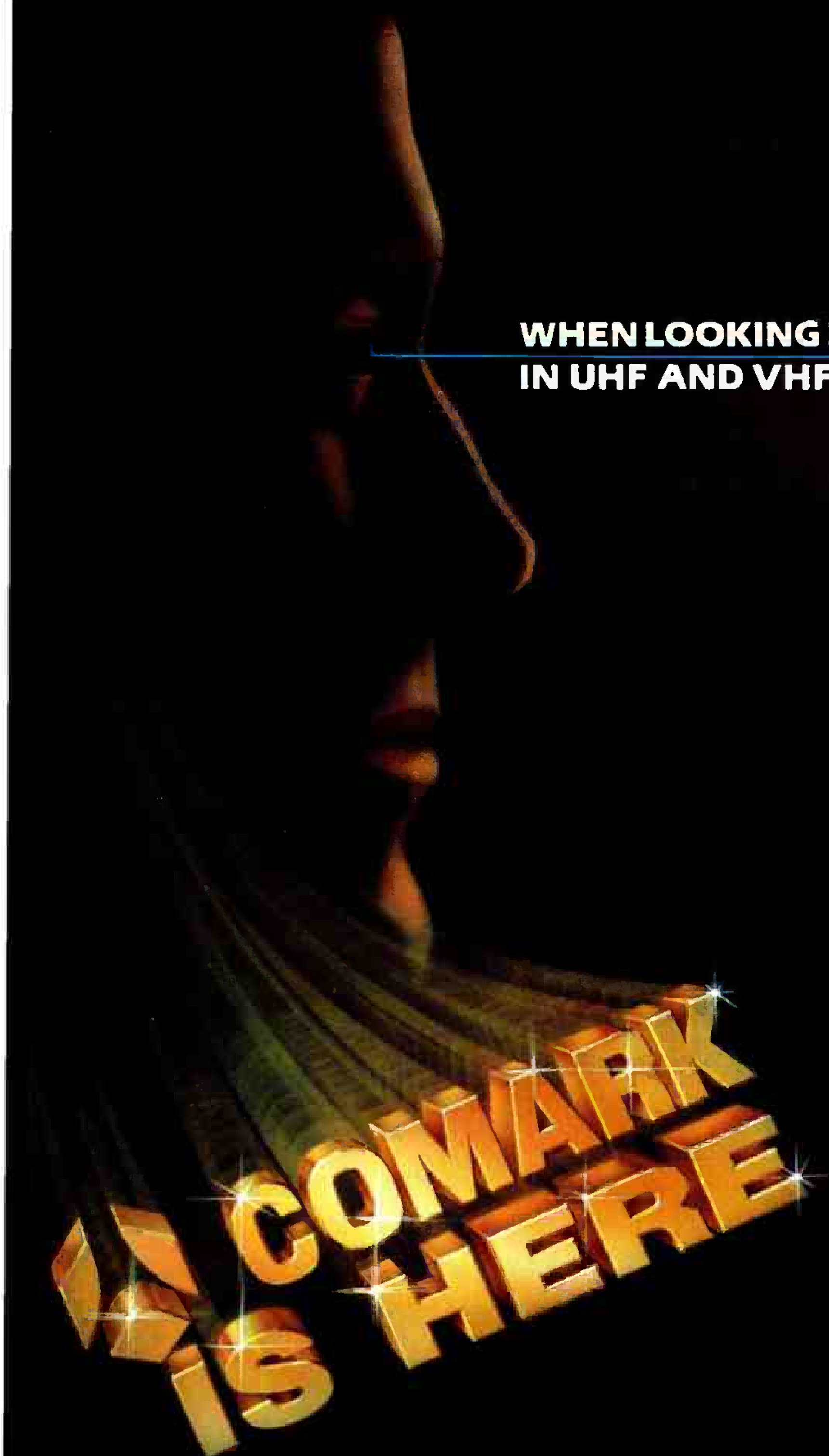

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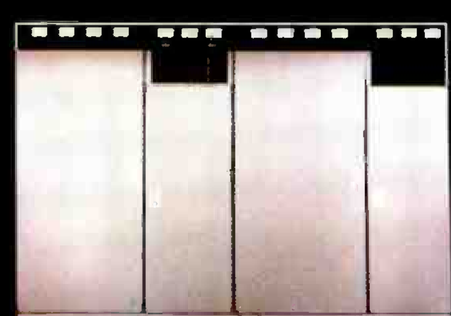

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Protecting the bottom line

The broadcast industry lives on technology. It thrives on electronic gadgets. Without competent engineering support, however, our electronic tools of the trade are of little value. Education for engineering personnel is, therefore, critically important, if, for no other reason than to protect the *bottom line*.

A broadcast engineer's most basic responsibility is equipment maintenence. It also is a responsibility that requires continuing education to keep pace with technology. This is ideally recognized by some method of certification of technical competence.

Although the first class FCC license is dead and buried, the concept of technical certification of radio and TV engineering personnel remains a high priority with broadcasters across the country.

It is our belief that the single most important industry-wide program designed to recognize technical competence with format certification and to encourage continuing education is the Society of Broadcast Engineers' certification program.

When the commission threw in the licensing towel in 1981, the SBE's program became the only game in town. First conceived in 1973, the effort was designed to provide a method whereby technical personnel could be evaluated by their peers.

The society doesn't claim that an engineer can't be qualified unless certified. Quite the contrary. Under the certification program, applicants need sufficient on-the-job experience to even take the examinations for the higher levels of certification.

The SBE has structured the examination and requalification process so that it is practically impossible to obtain—or retain—SBE certification without being actively involved in broadcasting. A major component of recertification involves education, either through continuing education unit (CEU) credits, attendance at major engineering conferences, authoring technical papers or other activities that demonstrate you are continuing to keep pace with technology.

Therein lies the major benefit to the individual of having SBE certification. It proves to the industry that you have a measure of experience, and that you have been able to use that experience and your technical expertise to pass an industry-recognized examination.

Much concern has been expressed in recent years about the lack of young people entering the broadcast engineering profession. Our industry has let this situation develop by failing to actively recruit talented engineering personnel from colleges and universities, and then failing to pay those engineers competitive salaries with the semiconductor and aerospace industries.

Broadcasters can correct this problem by recognizing that we all live—or die—by technology. And in the final analysis, every station's bottom line is directly affected by the competence of the line engineers who operate and maintain the production, distribution and transmission equipment.

The best way to protect that bottom line is for management to encourage continuing education and certification through the SBE's program, and to then pay their engineers a competitive salary.

Now, some six years after the official demise of the first class license, the broadcast industry has a standard by which we can measure technical competence. That standard is the SBE certification program.

SBE certification gives engineers a goal they can work toward. Moreover, according to the last three salary surveys conducted by **Broadcast Engineering**, personnel who have taken the time and trouble to gain certification are being rewarded for their efforts with bigger paychecks.

The equipment that broadcasters use is becoming increasingly complex, and this hardware requires competent technical personnel to keep it running. The need for trained engineers has never been greater. Our industry must look seriously at this issue, if only to protect the bottom line.

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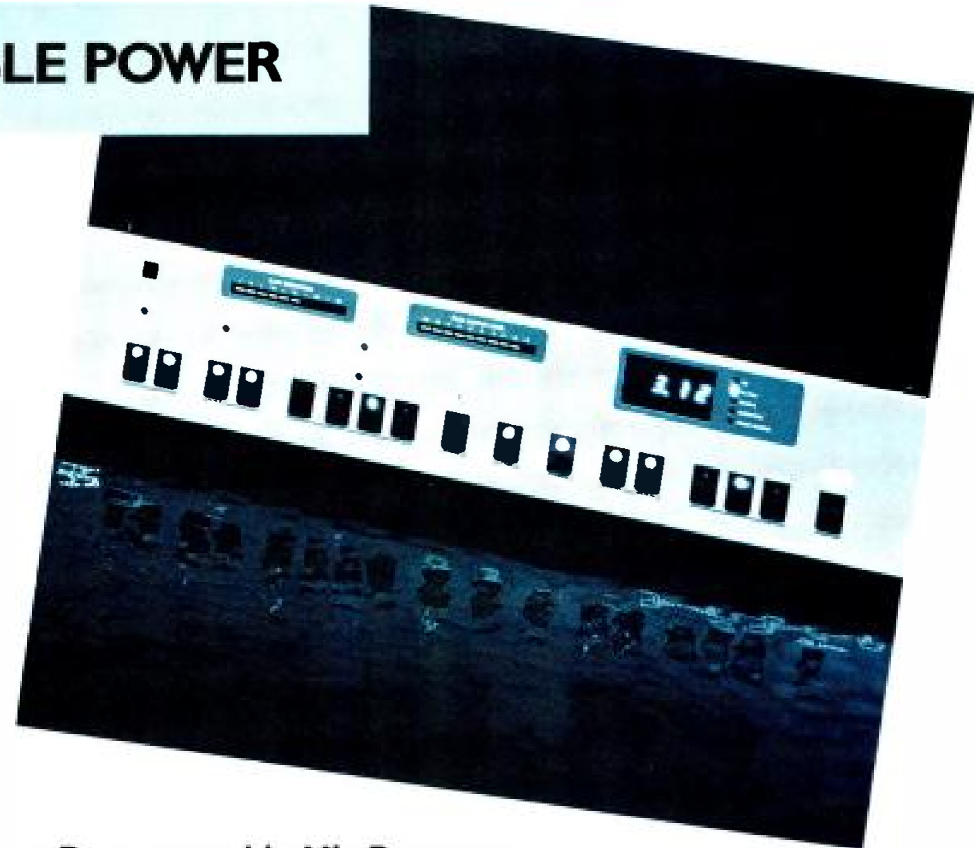

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FM technical rules are amended

By Harry C. Martin

The FCC has amended its FM station classification system by adding to the minimum and maximum power and antenna-height requirements a *reference distance* for each class reflecting the expected distance to the 1mV/m (60dBu) contour, rounded to the nearest kilometer. Under the new rules, stations are classified according to their maximum power restrictions, power/height combinations and new reference distances.

The commission proposed rule changes in April 1986 to clarify and simplify the allocation rules, particularly those affected by the creation of new station classes in Docket 80-90, and to expedite processing of FM station applications.

The first area of concern was the classification of stations not fitting into the basic classification system, which is based on antenna height and power. In this connection, the commission did not adopt its originally proposed *index* system, which would have employed a mathematical formula based on maintaining as a constant, the maximum predicted distance to the 1mV/m contour. Instead, the new reference-distance system will be used to classify a station if its class cannot be determined by its power or by its power/height combination. Overheight stations will be classified according to where their particular reference distances fall in relation to preset *class contour distances* for the six classes of FM stations. As in the past, antenna height may exceed the class maximum, now termed reference height, if the station's power is reduced. However, power cannot exceed the class maximum, regardless of the distance to the 1mV/m contour.

Also amended were rules allowing technical modifications to certain short-spaced FM stations. The table of mileage separations governing modifications to grandfathered short-spaced FM stations has been eliminated. Under the new rules, a grandfathered station may modify its facilities as long as its 1mV/m contour is not extended toward the station with which it is short-spaced. Also, second and third adjacent-channel stations are now included in the commission's policy permitting short-spaced stations to increase their facilities pursuant to a mutual agreement.

Predictions of coverage methods have been modified to require calculations based on the maximum ERP of the main lobe regardless of orientation. This refinement is necessary because the previous method of predicting coverage, based only on the horizontally radiated power of the FM antenna, is not an accurate indicator of coverage when applied to the higher and more complex antennas of today's FM stations.

With regard to the proposed modifications of intermediate frequency (IF) separations for station Classes B1, C1 and C2 to ensure no overlap of the 30mV/m contour, no action was taken. This issue will be the subject of a future proceeding.

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

Proposed rules for non-licensed RF devices

In another action, the commission proposed changes in Part 15 of its rules to create a new general class of RF devices with increased frequencies of operation and no restrictions on usage, bandwidth or type of modulation. Established nearly 50 years ago, the rules for non-licensed use of RF devices allowed operation using low-level RF signals and did not require individual licensing, as long as no harmful interference to licensed services was caused, and the device did not generate field-strength emissions exceeding a certain level.

The proposed rules are an attempt to restore the technical flexibility originally foreseen for non-licensed devices. The current regulations, based on a general field-strength standard, have been amended over the years to permit operation on higher frequencies by specific devices. The inconsistent Part 15 standards are the result. Furthermore, improvements in equipment and changes in frequency allocations of authorized radio services have brought about the need for revision of standards for protection against interference to licensed radio services.

Although the proposed rules attempt to eliminate unnecessary and exceedingly restrictive technical regulations, in some cases they would be more restrictive than those now contained in Part 15. To avoid hardship, the commission has proposed a grandfather period, usually to last 10 years, during which manufacturers may continue production of existing devices.

The commission's proposal also includes RF device kit authorization procedures. No changes are proposed for other RF device authorization procedures.

Cable rule proposals and changes

The commission initiated a rulemaking to revise the signal availability standard of its cable TV rules and, simultaneously, amended several rules implementing the Cable Communications Policy Act of 1984.

Cable systems will continue to be considered as facing effective competition, which frees them from local rate regulations on the basis of the availability of three Grade B or significantly viewed signals. However, the proposal would alter the assessment of the significant viewing standard by basing it on viewership data in individual cable communities. Previous studies had to be made on a countywide basis. County viewership data would continue to be used to establish a threshold standard for viewership, but community data will be used in making final determinations in contested cases.

The commission counts a signal as available as long as its Grade B signal covers a substantial portion of the cable community. A 75% bench mark for substantial community coverage is being proposed now.

The agency also is requesting suggestions for alternatives to the current method of establishing the basis for waiver of its coverage-based effective competition standards. In this connection, the commission is seeking less expensive, but reliable methods of field-strength measurement. It suggested permitting cluster measurements instead of mobile runs currently required, for measuring signal strength.

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Round three

By Carl Bentz, technical and special projects editor

Have we stirred up a hornet's nest. mixed in a pit full of vipers and then tossed in a bunch of rats? (See "Recipe for Change" in the August issue and "On the Receiving End" in the September issue.) Both articles have made rather serious statements in favor of the Super VHS (S-VHS) consumer format, something we rarely do in **BE**. Both items have generated comments on the CompuServe Broadcast Professional Forum, including statements to the effect that **BE** has gone off the deep end and abandoned true broadcast engineering. As a member of the staff, I can vehemently state that nothing can be more wrong.

Every member of the senior editorial group for **BE** has had a tour in television in an engineering capacity. We witnessed the move from quad to type C. Initially we questioned it, but economically, type C made sense (and quad began its slow fade to black).

Then we saw the advent of ¾-inch. "Just for ENG," production said. "Don't be overly concerned when the football field is blue, the sky is red and once-red uniforms are suddenly green." And so, H-format moved into more prominent use—in some cases, even full-time use. It's more economical, and the consumer (the viewer) probably won't know the difference. Consumers, after all, will buy just about anything.

The scuffle over ½-inch formats made us think, "Just how far can this go?" But we had to admit that Beta, M and M-II appeared to be a step or two up on H. (And some demonstrations of the ¼-inch format produced quite satisfactory pictures.) In fact, the ½-inch systems have moved from their original ENG (that's why the original record time was limited to 20 minutes) to full-production status.

As an engineer, I can't help but ask myself, "How did this happen?" It takes little thought to reach a conclusion. I like to think of myself as a conscientious engineer (and magazine editor now) with a concern for quality. Each one of you, I'm sure, feels the same way. We've never said, "That's good enough," when in our minds we knew that it could be better if we didn't have to give in to the force that really controls a broadcast operation—finance.

As equipment quality has improved, the need for dedicated engineers has dwindled. Witness the demise of the first-class radio-telephone license. If the viewer can't tell the difference (how many of your home TV receivers are sufficiently well-adjusted to really show what's in the signal?), then the need to produce quality is less critical. The need for truly qualified engineers (who were already forced to yield to production "Time is money—if the reels turn, we go with it" syndrome) becomes less important as well.

Now enter the studio-in-a-camcorder. With the innovations devised for smaller format broadcast products proving successful, manufacturers logically have introduced their discoveries into the consumer market, a far more lucrative one than broadcasting will ever be. Executives in any successful company will tell you that you must go where the money is, and so they have gone consumer.

This new crop of improved-definition, ½-inch products provides several advantages the consumer has never before enjoyed. We know that the Y/C approach to signal handling avoids decode/encode degradation. If it didn't, ¾-inch would never have gone as far as it has prior to SP-type machines). We know that wider bandwidth signals give more definition (that's physics and natural law). Mixed with a microprocessor craze that touched nearly every kind of product we can imagine, the limit of possibilities suddenly jumps beyond infinity.

Several critics of **BE**'s positive comments about S-VHS felt that the pictures "stunk." And that could be—not every demo goes as planned. But, not everyone sees television as engineers watch it in the control room on an $8,000 precision monitor from a distance of several feet. Across the living room from the television, say 12 to 15 feet or more, how much of the snow shows? Yes, snow. Every part of a transmission system has potential to introduce video noise (snow) and, unless properly maintained, even your half-million-dollar transmitter, installed just last year, may be producing a blizzard. STLs, DAs, exciters and home TV tuners may destroy what you created, but on your monitoring equipment you may not have the advantage of seeing all the possible degradation. Are you watching it out of the switcher or through the demod?

The consumer has been shown something new. In the direct link between a VCR and a monitor, the methods that we've seen develop over several years are suddenly available to a consuming public who has more awareness of the possibilities. They will find ways to afford this new gimmick, though from the demonstrations the **BE** editorial staff has seen, S-VHS and ED-Beta appear as more than gimmicks.

When the comments in **BE** suggested that S-VHS demos produced better than off-air signals, keep in mind that a convention hall may not always provide the best off-air signals. Keep in mind, also, that the equipment involves direct VCR-to-monitor connections.

Whether the new consumer products are better than broadcast is beside the point. What is important is that the products are better than what the consumer previously had. To us, as broadcasters, they challenge us to work harder in what we can do to provide a good product. If it means training people to properly adjust and operate equipment, then do it. If it means producing programs that have some real value, then do it. Complaining about what a magazine printed—a statement of what the writer witnessed—isn't going to do it.

Yes, we as magazine editors are no longer in the trenches. We don't have to keep a transmitter on the air, register a camera or fix a VTR tracking problem. (Frankly, sometimes we miss it, and, at the same time, we are sorry that some of you are saddled with that responsibility.) We are in a position to help monitor the industry and tell what we see. When we signed on to this tour of duty at **BE**, we pledged to ourselves not to be the pot that calls the kettle black, unless it is. The fact is, what we have recently observed, if it isn't black, is certainly a dark gray.

Know your DA

By John Battison, P.E.

We ended last month's column with a comment on careless logging. However, there are other real causes of antenna-monitor reading errors. If you have inherited an antenna system that is not properly documented, you should first check the original construction permit application and form 302 that were filed when the station first went on the air.

This information, together with all later filings should give the whole story. In many cases, this material is not available because of ownership changes and various engineers who have lost the material. Before you can be sure that the DA you have just inherited is working properly, you must first know how it is supposed to work. So, where do you find the data?

Locate the data

Various services in Washington will pull a station's files and make a copy of them for you. The cost can range from $30 to $60, depending on the time required to find the material and the number of pages to be copied. These services are usually well worth the cost.

As you read the material, check your installation against it and note any differences. There will be many differences in most stations. We'll assume that the antenna monitor is working properly, but the readings do not match those of the licensed parameters. Change the tower inputs and determine if you still get the same readings on different towers. You must, of course, make allowances for the tower parameters.

A cause of varying antenna-monitor readings that seems to be surfacing recently is sampling line problems. Most consulting engineers specify the sampling lines to be of equal length. This practice eliminates one potential error source. The sampling line length is, therefore, controlled by the distance to the farthest tower. The closer towers will then have excess line.

The commission requires that all sampling lines be stored and subjected to the same climatic and temperature conditions. This generally means burying the lines outside, or preferably indoors in a temperate area. If you observe antenna-monitor reading variations during extreme temperature change, be prepared to check the location of the excess lines. The commission will usually accept antenna-phase monitor readings within $\pm 3°$ and a ratio within 5% of the license value. Some stations may be required to maintain tolerances of $\pm 1°$ or 1%; these systems are known as *critical arrays*.

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

Careless logging

Careless logging is a problem at many stations. Typical logging errors include recording phase angles and base currents that are consistently outside tolerances and for which no corrective action appears to have been taken. When this happens, it's time to perform a skeleton proof of performance.

In some cases, if proper attention had been paid to log keeping during the preceding years, a costly license renewal delaying proof of performance would not now be required.

In fact, much of the consulting engineer's work is frequently due to carelessness and inattention to detail on the part of log keepers and the people who are responsible for ensuring that proper log entries are made.

On the other hand, such items as widely varying phase and current ratios on a particular tower usually indicate that changes have taken place in either the power supplied to the tower or the phase-monitor system.

Example

Such readings also might be caused by the problem I found at one station. This station had trouble obtaining consistent antenna-monitor and common-point current readings. Everything at the transmitter looked good, so I visited the tower bases. The reference tower was inspected first.

In the undergrowth at the base of the tower, I found the ATU cabinet. It had tilted, and the legs had rusted away. The cabinet was resting against the reference tower. Much of the time there was no firm contact. But, when the wind blew, the cabinet sometimes made a good contact with the tower. If the operator happened to be taking a reading at that time, then, of course, the readings were incorrect. Resetting the legs and securing the ATU cabinet cured the problem.

Know the rules

Some stations still do not maintain an up-to-date set of the FCC's rules and regulations. Although the commission no longer updates its old rules or provides them in a bound edition, they are available from other services.

There are four ways to obtain a set of the commission's rules and regulations. You can order a set of the Code of Federal Regulations, issued annually by the Government Printing Office. Order No. 47 CFR Parts 0-19, which contains part 17 tower regulations and No. 47 CFR Parts 70-79, which contains parts 73 and 74. The cost is $34.

Updated subscription services are available from three companies: Pike & Fischer, Rules Service Company and the Broadcast Service Bureau. These companies regularly update copies of the rules so you are sure to be informed about recent rule changes.

The commission expects stations to have a reasonably up-to-date copy of the rules on hand. Don't let the minor cost of obtaining them cause your station to be cited for an infraction of commission regulations.

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Satellite user's conference

By Elmer Smalling III

This year's annual satellite user's conference was held at the Infomart Center in Dallas. The event included more than 60 exhibitors of satellite paraphernalia and services as well as many papers and symposiums over the 3-day session.

Because the shuttle program has been discontinued and the backlog of military payloads and those, other than commercial satellites, that are slated for launch when the space shuttle project gets back on track, American ventures will have to rely on launching services, such as the European Arienne, the Chinese "Long March" and Japanese facilities for some time to come.

Manufacturers of satellites and space vehicles will be gearing designs to very wideband communications. These systems allow for reconfiguration by on-board software for large area or spot transmission or switched-beam data transmission. This scheme is used for the proposed advanced communications technology satellite (ACTS) being designed by TRW. The ACTS system will include TDMA digital transmission at rates from 4.8kbps to multiple T-1 (6Mbps) using 110Mbps beams, a satellite-borne switching matrix, Ka-band transmission, satellite-to-satellite laser transmission and a generation of new transmitters and receivers permitting bit-error rates as low as 10^{-6}. This technology should produce ripples that will affect broadcasters in the near future with an increase in the amount of digital transmission.

On the second day of my visit, many more exhibits were present than potential buyers. Most of the exhibits were directed at Ku-band and VSAT applications with at least two exhibitors touting launch vehicles. More European services were at this conference than at previous ones—probably because of the problems with NASA's launch capabilities.

Most of the exhibits dealing with terminals and transmission featured digital gear rather than analog video equipment. SCPC and TDMA encoders are available with data rates up to 100Mbits along with equipment for the newest communications buzz topic—*cellular data*. Systems that tie a personal computer to VSAT (very small aperture terminals) networks were shown, in the hopes that every office will be made into a mini-teleport.

If shows such as this are a barometer of the popularity of technology, C-band is becoming less popular. Of the 60-plus exhibits at the show, only a few mentioned C-band, and then only in the context of C-band/Ku-band applications.

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

New to the market

Two products stood out as being new and within the reach of most satellite communicators. One was a novel method for deicing antennas, long cable or waveguide runs, using a cable that heats up as the temperature gets lower. The cable appears similar to TV twin-lead with two conductors, separated by about ½-inch, in a poly jacket. The cable can be wrapped around horizontal runs of coax lines or waveguide, which might collect ice. It also can be fitted on the back of a dish antenna to prevent ice or snow accumulation.

The product contains a chemical substance that changes its electrical resistance with a change in temperature. The colder the temperature, the warmer the cable. As the resistance lessens between the two conductors, current flows to generate heat over the length of the cable. This simple system eliminates thermostats, controls, blowers and other elements that need attention. The deicing cable is available to operate at voltages (12V, 120V and 240V) that would normally be present at antenna sites.

The second new product shown by many of the exhibitors was the molded or stamped Ku-band off-set feed VSAT antenna. These antennas are made by processes similar to those used for home C-band dishes. The gains, apertures and illumination efficiencies are good, especially when the cost is considered. This new, inexpensive breed of offset-fed Ku-antennas is available in sizes from 0.4 meters to 3 meters. Many include simple pole-mounting units making installation easy. Most are at least 1.3 meters in diameter, thus meeting the FCC transmission requirements. The popularity of low-cost VSAT antennas will depend on the ease with which they can be pointed and mounted on the ground or on buildings.

In addition to the hardware exhibits, teleconferencing service companies were present. The relative ease of installation of VSAT antennas and the availability of many new lines of portable terminal equipment have caused service vendors to treat VSAT locations as simple LAN nodes. These service companies offer the small business conferencing and data communications with desirable features, such as high-baud rates and inexpensive use rates.

Leasing SCPC links has become an economical way to teleconference and has created much activity on many old and tired transponders. Many digital video transmission systems were shown because these systems require large transponder bandwidths and high data rates (at least 45Mbit data rates for a marginally acceptable signal or 88Mbits for high-quality video). Lower data rates require complicated algorithms that compromise some aspects of a full-motion video picture and require expensive encoding and decoding equipment. Delta coding and predictive coding are at the forefront of digital-video bandwidth compression-encoding schemes.

Editor's note: If you have a particular subject in the realm of satellite communications in which you are interested, or one that you would like explained or investigated in future columns, please write to **Broadcast Engineering**, P.O. Box 12901, Overland Park, KS 66212-9931.

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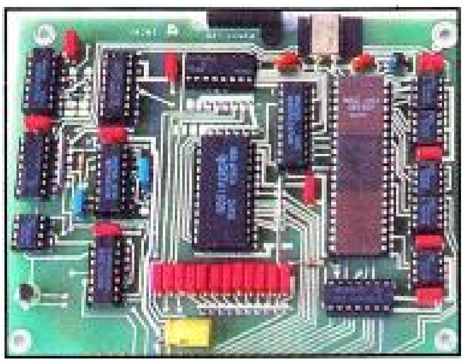
Part 14

Circuits

Inside digital technology



By Gerry Kaufhold II

Microprocessors are changing the way we use and maintain broadcast hardware. Although many different microprocessors are available today, the fundamental mode of operation can be modeled by the Z-80 microprocessor. The Z-80 has become a de facto standard for use in products that control machines in real time.

This month we will continue our examination on how the Z-80 operates. (Figure 1 of last month's column shows a typical pinout for the Z-80.)

Address and data

System control signals work in conjunction with the address lines and data lines to transfer information to and from the Z-80. The address lines set up a valid memory address on the bus.

The address bus is used for three functions: acquiring instruction operation codes from read-only memory (ROM); writing to or reading from read-write memory (RAM); and performing system input/output cycles. Typical I/O operations include the following:

- When a 16-bit address appears on the address lines, and both the MREQ and RD signals go low at the same time as M-1, then an OPCODE FETCH reads a valid Z-80 instruction from memory into the OPCODE decoder of the Z-80.
- When a 16-bit address appears on the address lines, and RD and MREQ both go low, data is read from memory into the Z-80.
- When a 16-bit address appears on the address lines, and WR and MREQ both go low while RD remains high, then data is written from the Z-80 into the selected memory location.

For input/output cycles, only the lower eight address lines are active. The upper eight lines duplicate the address selected by the lower eight. When IORQ goes low along with either RD or WR, an input/output cycle occurs.

The Z-80 family

The Z-80 family of integrated circuits includes special chips that directly connect to the Z-80 and use input/output cycles for their control. These ICs include:

- a serial input/output chip that connects to video terminals or telephone modems.
- parallel input/output chip that connects to parallel printers.
- direct memory access (DMA) controller that connects to floppy disk drives.
- counter-timer chip that provides timing signals.

Memory refresh

Two types of volatile random access read-write memory are available for use with a Z-80 system: *static* RAM and *dynamic* RAM. Static RAM memory cells comprise flip-flop circuits. Because flip-flops have two stable states, one (1) or zero (0), static RAMs will store information as long as power is applied. Static RAMs have rapid access but dissipate a large amount of energy (relatively speaking) and cannot be integrated with as many bits of storage per integrated circuit as other types of memory devices.

Dynamic RAM memory cells comprise field-effect transistors (FETs), which store a charge on the capacitance of the gate element. Dynamic RAMs run cooler than static RAMs and can be integrated many times more densely than static RAMs. Because dynamic RAMs store information on capacitive elements, they must be continually recycled or refreshed.

Charges stored in dynamic RAMs are recycled by a refresh circuit. This circuit counts through the memory space and reads the contents of each address. The circuit then rewrites the data back, thus refreshing the stored charge of each memory cell.

Refresh timing

Whenever dynamic RAM memory cells are used by the microprocessor, the cells must be available for memory access cycles from the system bus. The dynamic RAM refresh circuits must be synchronized to avoid causing delays to the microprocessor.

The Z-80 provides a signal called REFRESH, which is *active low*, and which signals to the dynamic RAM refresh circuits that the bus is clear.

In addition to providing the active low refresh signal, the Z-80 also increments its address counter onto the system address bus, and eliminates the need for the dynamic RAM refresh circuits to have a binary counter.

This complicated feature of the Z-80 is called *automatic dynamic RAM refresh*. It is one of the reasons why the Z-80 is so popular among designers of microprocessor systems.

An unfortunate side effect of automatic dynamic RAM refresh is that the address bus becomes very busy. For the technician trying to analyze a Z-80-based computer system, it might appear that a lot of extraneous signals are flying around.

When using a multiple-channel logic analyzer to view signals on a Z-80 system, it is important to remember that the Z-80 performs automatic dynamic RAM refresh continually. Depending on the capabilities of the logic analyzer, there may be ways to define the triggering setup so that the automatic dynamic RAM refresh signals will not be displayed, even though the signals are running all the time.

For those users who are limited to the use of an oscilloscope, the parallel system bus in a Z-80-based computer system may be nearly impossible to troubleshoot in the field.

If you thought automatic dynamic RAM refresh muddied up the waters, next month we will look at *interrupts*.

Kaufhold is an independent consultant located in Tempe, AZ.

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Today, after hundreds of hours of discussion and study, the standard finally exists that will allow receiver manufacturers to increase and flatten their frequency response without risk of increased interference. But for them to do this, broadcasters must implement the standard: a "modified 75μs" pre-emphasis specification brightens up the sound on older radios while minimizing interference to adjacent stations, while a sharp-cutoff 10kHz low-pass filter specification protects the second adjacencies by limiting occupied bandwidth.

Receiver manufacturers have stated their willingness to replace their current AM receiver designs (with their telephone-quality fidelity) with AM receivers having full 10kHz frequency response—but *only* if and when the NRSC standard is fully adopted by broadcasters. For the NRSC standards to be successful, broadcasters must change over *quickly*. If the new high-fidelity receivers generate complaints of interference caused by stations not complying with the new standard, the receiver manufacturers will revert back to the present low fidelity 3kHz designs! *Everyone* will lose.

Orban was the first to propose and implement AM pre-emphasis and low-pass filtering, and we were heavily involved in the Committee work and research. We strongly endorse the new NRSC standard. It's good engineering *and* good business, and we are making it easy for all OPTIMOD-AM owners to comply.

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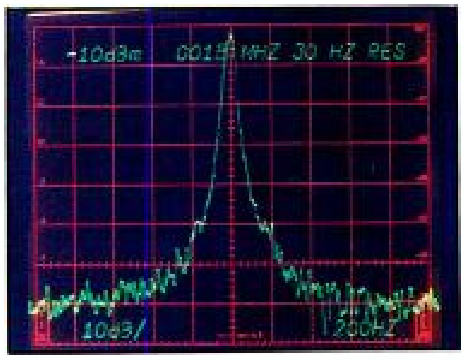
Part 4

Troubleshooting



Maintaining switching power supplies

By Gerry Kaufhold II

The key to troubleshooting switch-mode power supplies lies in understanding how they operate. Despite their apparent complexity, when viewed as individual circuits operating within one system, troubleshooting is easier.

In last month's column, we presented a simplified block diagram of a switching power supply (Figure 1). The four major elements of the system are:

- the ac-line input stage.
- regulated output supply.
- low-voltage power supply.
- the system control unit.

Refer to Figure 1 in last month's column as we continue our examination of how a switching power supply operates, and how to service it when a failure occurs.

Control stage

Input to the control stage (section D) is taken from one of the dc output lines and fed to an error amplifier through an isolating device. This signal may be derived from a *sense winding* of the transformer or via an opto-isolator. The error amplifier compares this feedback voltage against a known reference. The pulse-width modulator varies the on and off times of the power transistor and thereby determines the output voltage of the supply.

The base drive circuitry that feeds the control pulses to Q1 can become quite involved and accounts for much of the complexity of a line-operated, switch-mode power supply. Instead of applying an excess of drive current to push Q1 into heavy saturation, modern power-supply designs act as tuned circuits. In order to obtain maximum efficiency during the turn-on and turn-off periods, base drive current must follow the characteristics of the power-handling devices used (the switching transistor and inductor).

When troubleshooting such supplies, use an oscilloscope camera (one that is operating properly, if available) to photograph the base drive waveform of the unit under test. Some power-supply maintenance manuals also provide waveforms for reference.

Kaufhold is an independent consultant located in Tempe, AZ.

Planning for maintenance

Whenever new equipment is purchased, incoming inspection tests should be performed and the results documented before the equipment is installed. This is especially true for equipment that contains a switching power supply or any switching-regulator circuitry.

Unfortunately for broadcast engineers, most equipment that contains a switching supply will not include a schematic diagram or a theory of operation description, because the supply is an OEM (original equipment manufacturer) module that the broadcast manufacturer specified for production.

Many OEM switching power-supply units contain proprietary circuit designs, custom integrated circuits or other parts that are not readily identifiable. Furthermore, some switching power-supply modules are potted in epoxy and simply cannot be repaired. This is particularly frustrating to a maintenance engineer who knows that a supply can be fixed, but must return it and pay for factory repairs because of inadequate documentation.

Photocopying this series of articles and keeping them along with the equipment manuals would make good sense. Also, attaching a table of test results to each copy of the equipment technical manuals will help when you try to determine what to do with a failed switching power supply.

Incoming inspection

The importance of verifying the operation of equipment before installing it in a broadcast plant cannot be overstated. Even though it is often tedious, there is no better way to train yourself on how to use and repair equipment than to go through the gear carefully while it is new and operating properly. Furthermore, station management should insist that all new equipment be verified for proper operation immediately upon receipt.

Begin the tests by inspecting the power supply. This portion is often neglected because engineers assume they know how a power supply works. But power-supply technology is on the move, just like video editing, automation systems, cameras and everything else. You might be surprised to find yourself behind the times in power-supply design.

Get out your oscilloscope and DVM. Power up the supply and take readings of waveforms and voltages at all available test points. Set up the equipment to operate as it will be used when installed.

Troubleshooting a supply

Problems may eventually occur with any design of switching power supply and the best way to prepare for trouble is to understand how the circuit works and to stock the necessary spare parts. It is unrealistic to have a replacement part for every component in a power supply. You might just as well buy another supply to put on the shelf. However, by analyzing what parts may be prone to failure, a logical decision on what spare parts to stock can be made.

Begin by looking at the primary power-handling devices including:

- ac rectifier diodes.
- power transistors.
- switching-supply filter capacitor(s).
- control-system integrated circuit(s).
- switching-supply inductor.

Power semiconductor devices generally fail in either an open or short circuit. They are usually easy to spot during troubleshooting of the system. The transistors are chosen for fast turn-on, high-voltage breakdown characteristics and current switching capability.

Diodes used for the switching sections of a switching power supply are chosen for their capability to handle large forward currents and for fast-switching speeds from full-forward conduction to cutoff. Neither high-current capacity nor reverse recovery speed can be measured with a DVM diode checker.

The best preparation for troubleshooting is to order a stock of direct replacement power transistors and diodes. Be cautious when using general-purpose replacement semiconductors in a switching supply.

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Management for engineers

Managing upward

By Brad Dick, radio technical editor

Many people dream of moving up the corporate ladder or moving into another career field. They often seek higher positions for both money and prestige. Others simply want to make a lateral move into another field. The important element here is not whether the move is up or over, but whether the move is part of an overall plan.

Fill in the following blank. I want to be ________________ (name a position you would like to have). Now that you've identified the position you really want, what are you going to do about it?

Career planning

If you want to be successful in your career, it is important to know where you're going. Thirty years ago, people expected to remain in the same job for a lifetime. By the age of 30 or so, people were expected to have selected a job they liked (or could tolerate) and remain in that position or field until retirement. Today, much more career movement is tolerated and even expected.

Work toward the goal

After you've set your goal, it's important to begin working toward it. Step one is to give more than 100% effort. No one is going to promote a person who is not working to capacity. If you want a promotion, get noticed by working hard.

Step two is to train your successor. A mistake often made by supervisors (and others) is to assume that they are the only ones capable of doing their job. Consequently, they don't train anyone else to fill in. Then when it comes time for promotions, they are often overlooked. These supervisors have figuratively "dug themselves into a hole."

You can avoid such a problem by finding someone qualified to take your place. Don't view this person as a threat, but rather as an important element in your plan to get promoted. A willing successor also can help reduce your workload, thus freeing you to complete those special tasks, which may get you noticed.

Move over

Although promotions usually involve upward mobility, every career move need not be up the corporate ladder. In some instances, it may be more advantageous to move laterally. Let's examine a couple of instances where this might be true.

If your boss is firmly entrenched in the position, and has no desire to move, it's probably better for you to attempt a lateral move. Attempting to take your supervisor's job is risky at best. The drawbacks of losing such a quest are obvious.

In such a case, it's generally best to move around your supervisor by transferring to another department. Although this may seem like a lot of trouble, this tactic has an important advantage. A lateral move often allows you to acquire new skills, which may be needed later. For instance, if you want to be director of engineering at a TV station, you will need more than maintenance skills to be successful. Ask yourself what duties at the station would develop or emphasize your managerial skills.

A lateral move also can shift you into a different market. A person's range of experience is sometimes as important as depth of experience. For instance, someone who has held a variety of positions or worked in various environments may have an advantage over someone who has held the same job in the same company for many years.

Socialize

Socializing with various company groups cannot be overemphasized. This doesn't mean that you have to be the life of a party. It means that you need to meet the people who are important to your future. Group sports activities are excellent ways to make friends outside your normal working area.

If possible, also contact them on company time. Learn how they do their jobs, the language they use and their terms and issues. You need to be able to discuss and identify the key elements if you want to move into another area.

Asking for the promotion

Some of the same concerns we discussed when asking for a raise also apply to asking for a promotion. Be sure you have a current resume and that your supervisor is fully informed about your previous work.

Make your request at the appropriate time. Your company should be in good financial condition and you should have trained your successor. Choose a time when your boss is likely to be in a good mood and has time to discuss your request. If your supervisor is dealing with other important issues, wait for a better time. Review our discussions on identifying your boss's characteristics. (See July's column.) Use that knowledge to your advantage.

Present your case for a promotion much the same as you would when asking for a raise. Don't demand an immediate response, but let your supervisor give the proposition careful consideration.

Success

After you receive that well-deserved promotion, don't relax on the job. A number of people may have been involved in granting you that job and they may be looking closely at how you perform in the new position. Redouble your efforts and show that you appreciate the opportunity to advance and are willing to give that extra effort.

Next time you begin to feel trapped in your position, look around. There may be some exciting new opportunities in your own back yard. Even if your chances for advancement are limited within your company, the steps you take to get noticed can be applied outside to other organizations.

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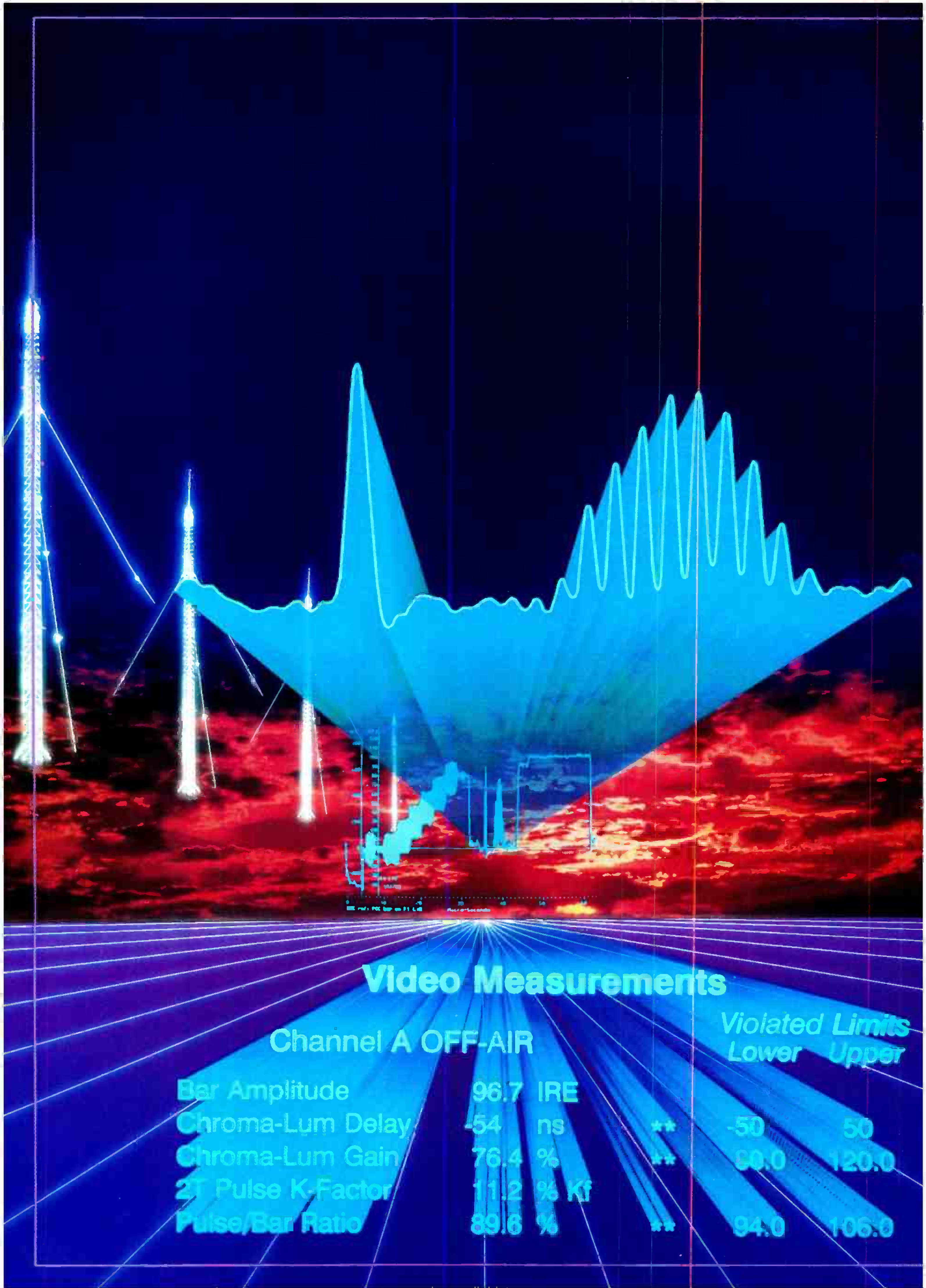
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4th annual station maintenance special

When a problem occurs, the maintenance engineer is in the hot seat.

Everyone at a broadcast station accepts the fact that, from time to time, equipment will fail. No piece of equipment is perfect, and no operator is perfect. Problems will occur because of routine component wear, operator error or outside forces such as lightning or other forms of severe weather. We all accept that these things are possible. But, when the inevitable comes, everybody's view of the situation changes.

Whether failures at a broadcast plant are minor or catastrophic, they evoke strong emotions from most of the people connected with the on-air product. Radio and TV broadcasting is an equipment-based profession. The end-product of any station is vulnerable to dozens of potential failure points that can delay a program, ruin an afternoon's work or lose a historic event that cannot be recreated.

Such is broadcasting, and such are the reasons behind our obsession with equipment reliability. Yes, equipment can break, but it must not break.

Enter the maintenance department. The job of a maintenance engineer at a broadcast station can be compared to that of an airline pilot. The pilot's job has been described as "hours of boredom punctuated by moments of sheer terror." For engineers, the boredom is the routine maintenance of cleaning equipment, making measurements, checking possible failure points, filling out reports and processing other paperwork. The terror occurs when something breaks.

Even the most rational and patient producer, director or engineering VP can be transformed instantly into a wild-eyed bundle of nerves when confronted with an equipment failure. By the time the maintenance engineer gets to the scene, the job ahead involves both an electronic and human element.

This month, in our 4th annual Station Maintenance Special Report, we examine vital areas of equipment reliability and maintainability. Our report includes the following articles:

The key to preventing problems is to understand what can cause a system to fail. The key to troubleshooting a problem after it has occurred is to know your test equipment. We examine both of these important topics this month.

Jerry Whitaker,
editorial director

1

Controlling ac line disturbances

Transient overvoltages represent the greatest single threat to equipment reliability.

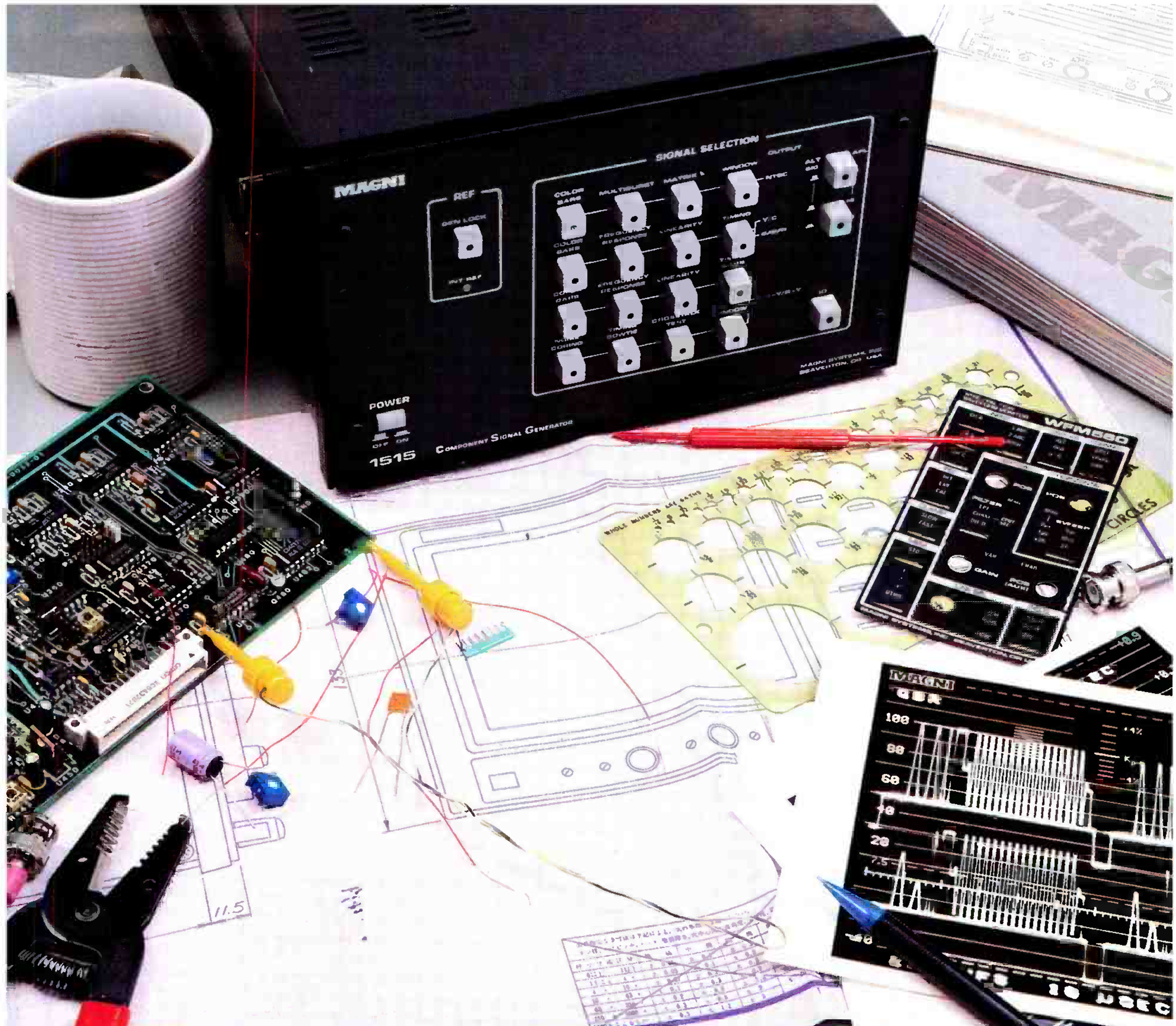
Transient disturbances are what headaches are made of. Whatever you call them—spikes, surges or power bumps—they can take you off the air and leave you with a complicated and expensive repair job.

During my years as a chief engineer, I held my breath every time a lightning storm rolled into town. Every time the lights flickered at the studio, I froze. Sound familiar?

Ensuring that the equipment at your station receives clean ac power has always been important. But now, with microcomputers being integrated into a wide variety of broadcast products, the question of ac power quality is more critical than ever. The high-speed logic systems prevalent today can garble or lose data because of power-supply disturbances or interruptions, causing problems to show up on air, or even causing your transmitter to crash. And if the on-air problems aren't enough, there's the usually difficult task of equipment troubleshooting and repair that follows a utility-system power fault.

Protection against transient disturbances is a science that demands attention to detail. This work is not inexpensive. It is not something that you can do overnight. You will, however, wind up paying for transient protection one way or another, either *before* you have problems or *after* you have problems. In the world of transient protection, there is truly no such thing as a free lunch.

Lightning provides the most dramatic demonstration of the damage potential of overvoltage disturbances at a broadcast plant. Equally damaging transients can, however, be generated by utility-company switching or distribution-system faults. (Photo courtesy of Visual Horizons/FPG.)



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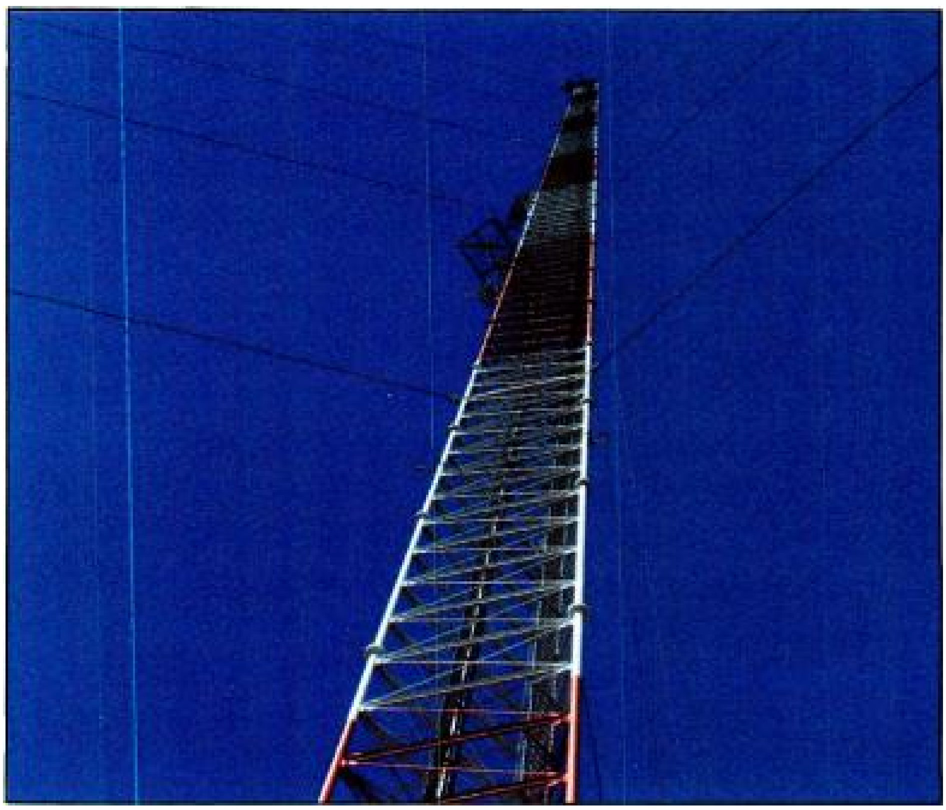
The scope of the problem

Transient protection is a good news, bad news situation. First, the bad news.

Every electronic installation requires a steady supply of clean power in order to function properly. The ac power line into a broadcast plant is, in fact, its lifeblood. It is also, however, a frequent source of equipment malfunctions and component failures. The first step in solving the problem is to find out how bad it is.



Broadcast towers make excellent lightning rods. Only through proper grounding and surge suppression can you protect sensitive equipment from damage.

Assessing the threat

The utility company feed into a broadcast plant contains not only the 60Hz power needed to run the facility, but also a variety of voltage abnormalities. These disturbances cause different types of problems for different types of equipment.

Figure 1 shows the four major classifications of short-term, ac-voltage disturbances. The generally accepted definitions for these disturbances are:

- *Voltage surge*—An increase of 10% to 35% above the normal line voltage for a period of 16ms to 30s.
- *Voltage sag*—A decrease of 10% to 35% below the normal line voltage for a period of 16ms to 30s.
- *Transient disturbance*—A voltage pulse of high energy and short duration impressed upon the ac waveform. The overvoltage pulse may be one to 100

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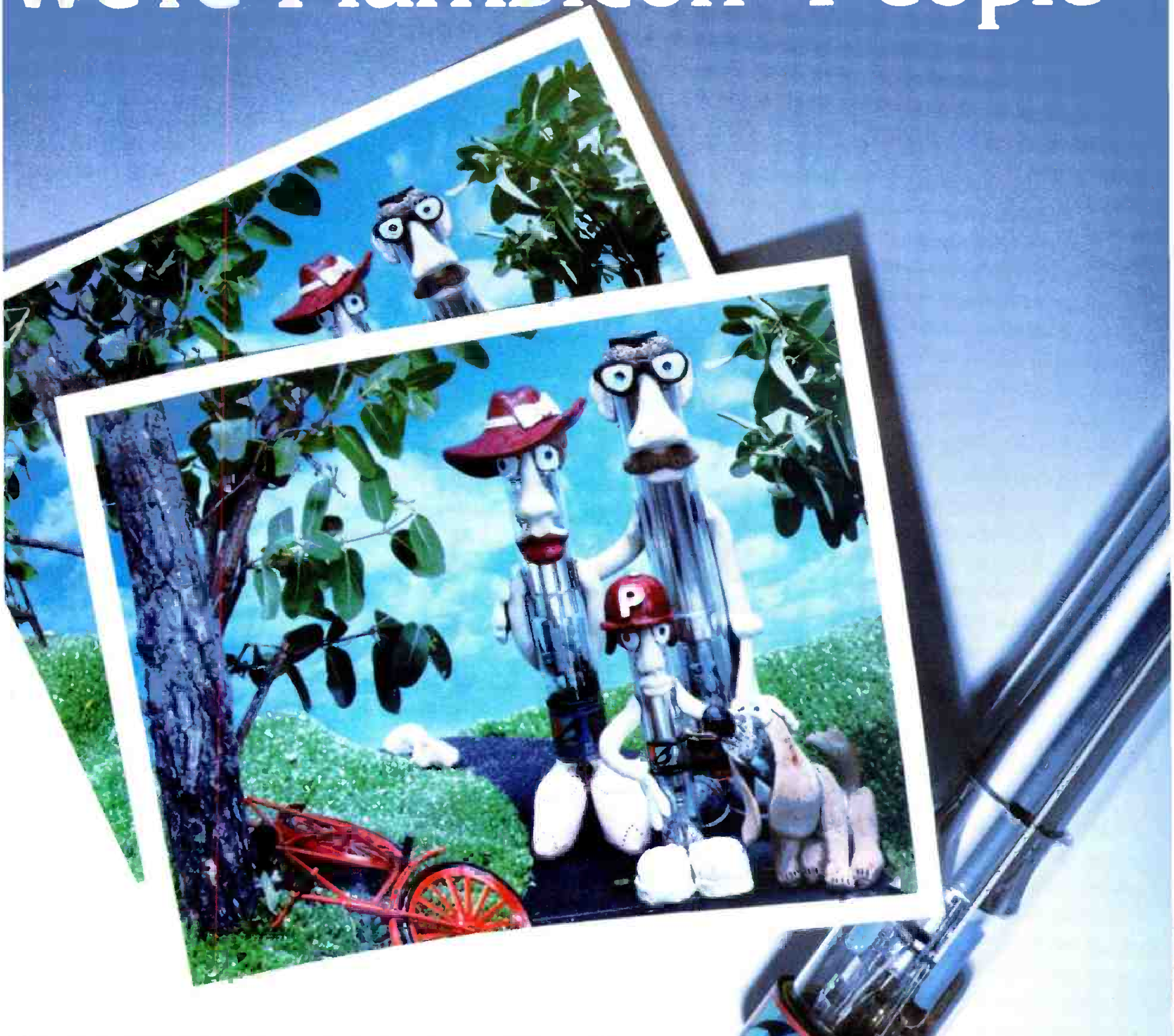

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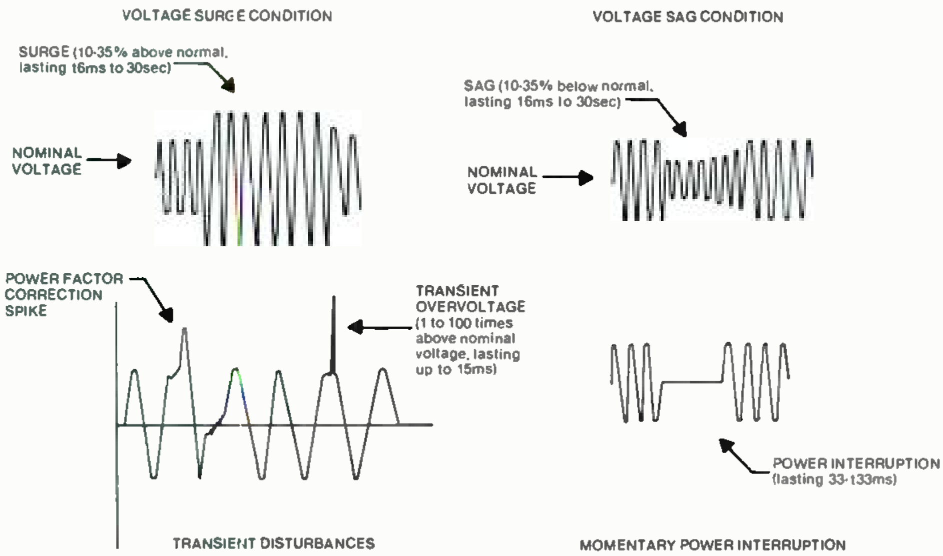

Figure 1. The four basic classifications of short-term power-line disturbances.

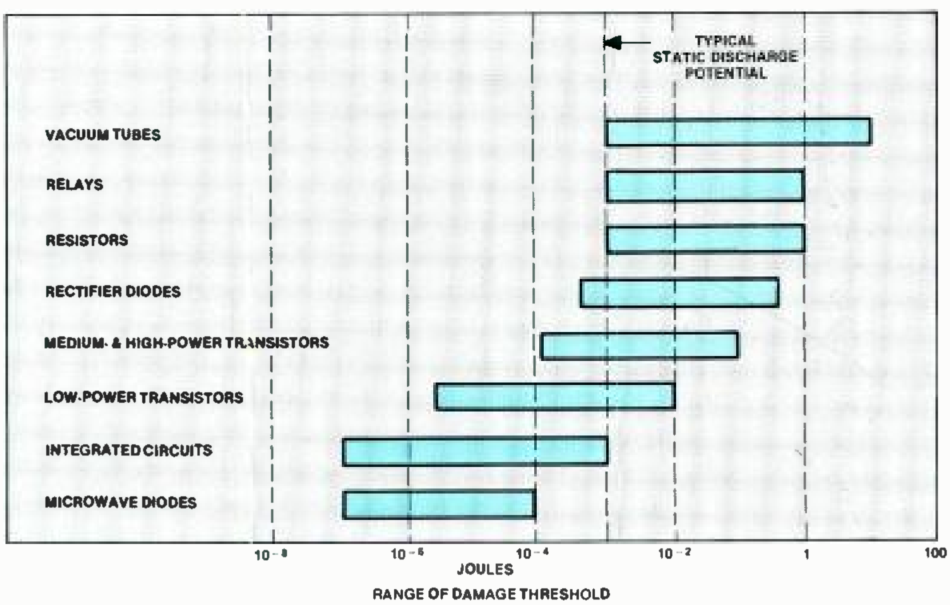

Figure 2. An estimation of the susceptibility of common electrical devices to damage from transient disturbances. The vertical line marked "static discharge" represents the energy level of a discharge that typically can be generated by touching a piece of equipment after walking across a carpeted floor. (Reference 1.)

DEFINITION	TYPE 1 Transient and oscillatory overvoltage	TYPE 2 Momentary undervoltage or overvoltage	TYPE 3 Power outage
CAUSES	Lightning, power network switching, operation of other loads	Power system faults, large load changes, utility company equipment malfunctions	Power system faults, unacceptable load changes, utility equipment malfunctions
THRESHOLD*	200 to 400% of rated RMS voltage or higher (peak instantaneous above or below rated RMS)	Below 80-85% and above 110% of rated RMS voltage	Below 80-85% of rated RMS voltage
DURATION	Spikes 0.5 to 200μs wide and oscillatory up to 16.7ms at frequencies of 200Hz-5kHz and higher	From 4 to 60 cycles depending on type of power system distribution equipment	From 2 to 60 seconds if correction is automatic; from 15 minutes to 4 hours if manual

*The approximate limits beyond which the disturbance is considered to be harmful to the load equipment.

Table 1. The types of voltage disturbances identified in the Key report.

times the normal ac potential and may last up to 15ms. Rise times can measure as short as 1ns.

- *Momentary power interruption*—A decrease to zero voltage of the ac power-line potential, lasting from 33ms to 133ms. (Longer-duration interruptions are considered power outages.)

Voltage surges and sags occasionally result in operational problems for equipment on-line, but automatic protection or correction circuits generally take appropriate actions to ensure that there is no equipment damage. Such disturbances can, however, garble computer system data if the disturbance *transition time* (the rise or fall time of the disturbance) is sufficiently fast. System hardware also may be stressed if there is only a marginal power-supply reserve or if the disturbances are frequent.

Momentary power interruptions can cause a loss of volatile memory in computer-driven systems and place severe stress on hardware components, especially if the ac supply is allowed to surge back automatically without *soft-start* provisions. Successful system reset may not be accomplished if the interruption is sufficiently brief.

Although voltage sags, surges and momentary interruptions can cause operational problems for equipment used today, the possibility of complete system failure because of one of these mechanisms is relatively small. The greatest threat to the proper operation of broadcast equipment rests with transient overvoltage disturbances on the ac line.

Transients are difficult to identify and difficult to eliminate. Many devices commonly used to correct sag and surge conditions, such as ferroresonant transformers or motor-driven autotransformers, are of limited value in protecting a load from high-energy, fast rise-time disturbances on the ac line. If not attenuated, these brief pulses, which sometimes last only a few microseconds, can destroy semiconductors, disturb logic operations or latch up microcomputer routines.

In the computer industry, the majority of unexplained problems resulting in disallowed states of operation actually are caused by transient disturbances on the utility feed. With the increased use of microcomputers in broadcasting, this warning cannot be ignored. The threat to broadcast facilities is compounded because microcomputers are being used at critical stages in the transmission chain, including program-automation equipment and transmitter-control systems.

Because of the high potential that transient disturbances typically exhibit, they not only cause data and program errors but also can damage or destroy electrical components. This threat involves sensi-

Type of disturbance	UPS system and standby generator	UPS system	Secondary spot network[1]	Secondary selective network[2]	Motor-generator	Shielded isolation XFMR	Suppressors, filters, lightning arresters	Solid-state line-voltage regulator
1	All source transients	All source transients	None	None	All source transients	Most source transients	Most transients	Most source transients
	No load transients	No load transients			No load transients	No load transients		No load transients
2	All	All	None	Most	Most	None	None	Some depending on response time of system
3	All	All outages shorter than battery supply discharge time	Most	Most	Only brown-outs	None	None	Only brown-outs

NOTES
1. Dual power feeder network
2. A dual power feeder network using a solid-state switch to select which line is fed to the load.

Table 2. *The types of systemwide protection equipment available to broadcasters and the ac line abnormalities that each approach is capable of handling.*

tive integrated circuits and many other common devices, such as capacitors, transformers, rectifiers and power semiconductors. Figure 2 illustrates the vulnerability of common components to high-energy pulses. What's more, the effects of transient disturbances on electronic devices are often cumulative, resulting in gradual deterioration and, ultimately, catastrophic failure.

Protection alternatives

Most utility companies make a good-faith attempt to deliver clean, well-regulated power to their customers. Most disturbances on the ac line are beyond the control of the utility company. Large load changes imposed by customers on a random basis, power-factor correction switching, lightning and accident-related system faults all combine to produce an environment in which tight control over ac power quality is, at best, difficult to maintain. Therefore, the responsibility for ensuring ac power quality must rest with the user of the sensitive equipment.

The selection of a protection method for a given facility is as much an economic question as it is a technical one. A wide range of power-line conditioning and isolation equipment is available. A logical decision about how to proceed can be made only with accurate, documented data on the types of disturbances typically found on the ac power service to that facility. This data can be gained from a power-quality survey, available from a number of consulting firms and power-conditioning companies. The typical procedure involves installing a sophisticated voltage-monitoring unit at the site for several weeks. During that time, data is collected on the types of disturbances the load equipment is likely to experience.

The type of monitoring unit used is of critical importance. It must be a high-speed system that stores disturbance data in memory and delivers a print-out of the data on demand. Slow-speed chart recorders, used by many utility companies, are too slow and lack sufficient sensitivity to accurately show short-duration

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Basis of comparison[1]	UPS system and standby generator	UPS system	Dual power feeders	Motor-generator	Shielded isolation XFMR	Suppressors, filters, lightning arresters	Solid-state line-voltage regulator
Installation and equipment costs	$1500 to $2000 per kVA	$1100 to $1500 per kVA	Installation cost will vary greatly depending on site	$250 to $400 per kVA	$50 to $150 per kVA	$1 to $10 per kVA	$250 to $280 per kVA
Maintenance costs	$2000 to $4000 per year	$1100 to $3000 per year	None	Less than $1000 per year	None	None	Less than $1000 per year
Operating efficiency[2]	80-85%	80-85%	100%	80-90%	Up to 98%	100%	90-98%

NOTES
1. A power conditioning system rated for approximately 25kVA is assumed.
2. Efficiency applies to the ac power conditioning equipment only. Losses in environment support systems are not taken into account.

Table 3. *The approximate cost of systemwide protection equipment installation and operation. Equipment prices can vary considerably depending on the hardware chosen.*

voltage disturbances. Chart recorders can confirm the presence of long-term surge and sag conditions (of 10s or more), but provide almost no useful data on transients.

The protection equipment chosen must be matched to the problems that exist on the line. Using inexpensive basic protectors may not be much better than operating directly from the ac line. Conversely, the use of a sophisticated protector designed to shield the plant from every conceivable power disturbance may not be economically justifiable.

Purchasing the transient-suppression equipment is only one element in the selection equation. Consider the costs associated with site preparation, installation and maintenance. Also consider the operating efficiency of the system. Protection units that are placed in series with the load consume a certain amount of power and, therefore, generate heat. These items may not be significant, but they should be taken into account. Prepare a complete life-cycle cost analysis of the protection methods proposed. The study may reveal that the long-term operating expense of one system outweighs the lower purchase price of another.

Dollars and sense

The amount of money a broadcaster is willing to spend on protection from utility-company disturbances generally depends on the engineering budget and how much the station has to lose. Spending $25,000 on systemwide protection for a major-market station, where spot rates can run into the hundreds or thousands of dollars, is easily justified. At small- or medium-market stations, justification is not so easy.

Electronic equipment's susceptibility to failure because of disturbances on the ac power line has been studied by many organizations. The bench mark study to date was conducted by the Naval Facilities Engineering Command (Washington, DC). The far-reaching program, directed from 1968 to 1978 by Lt. Thomas Key, identified three distinct categories of recurring disturbances on utility-company power systems. As shown in Table 1, it is not the magnitude of the voltage, but the duration of the disturbance, that determines the classification.

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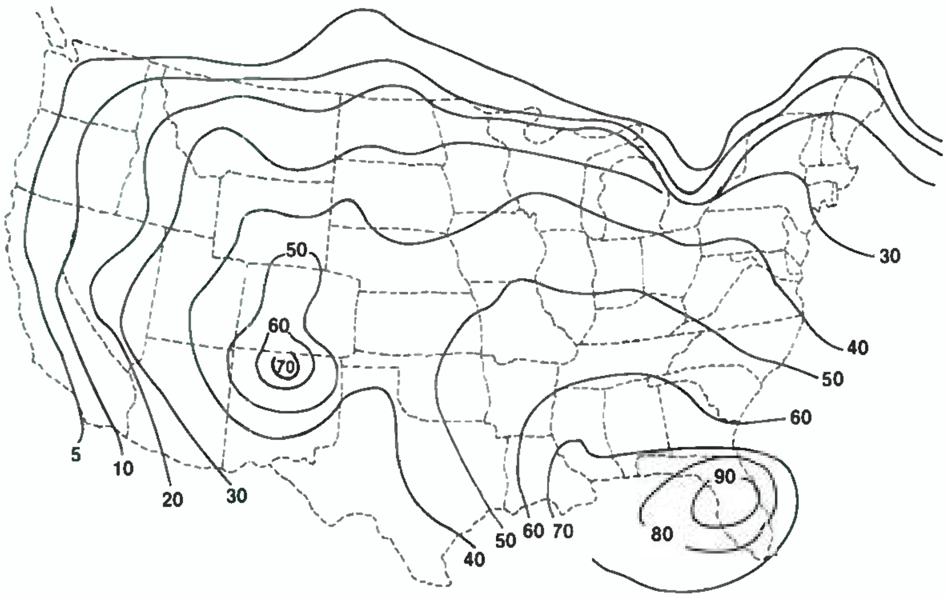

Figure 3. The Isokeraunic map of the United States, showing the approximate number of lightning days per year.

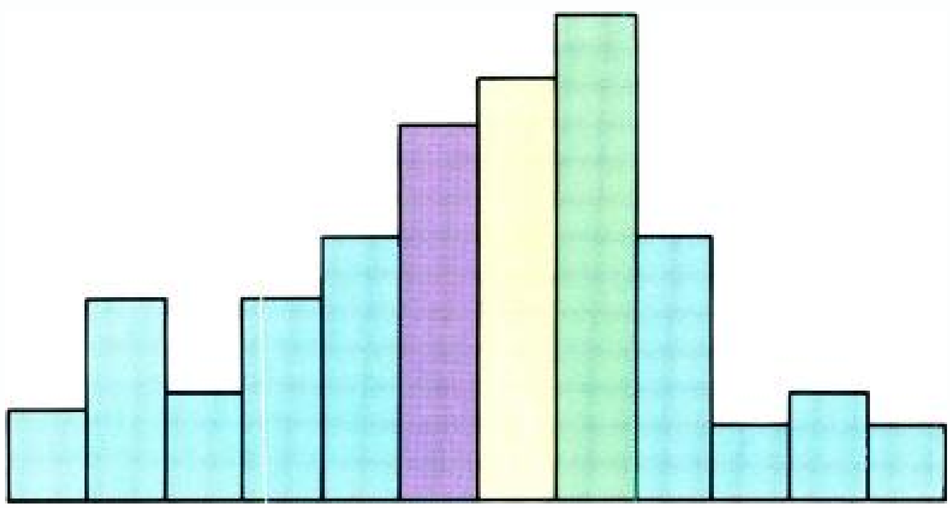

Figure 4. The relative frequency of power problems in the United States, classified by month. (Reference 1.)

In the study, Key found that most equipment (in this case, computer) failure caused by ac line disturbances occurred during bad weather. According to a report on the findings, the incidence of thunderstorms in an area may help to predict failures.

The type of power-transmission system used by the utility company also affects the number of disturbances observed on power-company lines. For example, an analysis of utility-system problems in Washington, DC, Norfolk, VA, and Charleston, SC, showed that underground power-distribution systems experienced one-third fewer failures than overhead lines in the same areas.

Tables 2 and 3 show the options available to station engineers to protect sensitive broadcast equipment from ac line disturbances. Approximate costs for that protection also are listed. Because each installation is unique, conduct a thorough investigation of the station's needs before purchasing equipment.

Assessing the lightning hazard

As identified by Key in his Naval Facilities study, the extent of lightning activity in an area significantly affects the probability of equipment failure caused by transient activity. The threat of a lightning strike to a facility is associated with the installation and its location. The geographic location, type and character of the facility, size of the plant and character of the lightning strike all are important factors.

The *Keraunic number* of a geographic location represents the likelihood of lightning activity in that area. Figure 3 shows the *Isokeraunic map* of the United States, which estimates the number of lightning days per year in various areas of the country. On the average, 30 storm days occur per year across the continental United States. This number does not fully describe the lightning threat because many individual lightning strikes occur during a single storm.

The structure of a facility has a significant effect on the lightning threat to equipment operation. Higher structures tend to collect and even trigger lightning strikes. Because storm clouds tend to travel at specific heights above the earth, conductive structures in mountainous areas more readily trigger lightning activity.

The *plant exposure factor* is a function of the size of the facility and the Isokeraunic rating of the area. The larger the physical size of an installation, the more likely it is to be hit by lightning during a storm. The longer a transmission line (ac or RF), the more lightning strikes it is likely to receive.

The character of a lightning strike covers a wide range of voltage, current and rise-time parameters. Making an accurate estimate of the damage potential of a strike is difficult.

A direct hit to a utility power line causes a high-voltage, high-current wave to travel away from the point of the hit in both directions along the power line. The waveshape is sawtooth with a rise time measured in microseconds or nanoseconds. The pulse travels at nearly the speed of light until it encounters a significant change in line impedance. At this point, it is reflected back down the line in the direction from which it came.

This action creates a standing wave containing the combined voltages of the two original pulses. A high-energy wave of this type can reach potential sufficient to arc over to another parallel line, a distance of about eight feet on a local feeder (typically 12kV) power pole. Not surprisingly, such energy can have devastating effects on electronic equipment.

The relative frequency of power problems appears to be seasonal in nature. As shown in Figure 4, most problems are noted during June, July and August. These high problem rates can be traced to increased thunderstorm activity and heavy, unpredictable air-conditioning loads in the summer months. **BE**

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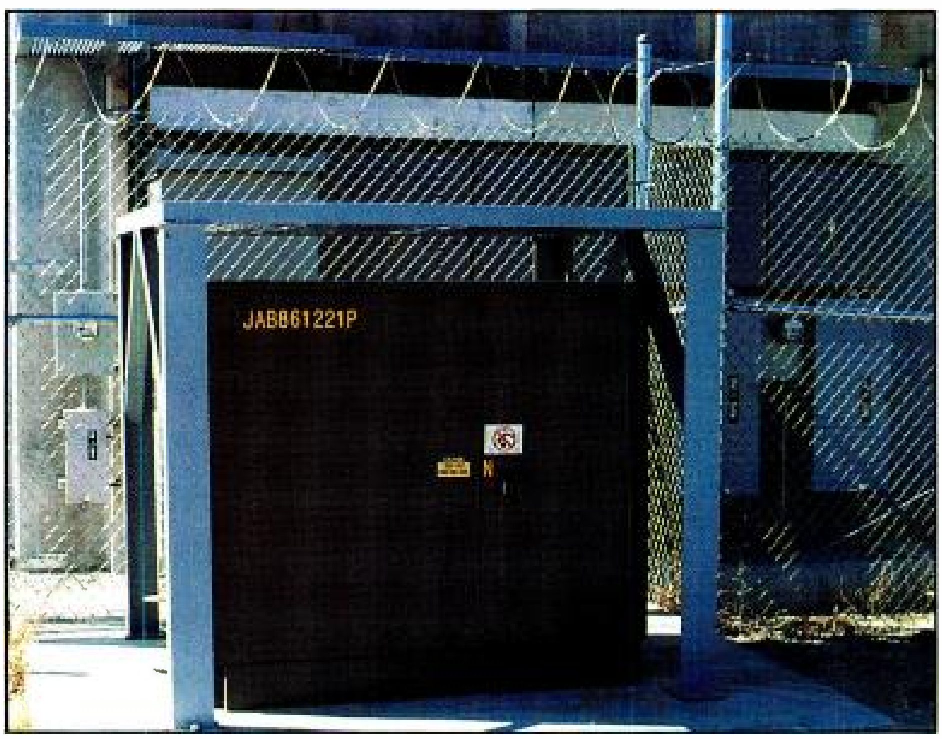
Facility-protection methods

Effective transient control requires attention to all elements in the broadcast plant.

Proper grounding of equipment and structures at a broadcast facility is basic to protection against ac line disturbances. This applies whether the source of the disturbance is lightning, power-system switching activity or a fault in the distribution network. Regardless of the protection approach, all protective devices and systems require a solid, low-impedance earth ground to operate properly. Grounding is important at both the studio and the transmitter plant. Probably the greatest challenge to proper grounding is a mountain-top transmitter.

Typical installation

The grounding arrangement for a remotely located grounded-tower (FM or TV) transmitter plant generally follows the guidelines shown in Figure 5. The tower and guy wires are grounded using 10-foot-long, copper-clad ground rods. The antenna is bonded to the tower, and the transmission line is bonded to the tower at the point where it leaves the structure and begins the horizontal run into the transmitter building. Before entering the structure, the line is bonded to



Most of the transient disturbances in a plant will come from the utility-company ac power line. Take precautions to stop these disturbances from entering your facility.

a ground rod through a connecting cable. The transmitter itself is grounded to the ac power-distribution-system ground, which, in turn, is bonded to a ground rod where the utility feed enters the building.

The design goal of this arrangement is to strip all incoming lines of damaging overvoltages before they enter the facility. One or more lightning rods are mounted at the top of the tower structure. The rods extend at least 10 feet above the highest part of the antenna assembly.

The grounding configuration shown in Figure 5, although commonly found at many installations, has built-in problems that can make it impossible to provide adequate transient protection to equipment at the site. Look again at the Figure 5 example. To equipment inside the transmitter building, two grounds actually exist: the utility-company ground and the antenna ground. One ground will have a lower resistance to earth, and one will have a lower inductance in the connecting cables or copper strap from the equipment to the ground system. Assume that a transient overvoltage enters the utility-company meter panel from the ac service lines. The overvoltage is clamped by a protection device at the meter panel, and the current surge is directed to ground. But *which ground*, the utility ground or the antenna ground?

The utility ground surely will have a lower inductance to the current surge than will the antenna ground, but the antenna probably will exhibit a lower resistance to ground than the utility side of the circuit. Therefore, the surge current will be divided between the two grounds, placing the transmission equipment *in series* with the surge suppressor and the antenna ground system. A transient of sufficient potential will damage the transmission equipment.

Transients generated on the antenna side because of a lightning discharge are no less troublesome. The tower is a conductor, and any conductor is also an inductor. A typical 150-foot self-supporting tower may exhibit as much as $40\mu H$ inductance. During a fast rise-time lightning strike, an instantaneous voltage drop of 360kV between the top of the tower and the base is not unlikely. If the coax shield is bonded to the tower 15 feet above the earth (as shown in Figure 5), 10% of the tower voltage drop (36kV) will exist at that point during a strike. The only way to ensure that damaging voltages are stripped off all incoming cables (coax, ac power and telephone lines) is to use a *bulkhead entrance panel*.

Bulkhead panel

The concept of the bulkhead is simple: Establish one reference point to which all cables entering the equipment building are grounded and to which all transient-suppression devices are mounted. Figure 6 shows the basic approach.

The bulkhead panel size depends on the spacing, number and size of the coaxial lines entering the building through the plate. The panel should be made of copper or brass. Do not use steel, unless it is stainless steel (18-8 type or the equivalent). To provide a weatherproof point for mounting transient-suppression devices, you can modify the bulkhead so that you have a subpanel, as shown in Figure 7. The subpanel, attached so that it protrudes through an opening in the wall, creates a secondary plate on which suppressors are mounted and grounded. To handle the currents that may be experienced during a lightning strike, the

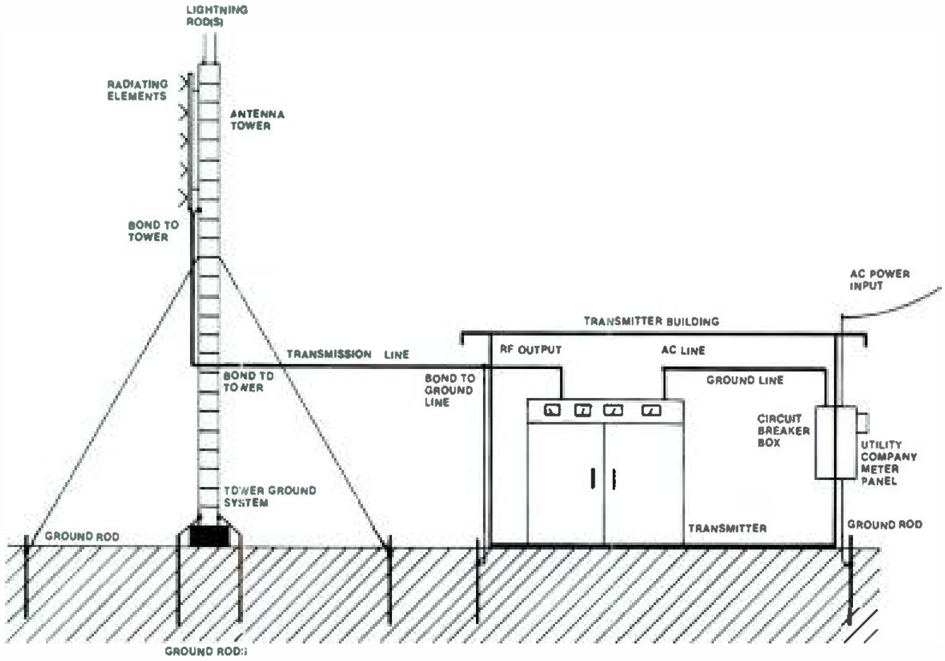


Figure 5. *The typical, but not ideal, grounding arrangement for a transmission facility using a grounded tower. A better configuration involves the use of a bulkhead panel through which all cables pass into and out of the equipment building.*

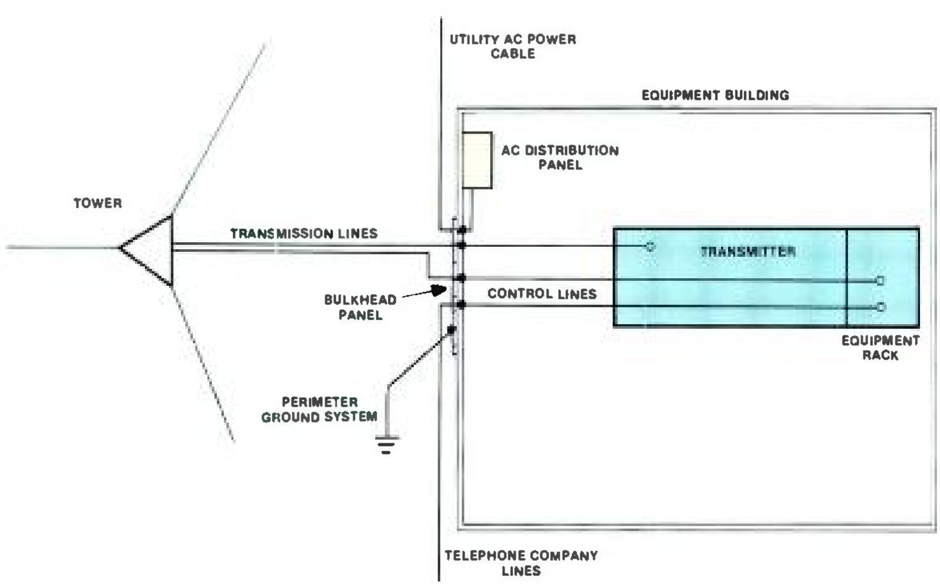


Figure 6. *The basic design of a bulkhead panel for a transmission facility. (Reference 2.)*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bottom-most subpanel flange (which joins the subpanel to the main bulkhead) must have a total surface-contact area of at least 0.75 square inches per transient suppressor.

Because the bulkhead panel will carry significant current during a lightning strike or ac line disturbance, it must be constructed of heavy material. The recommended material is ⅛-inch C110 (solid copper) ½ hard. This type of copper stock weighs nearly 5½ pounds per square foot and sells for about $2.25 per pound. Installing a bulkhead is an expensive job, but one that will pay dividends for the life of the facility. Use 18-8 stainless-steel mounting hardware to secure the subpanel to the bulkhead.

Because the bulkhead establishes the central grounding point for all equipment in the building, it must be tied to a low-resistance (and low-inductance) perimeter ground system. Ideally, the bulkhead panel will extend down the side of the building and tie into the perimeter ground below grade level. This will result in the lowest resistance and inductance to earth ground.

Checklist for proper grounding

Follow a logical series of steps to ensure that the needed protection can be achieved at the broadcast plant:

1. Install a bulkhead panel to provide mechanical support, electrical grounding and lightning protection for coaxial cables entering the equipment building.
2. Install an internal ground bus using No. 2 or larger solid-copper wire. (At transmission facilities, use copper strap that is at least three inches wide.) Form a "star" grounding system. At larger installations, form a "star-of-stars" configuration. Do not allow ground loops to exist in the internal ground bus. Connect the following items to the building internal ground bus: chassis racks and cabinets of all equipment and all auxiliary equipment (chargers, switchboards, conduits, metal raceway and cable trays).
3. Install a tower earth-ground array by driving ground rods and laying radials as required to achieve a low earth-ground impedance at the site.
4. Connect outside metal structures to the earth-ground array (towers, metal fences, metal buildings and guy anchor points).
5. Connect the power-line ground to the array. Follow local electrical code.
6. Connect the bulkhead to the ground array through a low-inductance and low-resistance bond.

Do not use soldered-only connections outside the equipment building. Crimped, brazed and *exothermic* (Cadwelded) connections are preferable. For a proper bond, all metal surfaces must be clean, any finish must be removed to bare metal and surface preparation compound must be applied (where necessary). Protect all connections from moisture by appropriate means (sealing compound and heat-sink tubing).

The ac wiring system

Most transient disturbances a facility will experience enter the plant through the utility-company ac power line. Effective transient suppression, therefore, begins with proper installation of the ac power-system wiring. Arrange with the local utility to have a separate transformer feed your facility. This may cost more initially, but it will reduce the chance for transient disturbances from nearby operations to affect your equipment. Do not allow the placement of noisy loads on the broadcast facility power line. Devices such as arc-welders, heavy electrical motors, elevators and other large loads can create an electrical environment that


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is prone to equipment malfunctions.

It should be noted, however, that because transient disturbances, by definition, are high frequency, they will capacitively couple from the primary to the secondary of a typical utility-company transformer. Simply installing a dedicated transformer that is not equipped with a special Faraday shield (utility transformers generally do not have such shields) will provide little protection from equipment damage. Installation of a dedicated utility-company transformer, however, will permit you to establish your own facility ground system independent of other users.

Insist that all ac wiring within the broadcast facility be performed by an experienced electrical contractor, and *always fully within the local electrical code.* Figure 8 shows a typical service-entrance panel, with the neutral line from the utility company tied to ground and to the ground rod at the meter panel. Where permitted by the local code, this should be the only point at which neutral is tied to ground in the ac distribution system.

Figure 9 shows a 3-phase power-distribution panel. Note that the neutral and ground connections are kept separate. Most ac distribution panels give the electrical contractor the ability to lift the neutral from ground by removing a shorting screw in the breaker-panel chassis. Insulate the neutral lines from the cabinet. Bond the ground wires to the cabinet for safety. Always run a separate, insulated green wire for ground. Never rely on conduit or other mechanical structures to provide ac system ground to electrical panels or equipment.

A single-phase power-distribution panel is shown in Figure 10. Note that neutral is insulated from ground and that the insulated green ground wires are bonded to the panel chassis.

Conduit runs often are a source of noise. Corrosion of the steel-to-steel junctions can act as an RF detector. Conduit-feeding sensitive equipment usually will contact other conduit runs powering noisy devices, such as elevators or air-conditioners. Where possible, eliminate this problem by using PVC pipe, Romex or jacketed cable.

However, if you are stuck with metal pipe, send the noise to the power ground rods instead of your equipment by isolating the green ground wire from the conduit with a ground-isolating (orange) receptacle. In a new installation, isolate the conduit from building metal structures or other conduit runs. Consult your local electrical code or an experienced electrical contractor before installing or changing any ac power system wiring.

The installation and wiring of equipment racks also must be carefully planned. Bond adjacent racks together with bolts, and clean the contacting surfaces by sanding down to bare metal. Install an ac receptacle box at each rack. Isolate the conduit from the rack. Isolate the power ground from the receptacle box. (One alternative to the isolated-ground receptacle is the use of an insulated bushing between the conduit and the receptacle box.) Mount a vertical power strip inside the rack to power the equipment. (The power strip doesn't need to be insulated from the rack). Additionally, bond the rack to the bulkhead ground or the green ground wire in the receptable box.

Mount equipment in the rack using normal metal mounting screws. If your facility is located in a high-RF field, clean the rack rails and equipment-panel connection points to ensure a good electrical bond. Power the equipment from the vertical power strip using standard 3-prong grounding ac plugs. *Do not defeat the safety ground connection.* Equipment manufacturers use this ground to drain transients.

Before implementing any type of ac

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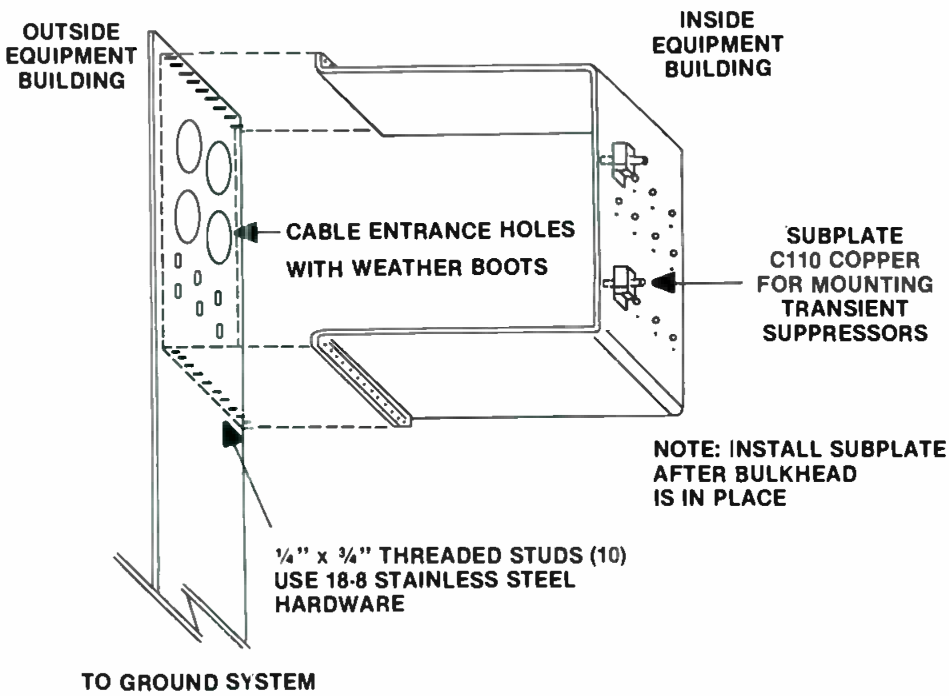

Figure 7. *The addition of a subpanel to a bulkhead as a means of providing a mounting surface for transient-suppression components that is not exposed to outside elements. (Reference 2.)*

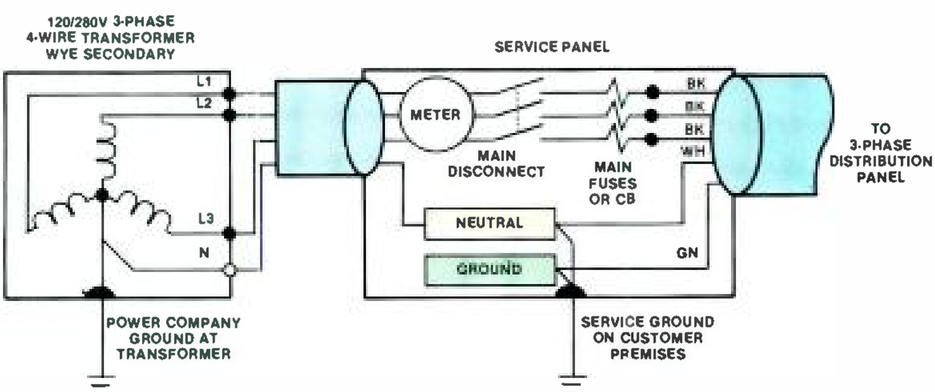

Figure 8. *The recommended connection method for a 3-phase utility-company service panel. (Reference 3.)*

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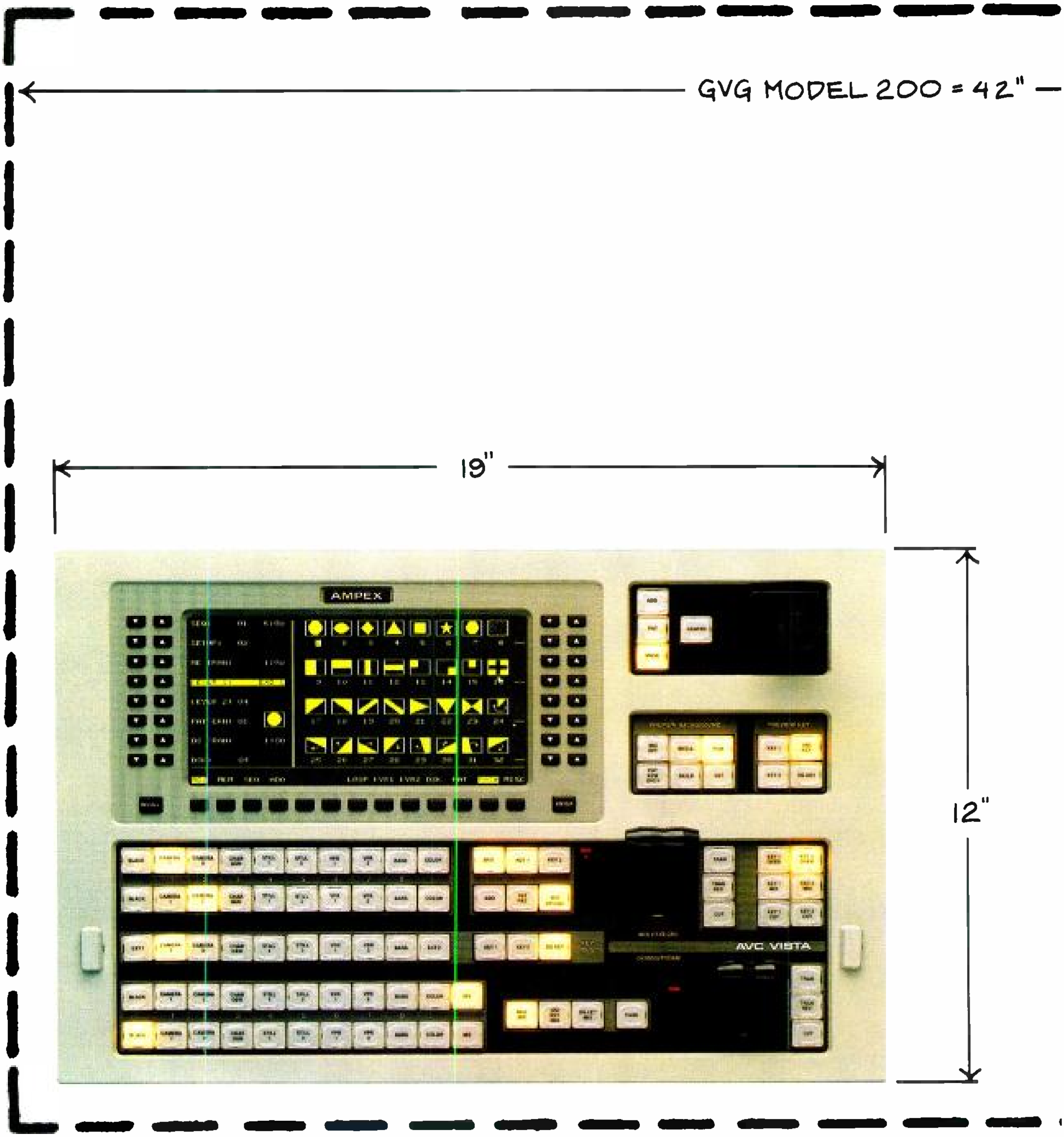

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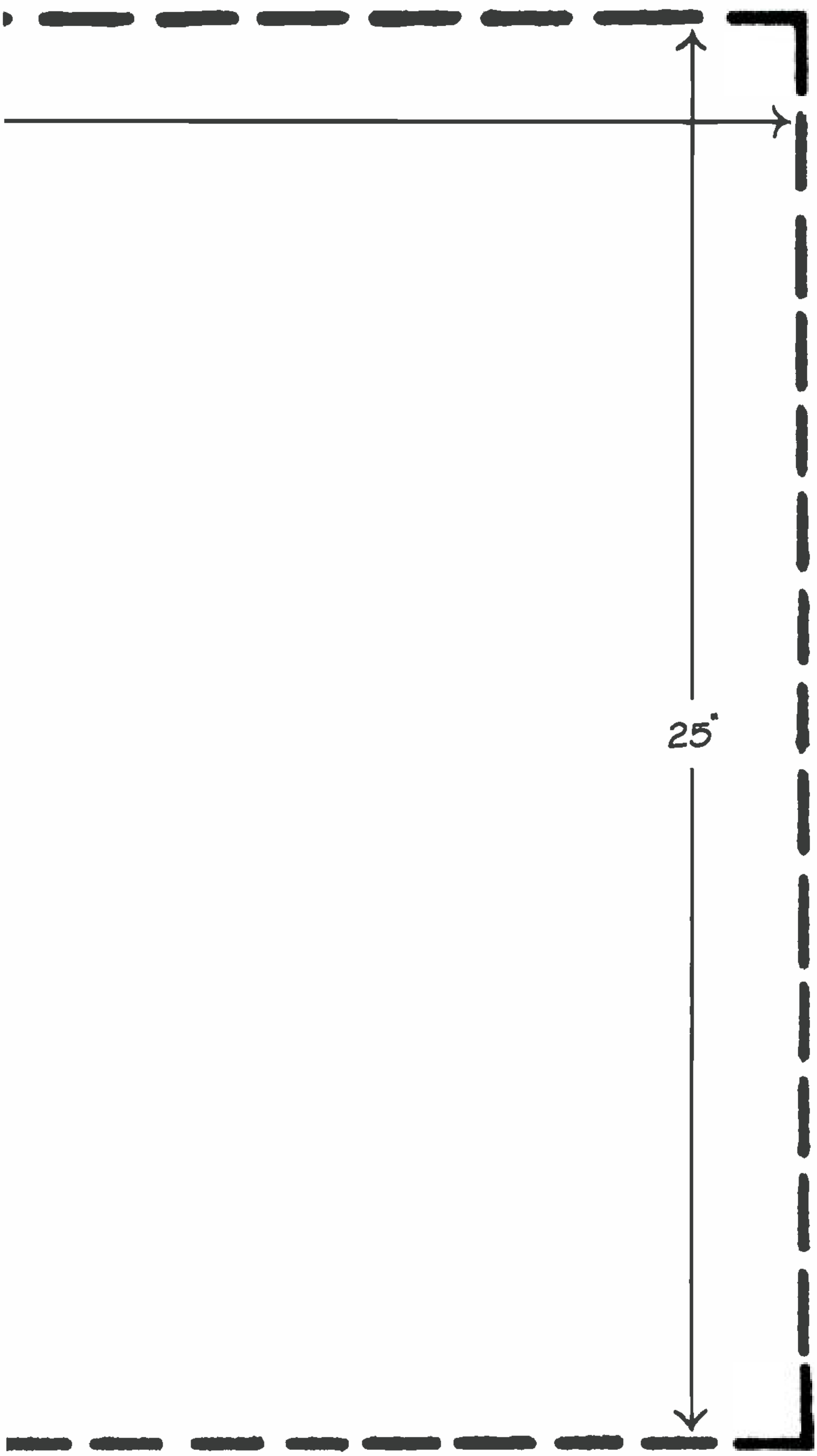

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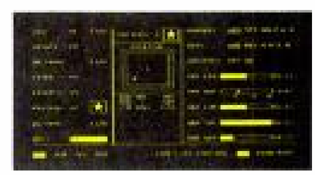

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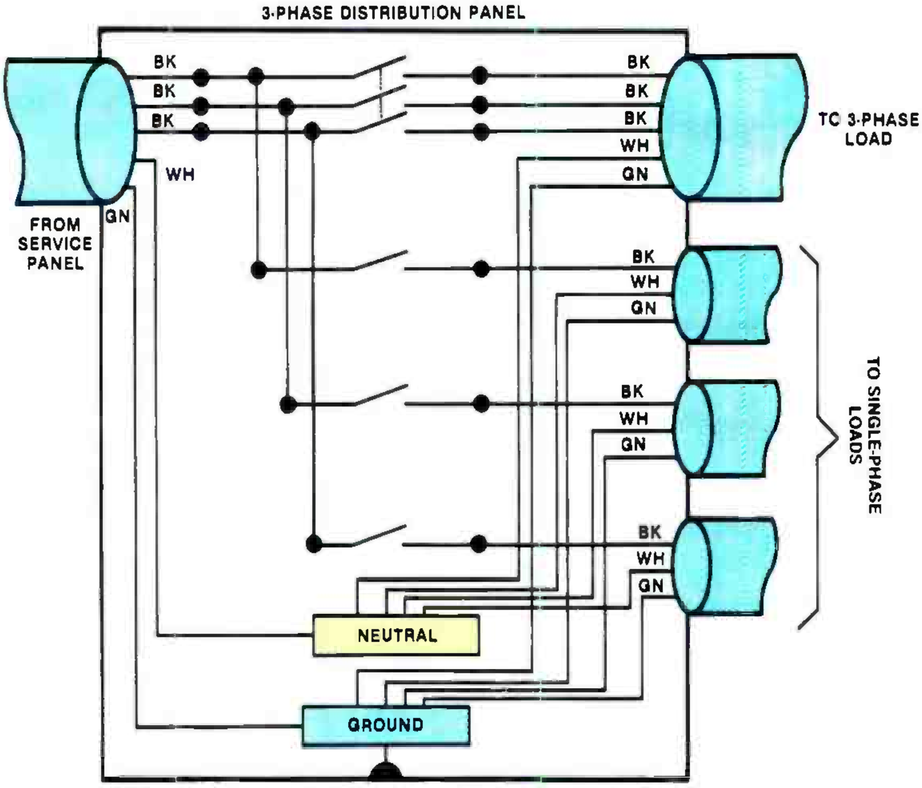

Figure 9. *Arrangement of the neutral and green-wire ground system for a 3-phase ac distribution panel. (Reference 3.)*

Continued from page 48

power-system changes, review the entire project with a qualified electrical contractor.

Discrete device protection

A broadcast facility can be protected from transient disturbances in two basic ways: the *systems* approach or the *discrete device* approach. Table 2 (see page 34) outlines the major alternatives available for the systems approach to transient suppression:

- UPS (uninterruptible power supply) system and standby generator.
- UPS stand-alone system.
- Secondary ac spot network.
- Secondary selective ac network.
- Motor-generator unit.
- Shielded isolation transformer.
- Solid-state line-voltage regulator/filter.

The systems approach offers the advantages of protection engineered to a particular application and need, and (usually) high-level factory support during system design and installation. However, it costs more. Many facilities cannot justify spending $5,000 or more for a sophisticated protection system. For such in-

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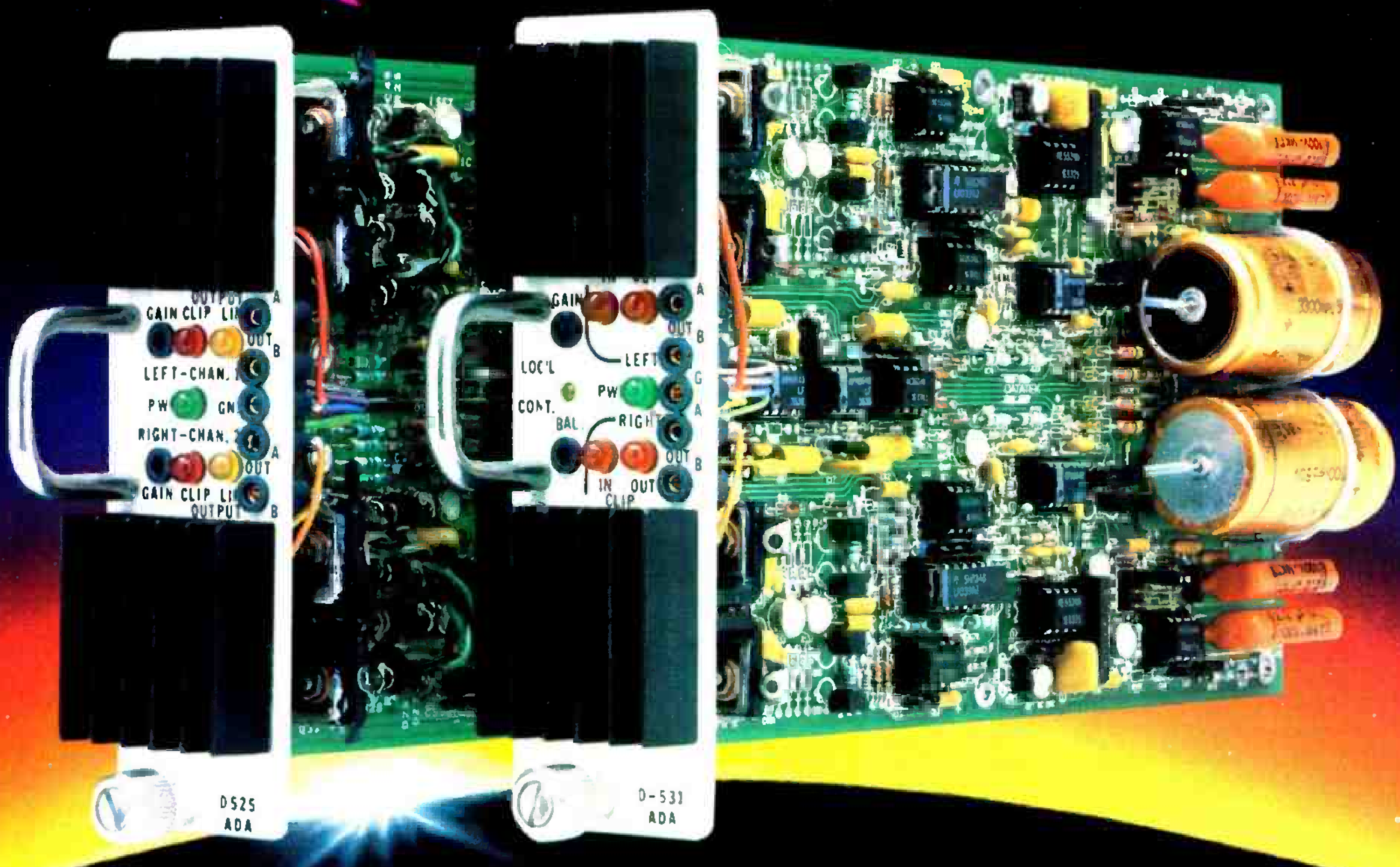

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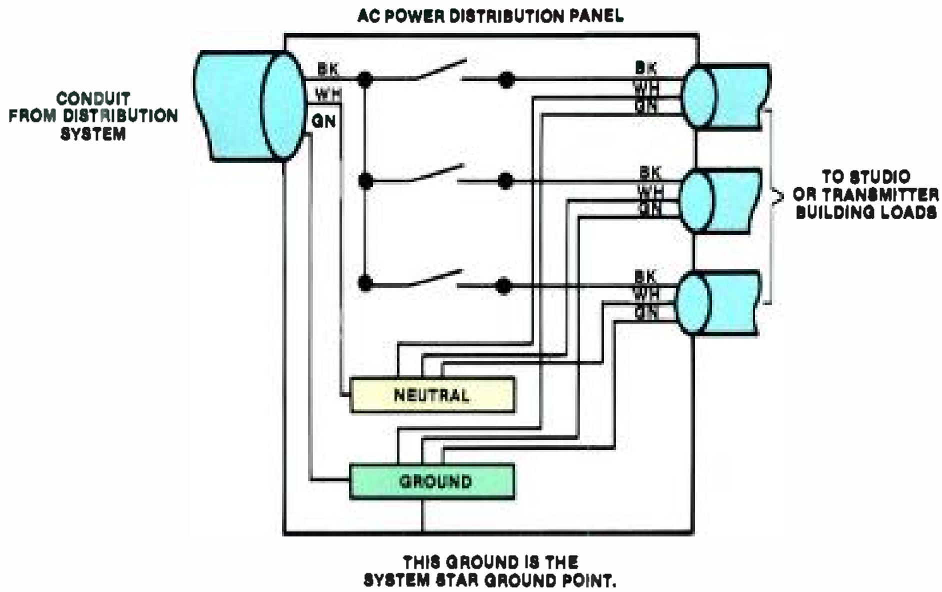

Figure 10. *Arrangement of the neutral and green-wire ground system for a single-phase ac distribution panel. (Reference 3.)*

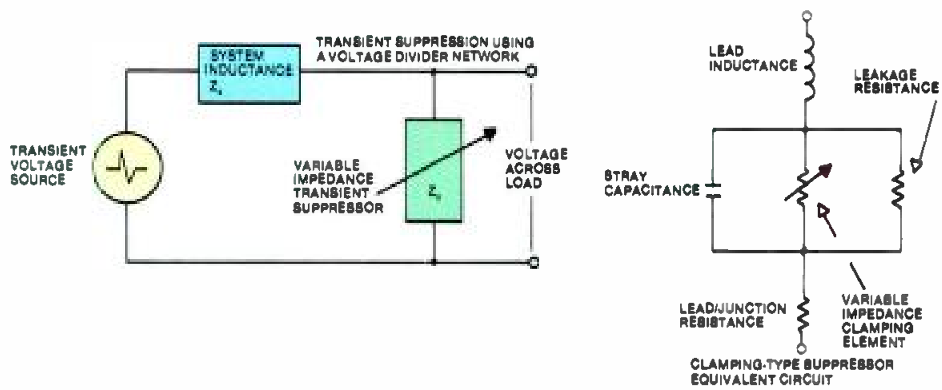

Figure 11. *The mechanics of transient suppression using a voltage-clamping device.*

stallations, the only alternative is to apply discrete protection devices at critical points in the ac power system.

In the business of transient protection, you get what you pay for. Discrete devices are less expensive and usually provide less protection compared with a sophisticated systems approach. It is unrealistic for a user to expect a group of discrete transient suppressors to do the job of a much more expensive systems design. However, properly applied discrete devices can prevent equipment damage from all but the most serious transient disturbances. The key to achieving this level of performance lies in understanding and properly applying discrete protection devices.

The performance of the discrete transient-suppression components available

Continued on page 58

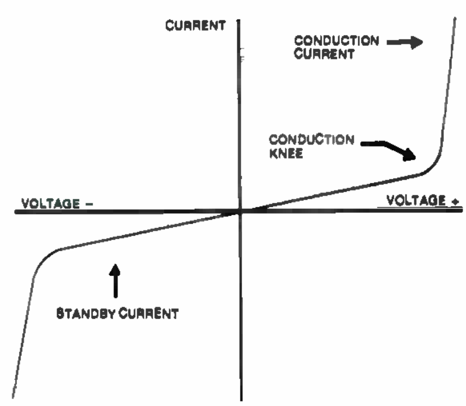

Figure 12. *The voltage-vs.-current curve for a typical bipolar voltage-clamping device. The component is designed to be essentially invisible in the circuit until the applied positive or negative potential reaches or exceeds the conduction knee of the device.*

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Continued from page 54
to the broadcast engineer has greatly improved in the past 10 years.

The variety of reasonably priced devices now available makes it possible to exercise tight control over unwanted voltage excursions and allows the complicated electronic equipment being manufactured today to work as intended. Much of the credit for transient-suppression work goes to the computer industry, which has been dealing with the problem for more than two decades.

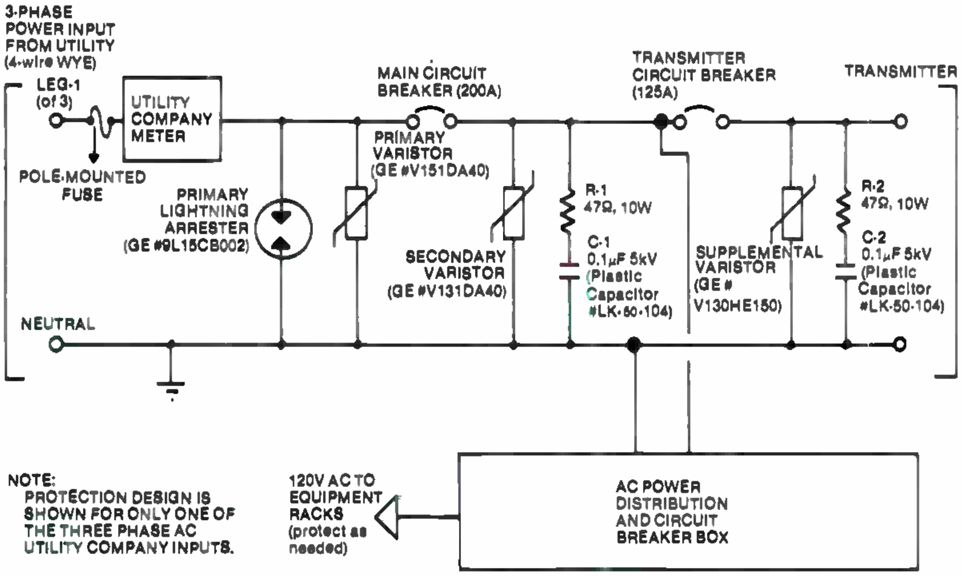

Figure 13. *The application of transient-suppression components to a systemwide protection plan. Install such hardware with extreme care, and only after consultation with the local utility company and an electrical contractor.*

Types of devices

Transient-suppression hardware can be divided into three categories: *ac filters, crowbar devices* and *voltage-clamping components.*

The simplest type of ac power-line filter is a capacitor placed across the voltage source. The impedance of the capacitor forms a voltage divider with the impedance of the source, resulting in the attenuation of high-frequency transients. This simple approach has definite limitations in spike-suppression capability and may introduce unwanted resonances with inductive components in the ac power-distribution system.

The addition of a series resistance will reduce the undesirable resonant effects, but it also will reduce the capacitor's effectiveness in attenuating a transient disturbance.

Crowbar devices include gas tubes (also known as spark-gaps or *gas-gaps*) and semiconductor-based *active crowbar* protection circuits. Although these devices and circuits can shunt a substantial amount of transient energy, they are subject to *power-follow* problems.

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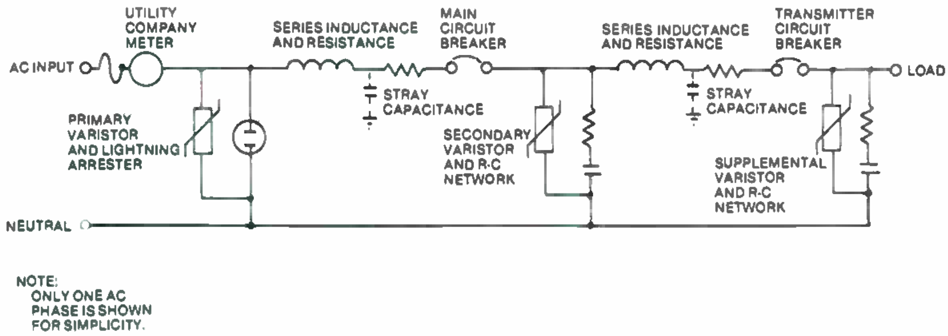

Figure 14. The use of ac system series inductance and resistance to aid transient suppressors in controlling line disturbances. This technique is known as staging.

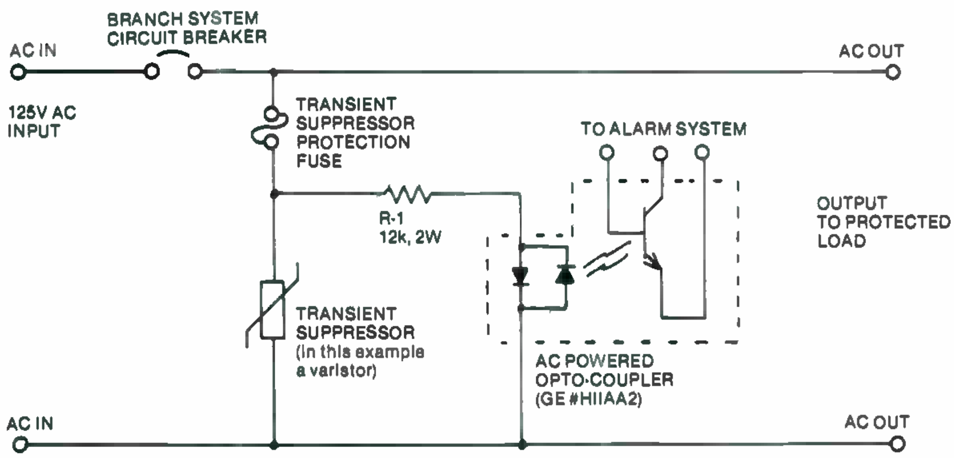

Figure 15. An open-fuse alarm circuit for a fused transient suppressor.

tection circuit has fired, the normal line voltage and the transient voltage are shunted to ground. This power-follow current may open protective fuses or circuit breakers if a method of extinguishing the crowbar clamp is not provided.

Voltage-clamping devices are not subject to the power-follow problems common in crowbar systems. Clamping devices include selenium cells, zener diodes and varistors of various types.

Zener diodes, using improved silicon rectifier technology, provide an effective voltage clamp for the protection of sensitive electronic circuitry from transient disturbances. On the other hand, power dissipation for zener units is usually somewhat limited (compared with other suppression methods).

Selenium cells and varistors are differ-

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ent in construction, but act similarly on a circuit exposed to a transient overvoltage. Figure 11 illustrates the variable non-linear impedance exhibited by a voltage-clamping device. It also shows how these components can reduce transient overvoltages in a particular circuit.

The voltage-divider network established by the source impedance (Z_s) and the clamping device impedance (Z_c) attenuates voltage excursions at the load. It should be understood that the transient suppressor depends upon the source impedance to aid the clamping effect. A protection device cannot be fully effective in a circuit that exhibits a low source impedance because the voltage-divider ratio is reduced proportionately.

A typical voltage-vs.-current curve for a voltage-clamping device is shown in Figure 12. When the device is exposed to a high-voltage transient, the impedance of the component changes from a high-standby value to a low-conduction value, clamping the voltage at a specified level.

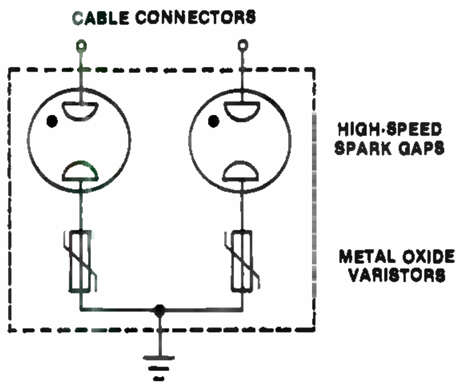

Figure 16. A hybrid voltage-protection device incorporating a gas tube spark gap and varistor in each suppression element. The design goal is to extend the life of the varistor. (Reference 4.)

Selecting a protection device

Selecting a transient-suppression device for a particular application is a complicated procedure that must take into account the following factors:

- The steady-state working voltage, including normal tolerances.
- The transient energy to which the device is likely to be exposed.
- The voltage-clamping characteristics required in the application.
- Circuit-protection devices (such as fuses or circuit breakers) present in the system.
- The consequences of protection-device failure in a short-circuit mode.
- The sensitivity of the load equipment to transient disturbances.

Most transient-suppression equipment manufacturers offer detailed application handbooks. *Consult such reference data whenever you plan to use a protection device.* The specifications and ratings of suppression components are not necessarily interchangeable from one manufacturer to another.

Carefully weigh the addition of transient-suppression devices to a piece of equipment or ac power-distribution system. Make allowances for operation of the circuit under all conditions.

Power protection

Transient-protection methods for a broadcast facility vary considerably depending on the size and complexity of

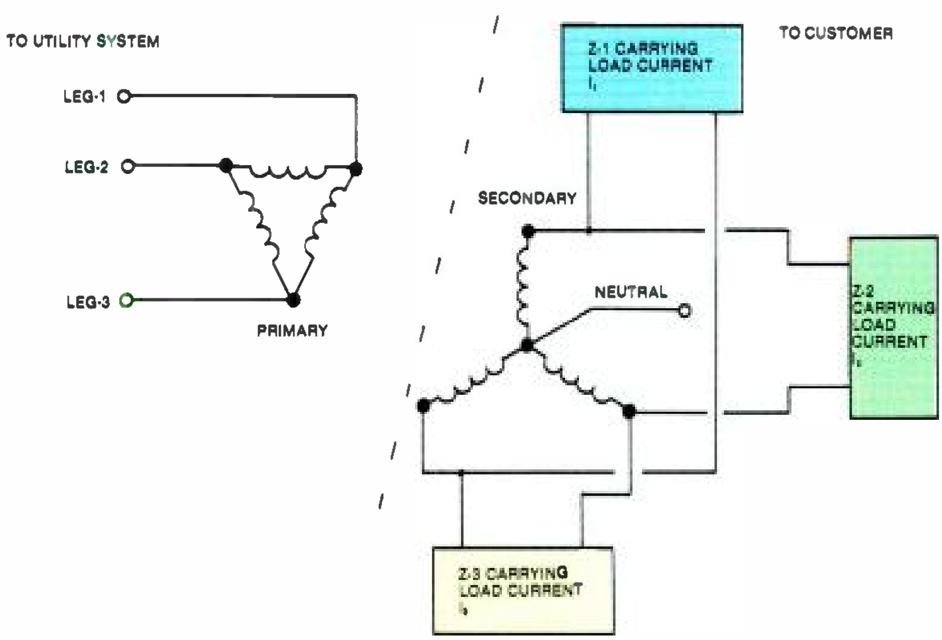

Figure 17. The Delta-Wye transformer configuration for utility-company power distribution.

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the plant, the sensitivity of equipment at the facility and the extent of transient activity on the primary power lines.

Figure 13 shows one possible approach to transient suppression for a broadcast facility. Lightning arresters are built into the 12kV to 208V 3-phase pole-mounted transformer. The service drop comes into the meter panel and is connected to a *primary lightning arrester* (General Electric Company No. 9L15CB002) and a *primary varistor* (GE No. V151DA40).

The circuit shown in Figure 13 is duplicated three times for a 3-wire Wye (208V phase-to-phase, 120V phase-to-neutral) power system.

The primary arrester and varistor are placed at the service drop input point to protect the main circuit breaker and power-system wiring from high-voltage transients that are not clipped by the lightning arrester at the pole or by the varistors later in the circuit path.

The primary varistor has a higher maximum clamp voltage than the varistors located after the main breaker, causing the devices downstream to carry most of the clamp-mode current when a transient occurs (assuming low system inductance). If the main circuit breaker opens during a transient disturbance, the varistor at the service drop entrance will keep the spike voltage below a point at which it could damage the breaker or system wiring.

Placing overvoltage protection before the main service breaker may be considered *only* when the pole-mounted transformer feeds a single load and when the transformer has transient protection of its own, including lightning arresters and primary-side fuses. *Consult the local power company before you place any spike-suppression devices ahead of the main breaker.*

Transient protection immediately after the main breaker consists of a *secondary varistor* (GE No. V131DA40) and a capacitor (0.1μF at 5kV) between each leg and neutral. A 47Ω 10W series resistor protects the circuit if the capacitor fails. It also reduces the resonant effects of the capacitor and ac distribution-system inductance.

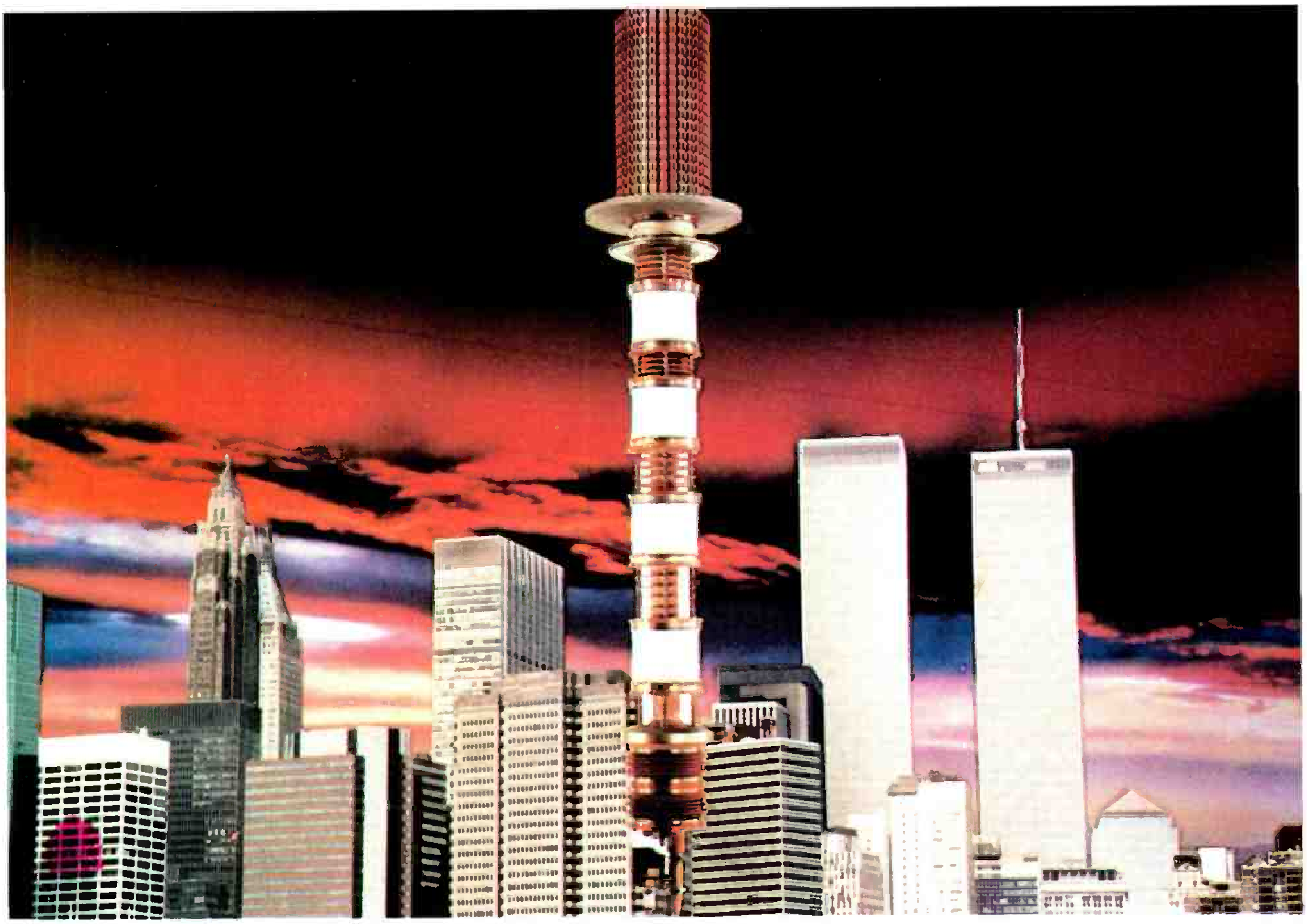
The varistor clips overvoltages as previously described, and the resistor-capacitor network helps eliminate high-frequency transients on the line. The capacitor also places higher capacitive loading on the secondary of the utility-company step-down transformer, reducing the effects of turn-on spikes caused by capacitive coupling between the primary and the secondary of the pole- or surface-mounted transformer.

As an extra measure of protection, a *supplemental varistor* (GE No. V130-HE150) and RC snubber are placed at the primary power input to the transmitter. Transient suppressors are placed as needed at the ac power distribution and circuit-breaker box.

Staging

The transient-suppression system shown in Figure 13 uses a technique known as *staging* of protection components. An equivalent circuit of the basic system is shown in Figure 14. The staging approach takes advantage of the series resistance and impedance of the ac wiring system of a facility to aid in transient suppression.

When appreciable inductance or resistance exists in an ac distribution system, the protection components located at the utility-company service-drop entrance (the primary suppressors) will carry most of the suppressed-surge current in the event of a lightning strike or major transient disturbance. The varistors and RC networks downstream (the secondary and supplemental suppressors) are rated for clamp voltages lower than the primary protection devices. With the assistance of the ac circuit series resistance



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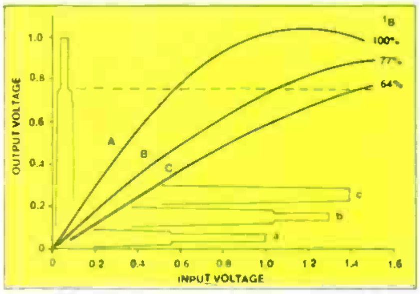

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and impedance, they exercise tight control over voltage excursions.

Staged suppression design also protects the system from exposure caused by a transient-suppression device that becomes ineffective. The performance of an individual suppression component is more critical in a system that is protected at only one point than it is in a system protected at several points. The use of staged suppression also helps prevent transients generated by load equipment from being transmitted to other sections of a facility, because suppressors can be located near offending loads.

Do not place transient suppressors of the same type in parallel to gain additional power-handling capability. Even suppressors that are identical in part number have specified tolerances, so devices placed in parallel will not share the suppressed-spike current equally.

Design cautions

Install transient suppressors at the utility service entrance with extreme care and only after consulting an experienced electrical contractor and the local utility company's engineering department.

Although the addition of transient protection to an ac feed is vital to the long-term survival of the equipment downstream, the action of surge-suppression devices can cause one or more of the fuses at the service-drop transformer to open, creating a *single-phasing* condition. Positive protection against continued operation under such a condition is necessary if transient-protection devices are installed at the service entrance of a facility.

Protection-device failure is rare, but it can occur, causing damage to the system unless the consequences of the failure are taken into account. Before installing a surge-limiting device, examine what would happen if the device failed in a short circuit (which is generally the case).

Check for proper fusing on the protected lines, and locate transient-limiting devices in sealed enclosures to prevent damage to other equipment or injury to people if a device failure occurs.

In the failure mode, current through the protection device is limited only by the source impedance. High currents can cause the internal elements of the device to melt and to result eventually in an open circuit. However, the high currents often cause the component package to rupture, expelling package material in both solid and gaseous forms.

A transient suppressor must be fused if the line on which it is operating has a circuit breaker (or fuse) rating beyond the point that would provide protection against package rupture of the suppressor. Selecting the fuse is a complicated

procedure involving an analysis of the transient energy that must be suppressed, the rupture current rating of the suppressor and the time delay of the fuse. Transient-suppressor manufacturers can provide guidance on fuse selection.

The monitoring circuit shown in Figure 15 can be used to alert maintenance personnel to an open fuse. This provision is important for continued safe operation of sensitive load equipment.

Lead length is another important factor to consider when installing surge-suppression components. Use heavy, solid wire (such as No. 12 of minimum length) to connect protection devices to the ac lines. Avoid sharp bends. If possible, maintain a minimum bending radius of eight inches for interconnecting wires. Long leads act as inductors in the presence of high-frequency transients and as resistors when high-current surges are being clamped.

Give careful attention to proper heat-sink design when installing transient-suppression devices. Some suppressors require an external heat-sink to meet their published specifications. Failure to provide an adequate heat-sink can result in premature device failure.

Spike-suppression components fail when subjected to transients beyond their peak current/energy ratings. They also can fail when operated at steady-state voltages beyond their recommended values.

Examine the manufacturer's product literature for each discrete protection device that you are considering. Many companies have applications engineering departments that can assist in matching their product lines to your needs.

Consider using hybrid protection devices that provide increased product lifetime. For example, a varistor normally exhibits some leakage current. This leakage can lead to device heating and eventual failure. Hybrid devices are available that combine a varistor with a gas-filled spark-gap device to hold the leakage current to zero during standby operation, extending the expected product lifetime. During a transient, the spark gap fires and the varistor clamps the pulse in the normal way. (See Figure 16.)

Utility-company interfacing

Most utility-company connections in the United States are the standard *Delta-Wye* type, as shown in Figure 17. This transformer arrangement usually is connected with the Delta side facing the high voltage and the Wye side facing the load. This arrangement provides good isolation of the load from the utility and retards the transmission of transients from the primary to the secondary. The individual 3-phase loads are denoted by Z1, Z2 and Z3. They carry load currents as shown.

When using a Wye-connected system, it is important that the building's neutral lead be connected to the midpoint of the transformer windings. The neutral line provides a path for the removal of harmonic currents that may be generated in the system because of rectification of the secondary voltages.

Some utility connections, however, use the *Open-Delta* arrangement shown in Figure 18. Customers often encounter problems when operating a sensitive 3-phase load from such a connection because of the system's poor voltage-regulation characteristics during varying load conditions. The Open-Delta configuration also is subject to high third-harmonic content and transient propagation. The three loads and their respective load currents are shown in the diagram.

Other primary power connection arrangements are possible, such as *Wye-to-Wye* or *Delta-to-Delta*. Like the Delta-to-Wye configuration, these systems are not susceptible to the problems that can be experienced with the Open-Delta (or V-V) service.

The Open-Delta system can develop a considerable imbalance between the individual phases in either voltage or phase, or both. Such an occurrence can introduce a strong 120Hz ripple frequency in 3-phase power supplies, which are designed to filter out a 360Hz ripple. The possible effects of this 120Hz ripple include increased noise in the supply and possible damage to protection devices across power-supply chokes.

Depending on the loading of an Open-Delta transformer arrangement, high third-harmonic energy can be transferred to the load, producing transients of up to 300% of the normal voltage. These transients can severely strain rectifiers, capacitors and inductors in the power supply as well as add to the supply's output noise.

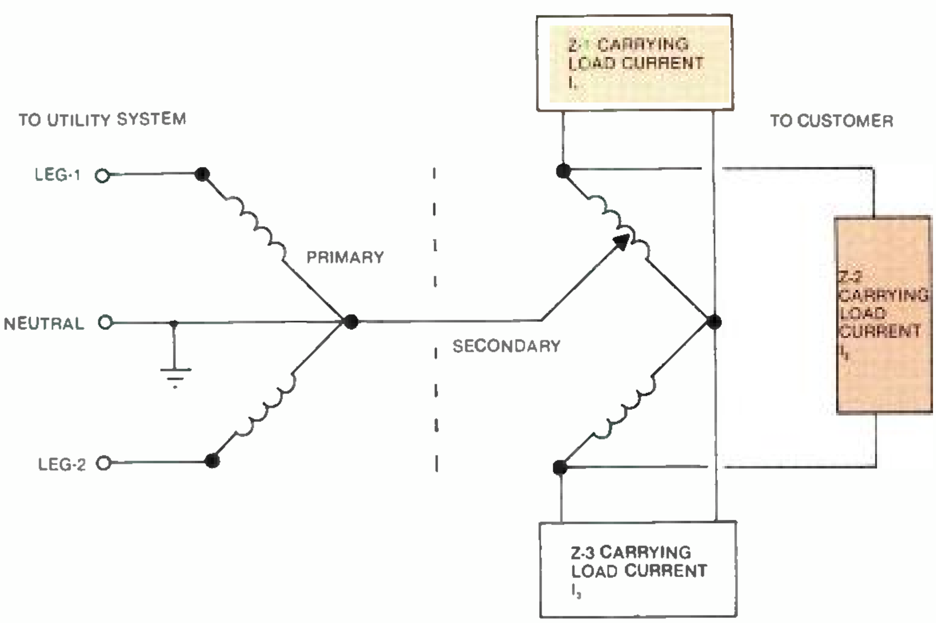

Figure 18. The Open-Delta (or V-V) utility-company service connection. Use of this configuration is not recommended because of the system's poor voltage regulation, high third-harmonic content and transient disturbance propagation characteristics.

Phase-to-phase balance

The phase-to-phase voltage balance o a utility company line is important to a broadcast facility, not only because o the increased power-supply ripple an im balance may cause, but also because o the heating effects that may result. Even simple 3-phase devices such as motors must be operated from a power line tha is well-balanced (preferably within 1%).

Studies have shown that a line imbalance of only 3.5% can produce a 25% increase in the heat generated by a 3-phase motor. A 5% imbalance can cause a 50% increase, which is potentially destructive. Similar heating also can occur in the windings of 3-phase power transformer used in broadcast equipment.

Phase-to-phase voltage balance can be measured accurately over several day with a slow-speed chart recorder. The causes of unbalanced operation usually are large single-phase power users on the 12kV distribution line. Uneven currents through the utility-company power-distribution system will result in uneven line-to-line voltages at the customer's service-drop entrance.

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Circuit-level applications

Equipment reliability can be increased by building transient protection into broadcast hardware.

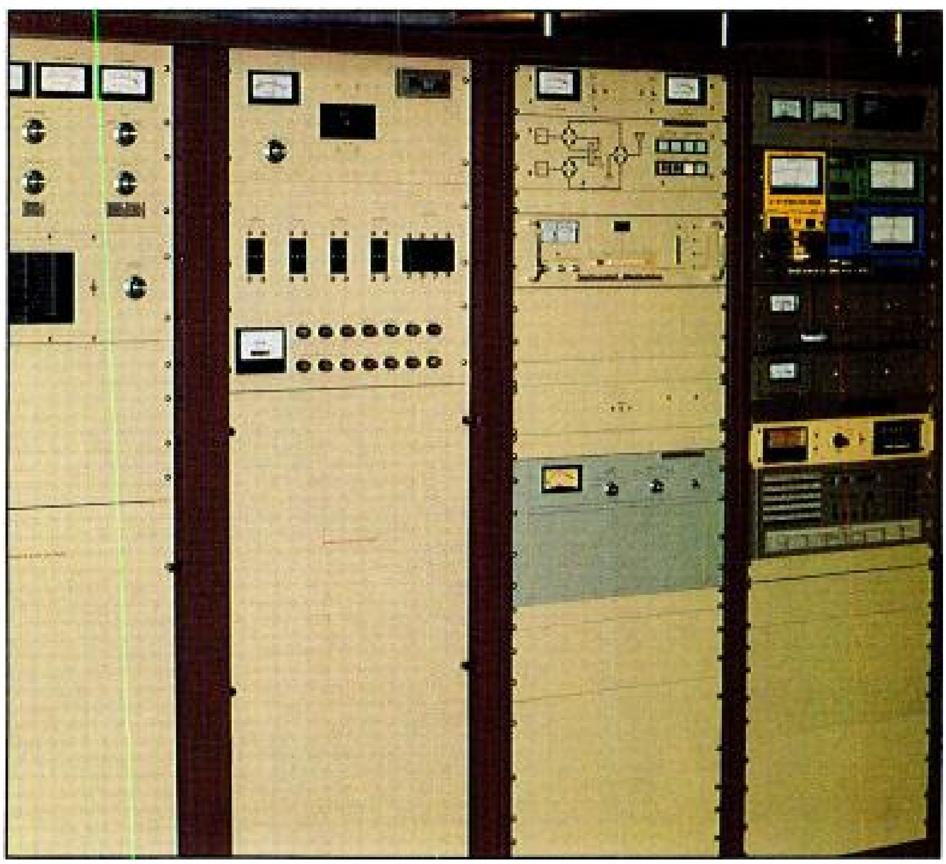
The design of any piece of electronic equipment is a complicated process that is the domain of design engineers, *not users in the field.* Many manufacturers are now building transient protection into their products. This work is welcomed because effective transient suppression is a *systems problem* that extends from the utility-company ac input to the circuit boards in each piece of equipment. Although progress has been made, more work needs to be accomplished on circuit-level transient suppression.

Case histories

Some low-voltage power supplies used in broadcast equipment are, at best, only adequate. All too often, power to an expensive piece of equipment is derived from a circuit that has virtually no transient overvoltage protection. This type of supply certainly will work, but it falls short of the "state of the art," and is less than the industry should expect from professional equipment.

Figure 19 shows the recommended transient protection for a typical low-voltage series-regulated power supply. MOV1, 2 and 3 clip spikes on the incom-

Acknowledgment: The author wishes to thank Roger Block, president of PolyPhaser Corporation, Gardnerville, NV, and Howard Mullinack of Orban Associates, San Francisco, for their help in preparing this report.



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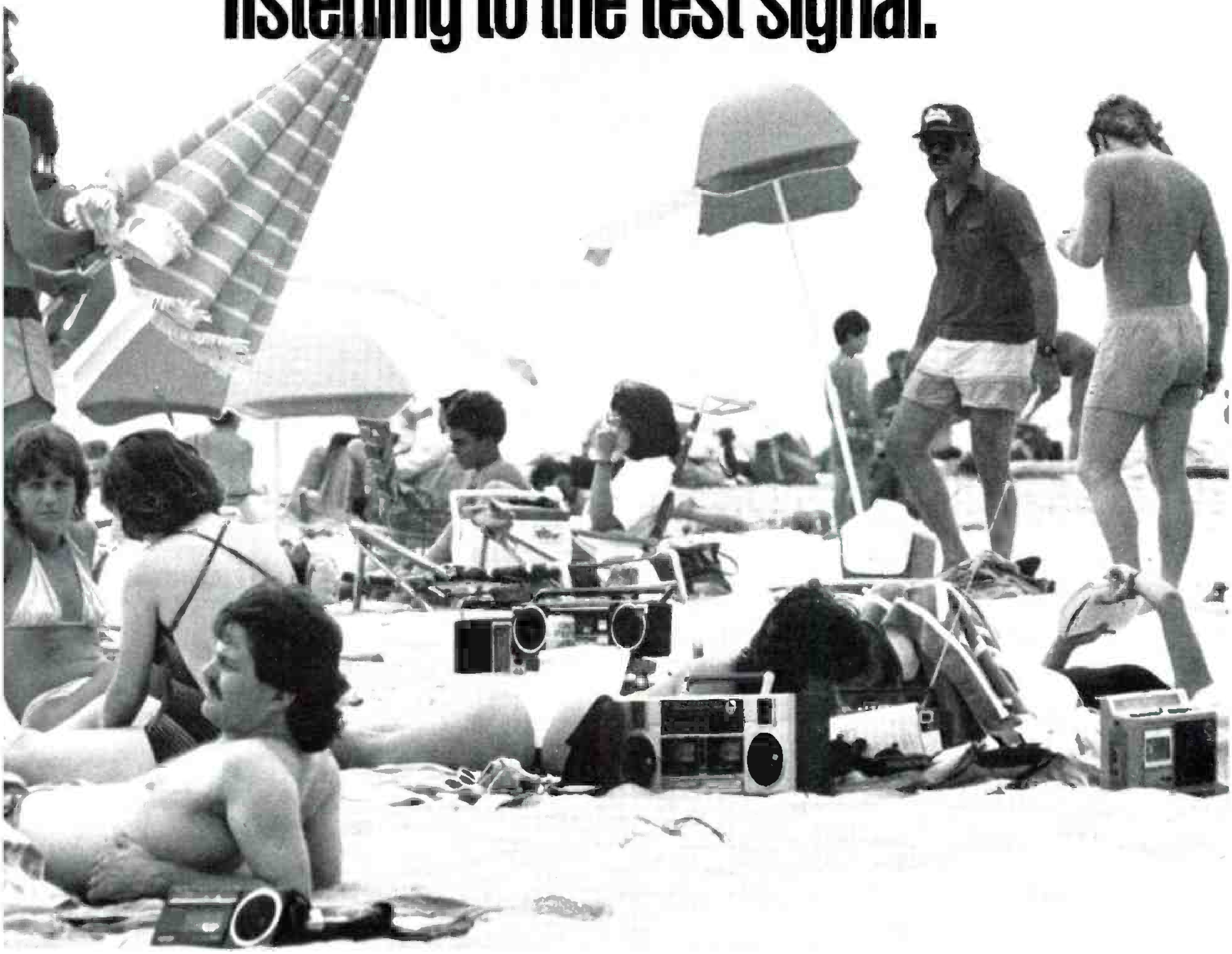

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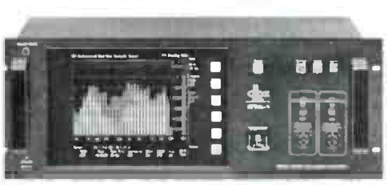

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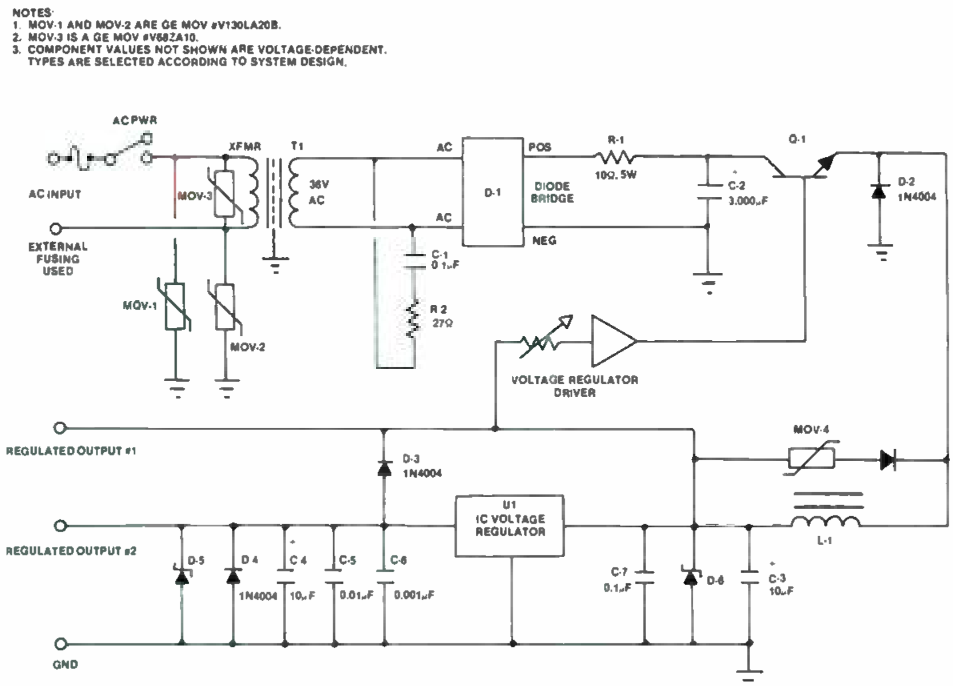


Figure 19. The recommended transient overvoltage protection for a low-voltage power supply. A circuit such as this will survive well in the field despite frequent transient disturbances.

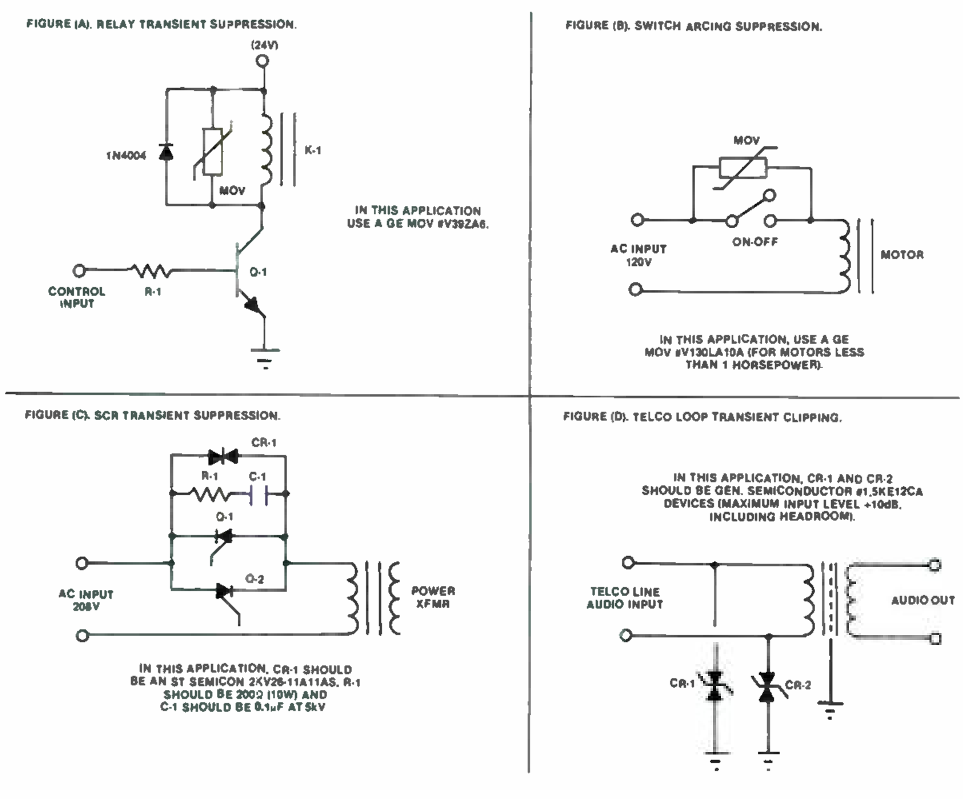


Figure 20. Transient-suppressor applications for several common circuit configurations.

ing ac line, and C1 aids in shunting turn-on, turn-off and fault spikes on the secondary of T1. Resistor R1 protects diode bridge D1 by limiting the amount of current through D1 during turn-on, when capacitor C2 (the main filter) is fully discharged. MOV4 protects series regulator Q1 and the load from damage because of transients generated by fault conditions and load switching. The varistor is chosen so that it will conduct current when the voltage across L1 is greater than would be encountered during normal operation. Diode D2 protects Q1 from back-EMF kicks from L1.

Three-terminal integrated-circuit voltage-regulator U1 is protected from excessive back-current because of a short circuit on its input side by diode D3. Capacitors C3, 4, 5, 6 and 7 provide filtering and protect against RF pickup on the supply lines. Diode D4 protects U1 from back-EMF kicks from an inductive load, and zener diode D5 protects the load from excessive voltage in case U1 fails (possibly impressing the full input voltage onto the load). D5 also protects U1 from overvoltages caused by spikes generated through inductive load-switching or fault conditions. D6 performs a similar function for the input side of U1.

Figure 20 shows additional circuit-level applications for transient suppressors. Any transistor that switches an inductive load must be provided with transient protection, as shown in Figure 20(a). Protection also is required for switches that control an appreciable amount of power, as illustrated in Figure 20(b). The use of a spike suppressor across switch or relay contacts will greatly extend the life of the switching elements.

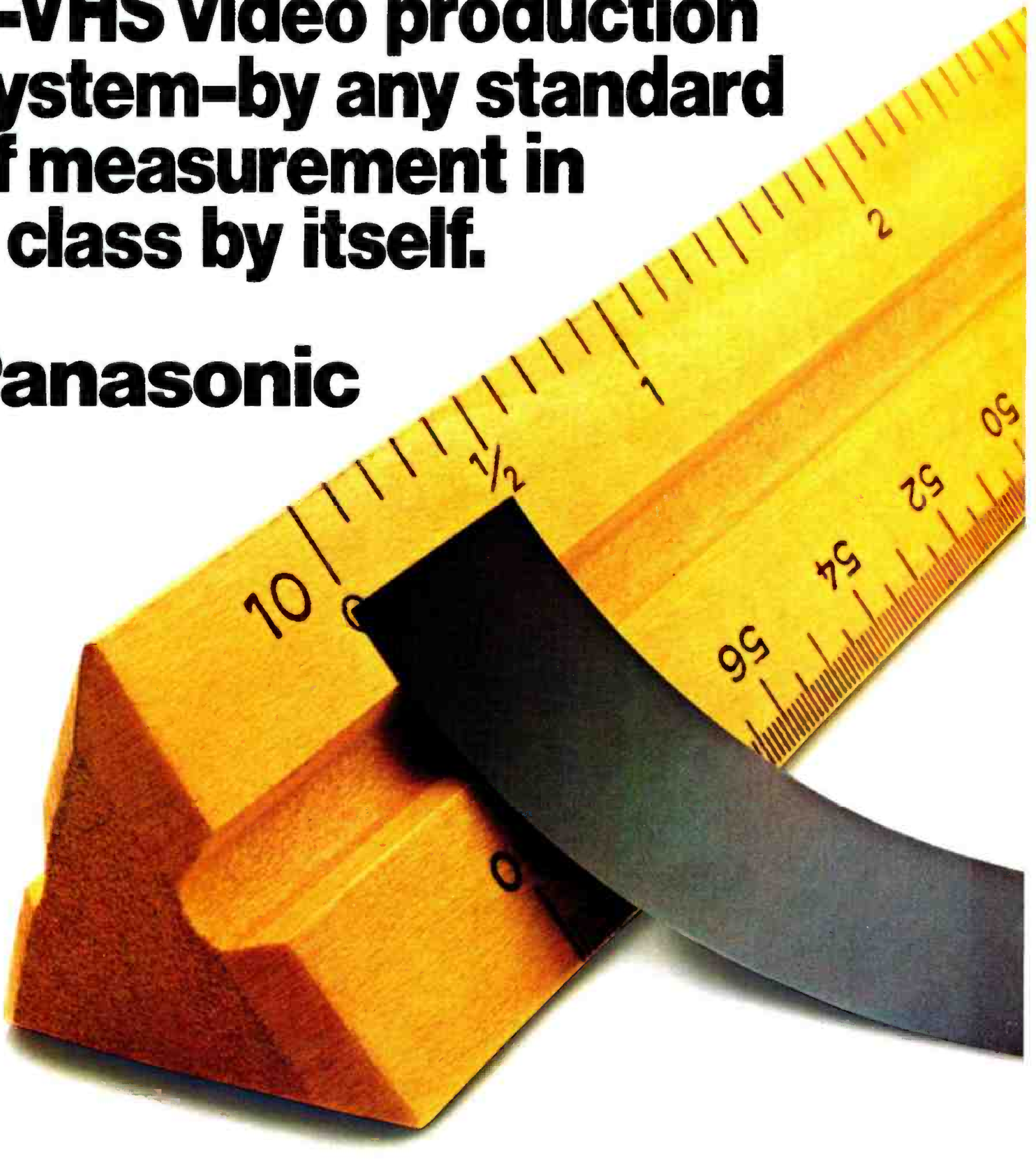
SCR control of the power input to a large transformer is common in transmitter equipment today, and some form of protection is vital to long-term reliability. The surge protector shown in Figure 20(c) will clip spikes generated by the transformer during retarded-phase operation.

Transient suppression often is desirable on telephone company audio or data loops. The spike-clipping devices shown in Figure 20(d) are selected based on the typical audio voltage levels (including headroom) used on the line.

For maximum protection of microcomputer equipment, transient suppression must be designed into individual circuit boards. Figures 21(a) and (b) illustrate typical applications of on-the-board spike suppression. The devices used are General Semiconductor DQA/DQB series DIP *TranZorbs*. Four individual TranZorb devices are included in each DIP package, making it possible to conveniently place them on crowded printed circuit boards. Figure 21(c) shows an application of transient suppression in a voltage-follower circuit, common in many analog data-acquisition systems. Note the use of suppression devices at the power-supply pins of the circuits shown in Figures 21(a) through (c).

Figure 21(d) illustrates an alternative to the transient-protection arrangement shown in Figure 20(d). The Figure 21 cir-

Continued on page 78



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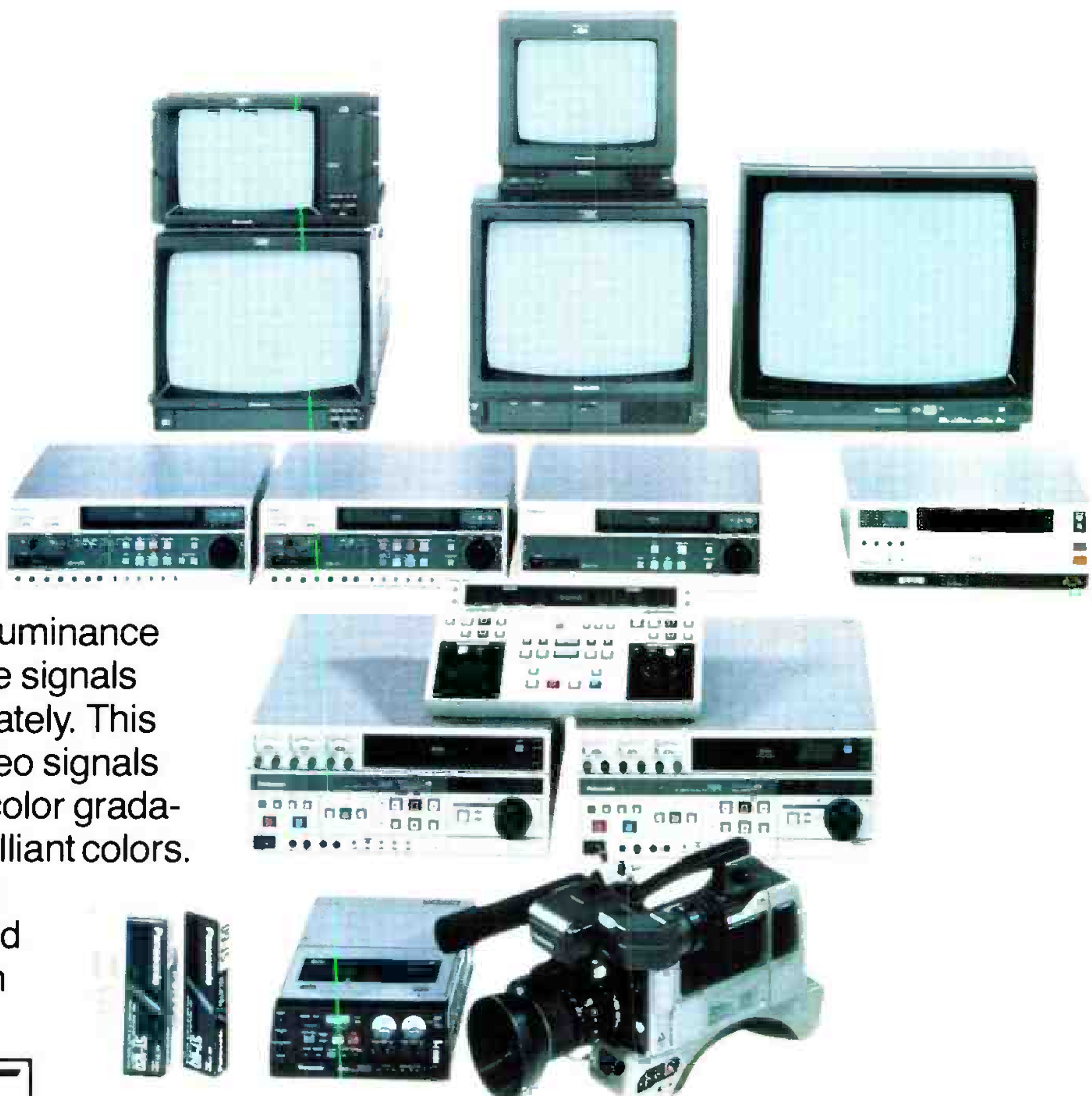

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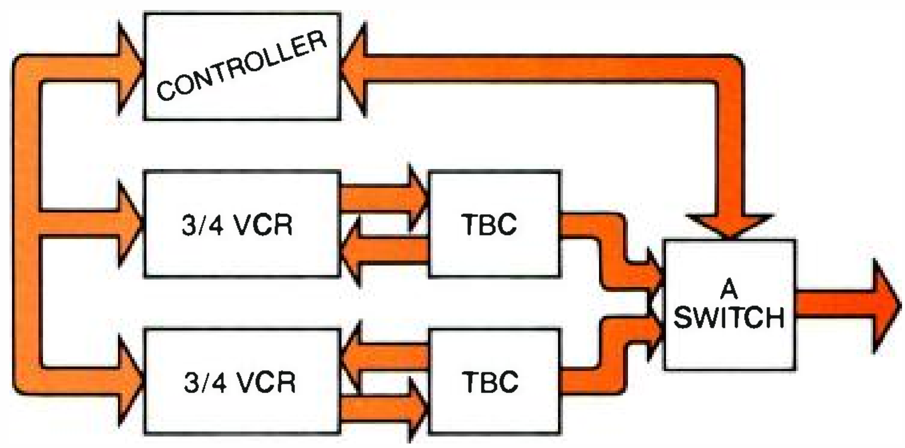

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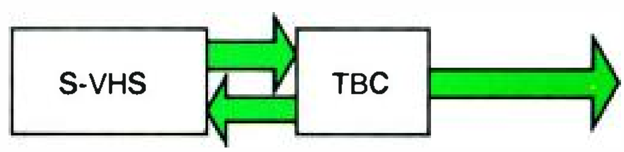

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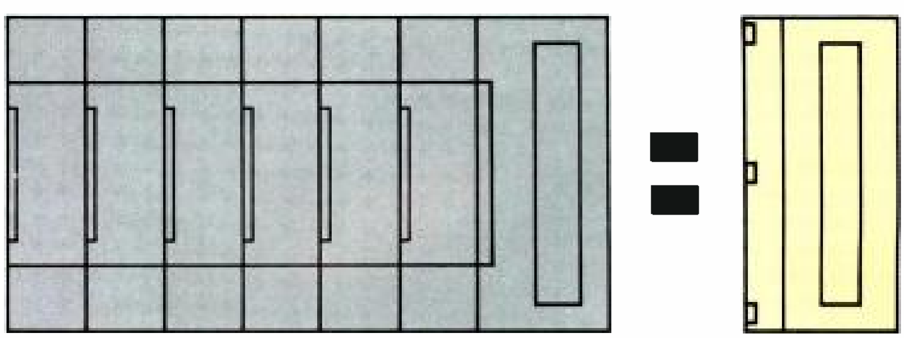

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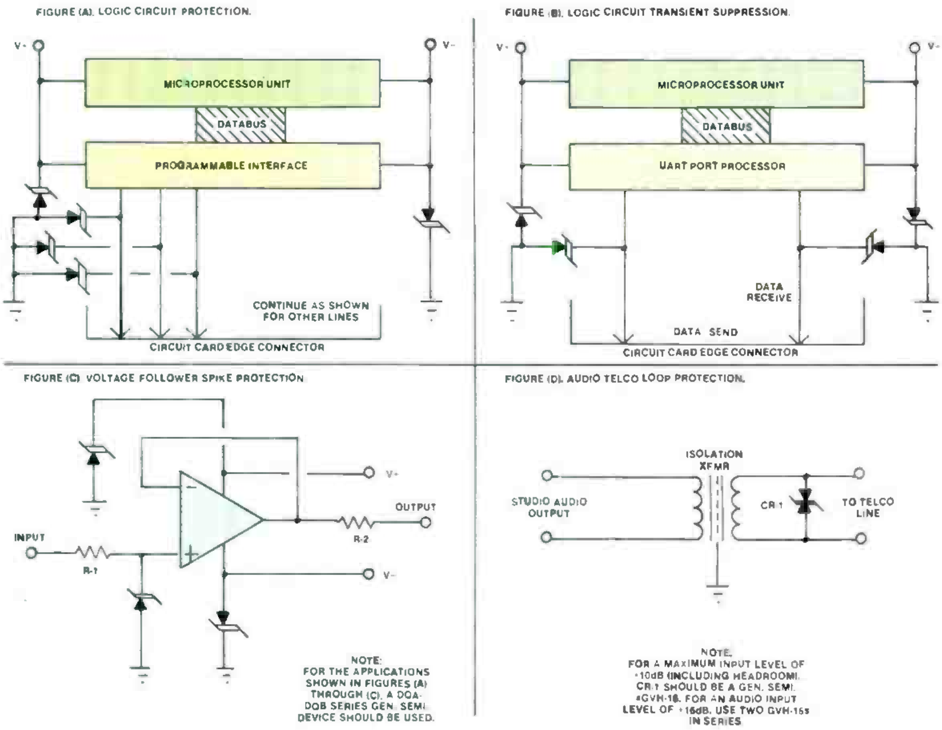


Figure 21. *Application of transient-suppression devices to microcomputer, analog voltage sampling and audio circuits.*

Continued from page 74

cuit prevents the introduction of noise into high-quality audio program lines because of common-mode imbalances that may result from transient suppressors being tied to ground. The use of a low-capacitance suppressor (as specified) ensures minimum capacitive loading on the telco circuit.

The traditional protection element used for telephone company lines is the *gas tube*, which has been used for many years to replace the older carbon buttons that became noisy with time. The gas tube (and its carbon predecessor) protects central office personnel if a high-voltage power line comes in contact with a telephone cable. Protection of customer equipment is of secondary importance.

For balanced telco lines, critical transient considerations include both the above-ground voltage of the two conductors (the *common-mode voltage*) and the voltage between the two conductors (the *differential-mode voltage*). When individual clamping devices are used on each conductor, as shown in Figure 20(d), one device will inevitably clamp before the other. This action can create a significant

differential voltage that can damage sensitive equipment on the telco line.

The best solution is to install a 3-element gas tube. The device has a common gas chamber with two gaps, one on each side of the grounded electrode. When one side of the line reaches the ionization potential, both sides fire simultaneously to ground.

Figure 22 illustrates the application of device staging to a broadcast transmitter high-voltage power supply. As detailed previously for line-voltage ac distribution systems, the staging approach uses the series resistance and inductance of interconnecting wiring to assist in suppressing transient disturbances. The Figure 22 circuit includes two sets of varistors, primary and secondary units. The secondary set is rated for a lower clamp voltage, and, together the varistor groups exercise tight control over disturbances entering the transmitter from the ac utility company input.

Additional transient-suppression devices (CR1 through CR3) and three sets of RC snubbers (R1/C1 through R3/C3) clip transients generated by the power transformer during retarded-phase operation. On the transformer secondary, three groups of RC snubbers (R4/C4a-b through R6/C6a-b) provide additional protection to the load from turn-on/turn-off spikes and transient disturbances on the utility line.

The transient-suppression applications presented here are intended only as examples of ways to build protection into equipment to increase reliability. *Do not attempt to modify existing equipment to provide increased transient-suppression capabilities.* Such work is the domain of the equipment manufacturer. Transient suppression must be engineered into products during design and construction, not added on later in the field.

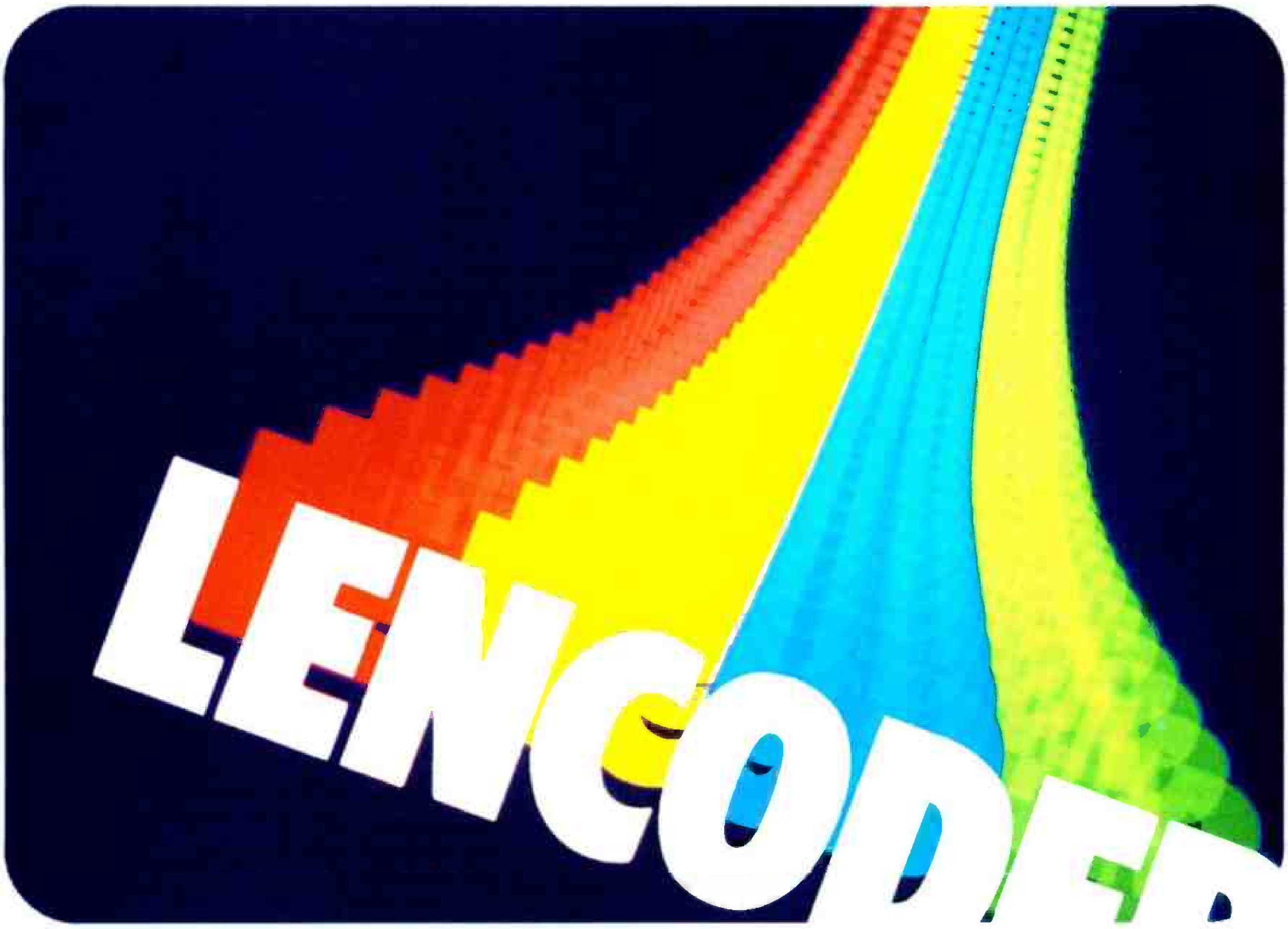
Device application problems

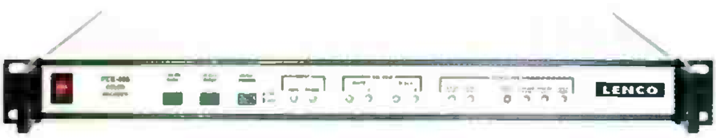
Building transient-suppression capability into a product is not as easy or straightforward as it might appear. Misapplication of a suppressor can *reduce* equipment reliability, not increase it.

For example, Figure 23 shows two transient-suppression arrangements that should be avoided. In 23(a) the relay contacts of K1 are protected by three spike suppressors. Although this is an acceptable application of the devices, the possibility of suppressor failure always must be considered. The usual failure mode is a short circuit. This being the case, a failure of any two of the three devices shown will cause a single-phasing condition, probably damaging the motor.

A better arrangement is shown in Figure 23(b). Device failure in this configuration will open the circuit breaker, shutting down the system but not destroying the motor. Figure 23(c) shows what appears to be a safe application of a surge suppressor, but when power is applied, the filament transformer-Variac combination can generate turn-on spikes that appear "amplified" at the primary of the Variac because of the step-up action from the secondary to the primary. With the filtering resistors and inductors in the line, the primary will ring at point "A" from the spikes generated in the secondary. Depending on the component values involved, CR1 could be destroyed by these normally occurring transients. An appropriate location for CR1 is shown in Figure 23(d).

Another example of an inappropriate transient-suppression application is shown in Figure 24. Diagram 24(a) shows a protection device placed across the high-voltage-on button of a broadcast





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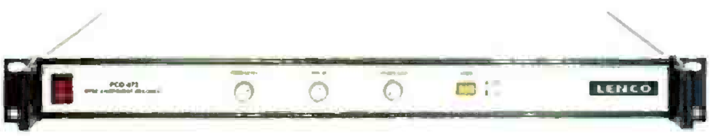

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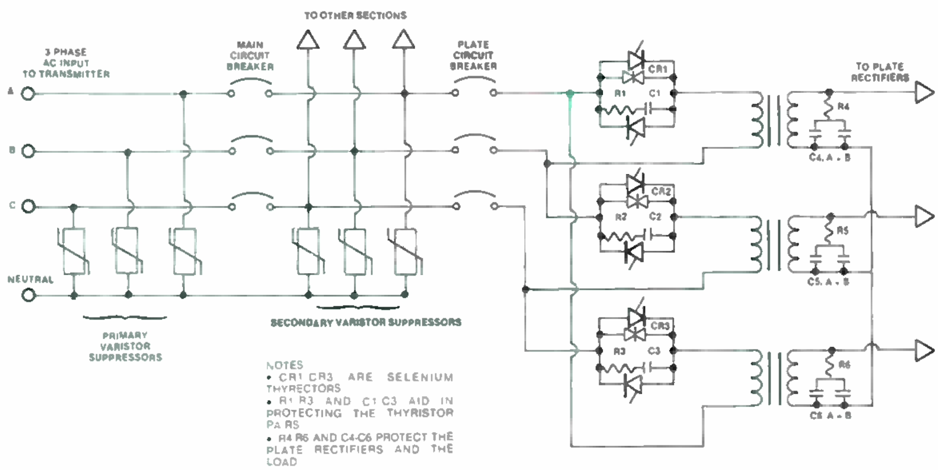
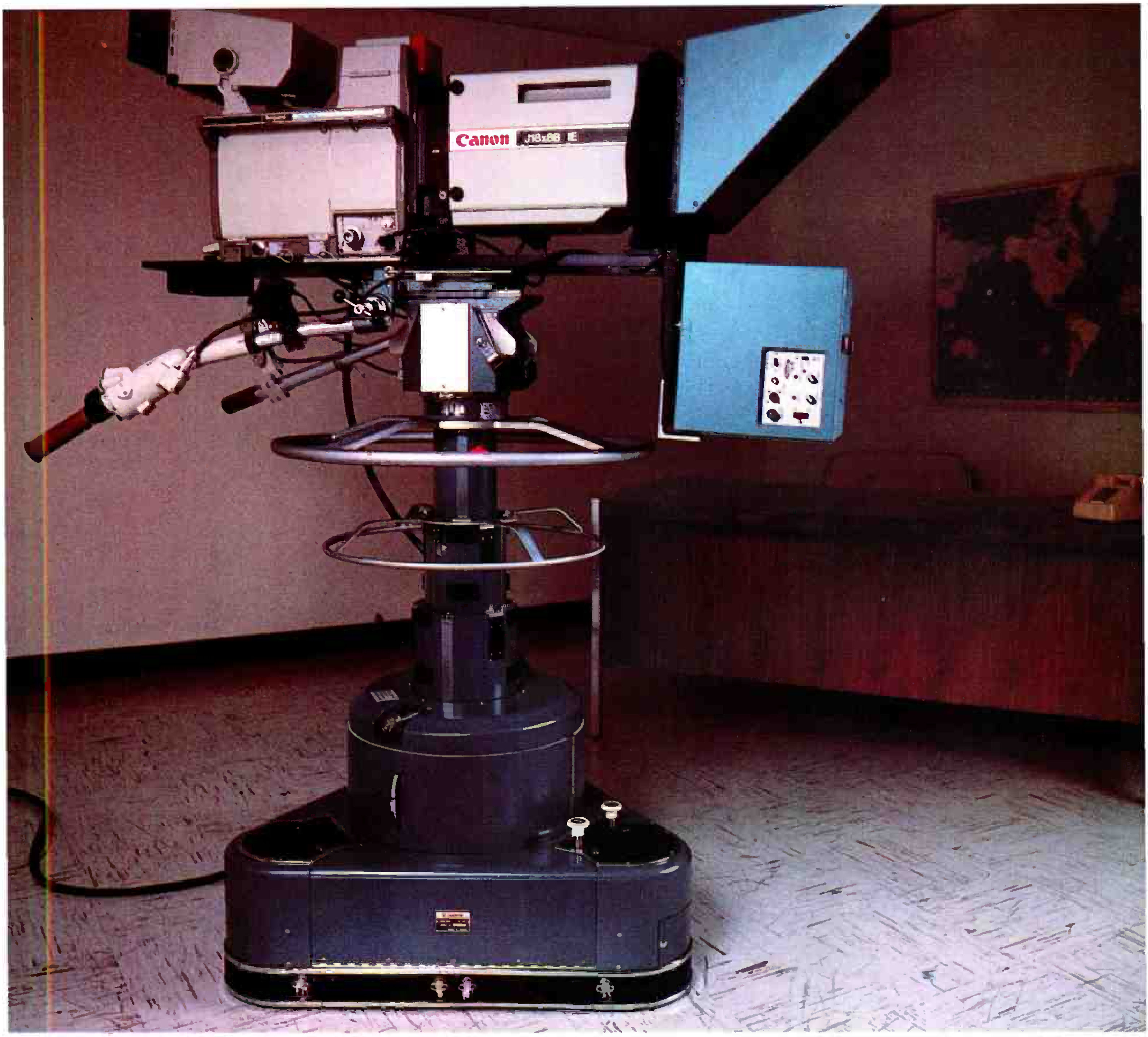


Figure 22. *The use of ac system series inductance and resistance to aid transient suppressors in controlling line disturbances in a broadcast transmitter high-voltage power supply.*

transmitter. Although this arrangement will extend the life of the switch contacts (especially if the button is switching 120Vac or 208Vac), failure of the device could prevent the transmitter high-voltage supply from being turned off in the event of an overload. Serious equipment damage could result. Figure 24(b) shows a preferable transient-suppression arrangement, in which the protection device is placed across the relay coil. Failure of the device in this configuration would shut down the transmitter and prevent any further damage.

It is important to choose the correct application of a transient-suppression device and to select one capable of carrying the transient energy that will be present in the circuit as well. This point is illustrated by the application shown in Figure 20(d) for telco audio or data loops. In the circuit, two General Semiconductor No. 1.5E12CA protection devices are tied between ground and the telco loop. The devices used will clip at about +20dBm, more than the maximum audio level expected on the line.

In an actual application of several pairs of these devices, however, it was found that, after several months of service, some of the suppressors began to fail. Those failures surfaced because of continual overstressing of the components caused by telephone company fault conditions. Voltages normally used in the dial-up telco network typically run about −48V and could destroy the specified protection devices, depending on where the crossed lines occurred. The symptom noticed on the telco loops was increased noise, a result of the unbalanced condition created by the failure (in a short-circuit mode) of one of the transient suppres-



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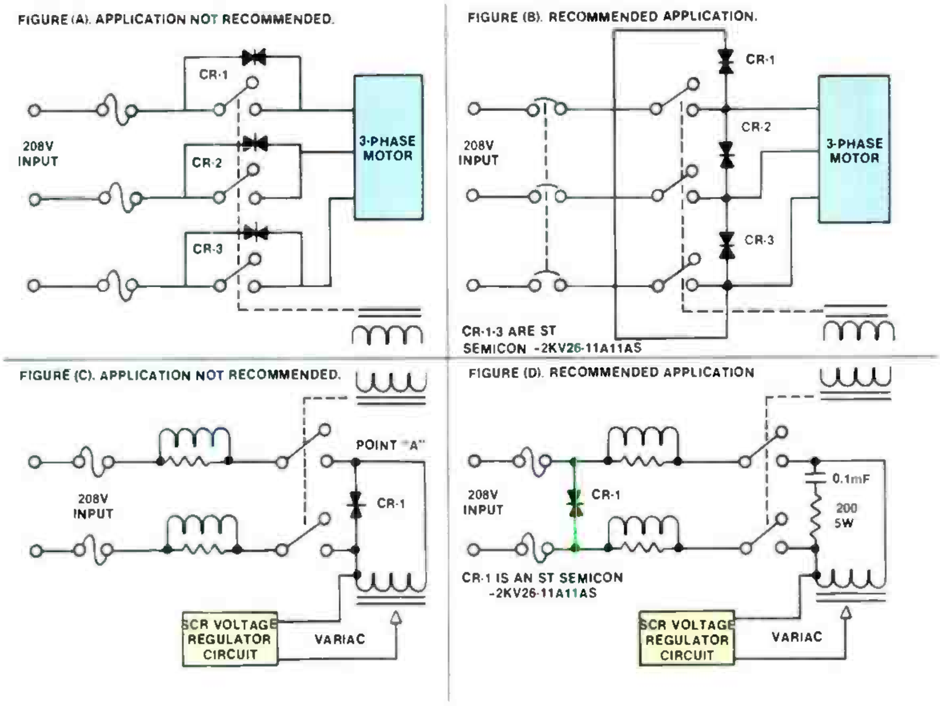

Figure 23. *Transient-suppression circuit arrangements that should be avoided (a) and (c), and the alternate configurations that provide fail-safe operation (b) and (d). The application of any transient-suppression component must be considered carefully, keeping in mind the various modes of operation and the possibility of protection-device failure.*

sors between a given line and ground.

The problem in this application was not with the protection device, but with the telephone company, which repeatedly crossed dial-up network voltages onto audio loops. In light of this situation, the dissipation rating of the protection device must be increased to deal with the failure modes that were observed to occur at the facility.

Plan ahead

Transient disturbances are a fact of life. The power quality in the United States is not improving. With increased loading and diminished reserves in some areas, it is becoming worse. Broadcasters will have to pay the bill for transient disturbances one way or the other—either for protection hardware or for equipment maintenance after the fact.

There is nothing magical about effective transient suppression. Disturbances on the ac line can be suppressed if the protection method applied has been designed carefully and installed properly. Whether the protection method your station chooses involves a systems approach or discrete devices at key points

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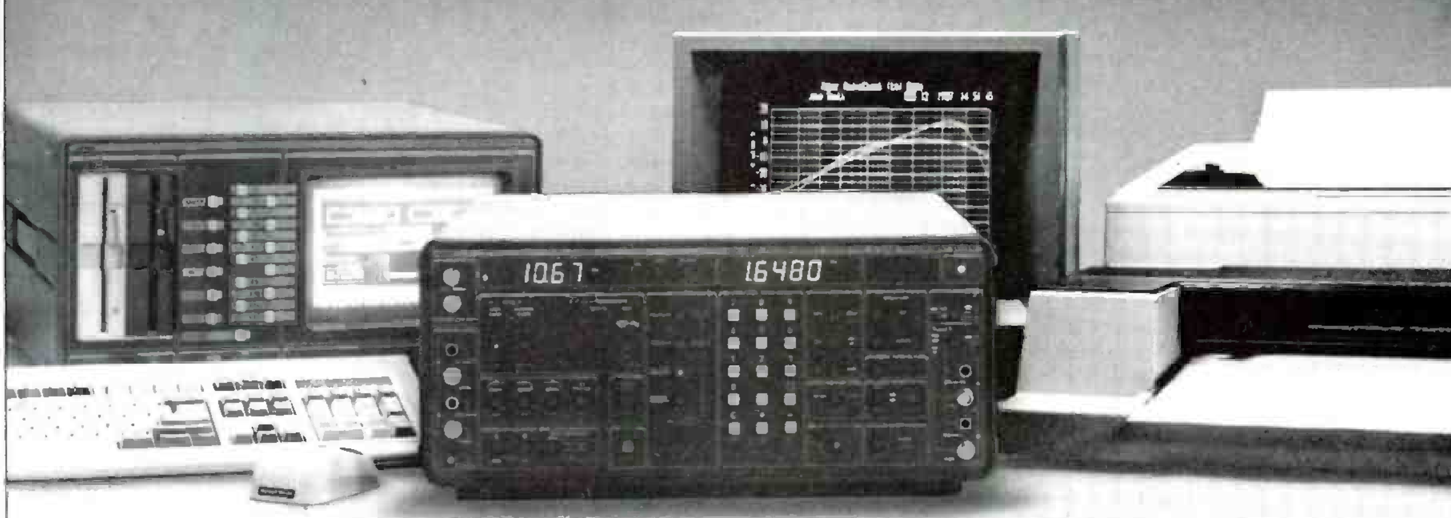

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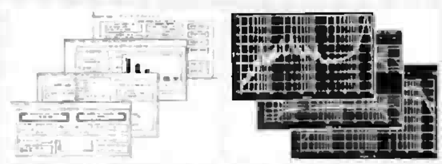

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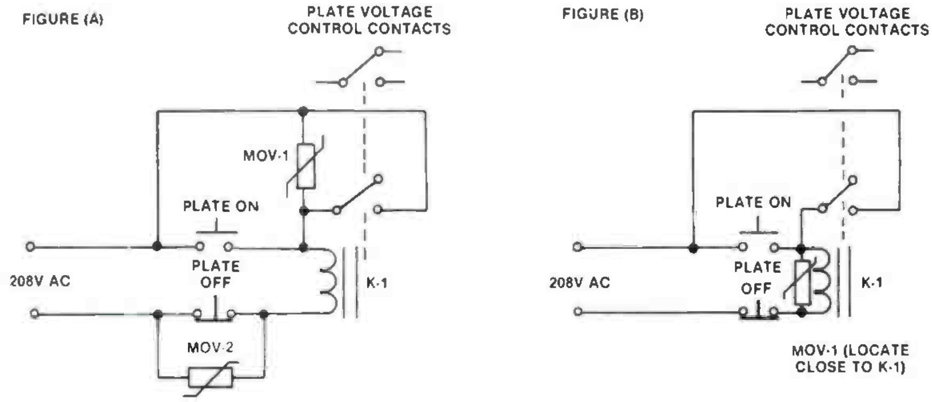

Figure 24. *A transient-suppressor application that should be avoided (a), and the proper method (b) of suppressing switch contact arcing in a transmitter control system. In any application, the consequences of protection-device failure (generally in a short circuit) must be considered.*

in the broadcast plant, the time and money spent incorporating protection into your facility will yield a good return on investment.

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2

The commission is watching

By Brad Dick, radio technical editor

Fewer regulations may mean tougher enforcement.

"Hi, I'm from the FCC and I'm here to help you."

FCC engineers probably don't greet station engineers and managers quite this way, but in this era of relaxed restrictions, it doesn't seem as far-fetched as it once might have. With deregulation, unregulation or reregulation (whatever you want to call it), the commission has assumed a quieter role. Of course there are rules to be followed, but far fewer than before. The number of field inspections also has been greatly reduced. However, some stations have found out the hard way that inspections still take place, and violations still bring fines.

Out with the old

The relaxation of regulations, which means fewer logging and inspection requirements, has caught some stations off guard. Many smaller stations no longer have full-time engineers. Consequently, a potentially troublesome technical matter might go unnoticed and eventually wind up as a problem that results in a violation notice. Even larger stations are not immune to the long arm of the commission.

The reduction of logging and inspection requirements is generally welcomed by the industry. Logs, for the most part, are a thing of the past. The required technical inspection is another task that engineers aren't sorry to see eliminated. Many of the deregulatory changes are simply reflections of modern technology. When was the last time your FM transmitter drifted in frequency by more than 100Hz? How about the transmitter power level? Is it automatically controlled? Today's equipment is just more stable and reliable than when many of the old rules were implemented.

Even so, stations must continue to meet the remaining applicable FCC requirements. One drawback to fewer regulations seems to be that the commission is now strongly enforcing the remaining ones. The emphasis is on compliance. It is more important than ever to know the rules and to follow them carefully.

TABLE 1. SAFETY VIOLATIONS

1. All tower lights out, FAA not notified within 30 minutes as required. *17.56, 17.48, 73.1213* ($2,000)
2. Majority of tower lights out and/or loss of top flashing beacon, FAA not notified within 30 minutes. *17.56, 17.48, 73.1213* ($1,000)
3. Tower lights not observed at least once each 24 hours. *17.47, 73.1213* ($500)
4. Temporary warning lights not present/operational during construction. *17.45, 73.1213* ($1,000)
5. Tower not properly painted, e.g. not the required color bands. *17.50, 73.1213* ($750)
6. High RF voltage at antenna base, hot base at antenna towers not enclosed, damaged fence allowing entry. *73.49* ($1,000)
7. High-voltage equipment not protected so as to prevent injury to operating personnel, damaged interlock, exposed wiring. *73.49, 73.317(b)* ($750)
8. Failure to conduct EBS tests. *73.961* ($300)
9. EBS monitor receiver and/or tone generator not operational or not installed. *73.932* ($1,000)

A matter of policy

To stress the importance of following the rules still in effect, the commission issued a memorandum in December 1985 that outlines a basic policy for field offices in the issuance of violation notices. The policy also suggests specific fines for certain violations.

The memorandum outlines a tiered enforcement program for rule violation of Parts 73 and 74. Under the policy, a *notice of radio station conditions* (FCC form 790) is issued for minor technical matters. This first-level notification concerns infractions that are not as serious as rule violations, but are likely to become violations or cause problems if left uncorrected. A notice also can be issued for minor technical rule violations that have little potential for adverse effects on others or on signal quality. No licensee response is required for this notification.

The second, and more serious, level is the *official notice of violation* (FCC form 793). This notification requires a response from the licensee. It may be issued when the technical violations are more serious than those for which a form 790 would be issued, but are not specifically designated in the policy statement and do not fall under the general categories of safety, interference-harm actual/potential or service quality violations. A notice of violation also can be issued for other specific technical rule violations designated by the mass media bureau.

The third, and most serious, notification level is the *notice of apparent liability* (NAL). This notice is issued for the willful or repeated violation of:

- Specific technical rules detailed in the memorandum.
- Technical rule violations more serious than would be appropriate for issuance of form 790 and which fall into the general categories of safety, interference-harm actual/potential, or service quality violations.
- The specific administrative and non-technical rule violations described in the policy statement.

Pay up

The process of fining a station can be

Continued on page 92

TABLE 2. INTERFERENCE-HARM ACTUAL/POTENTIAL

1. Overpower operation, frequency tolerance, excessive modulation resulting in interference, spurious and/or harmonic emission. *74.636, 74.661, 73.1560, 73.1545, 73.1570, 73.44, 73.317, 73.687* ($1,000 to $2,000)
• Examples:
Output power grossly exceeding the authorized power. ($1,000)
Where numerous complaints occur or where deliberate or malicious interference occurs or where significant harm is caused. ($1,500 to $2,000)
2. Failure to cease operation by remote control when a malfunction occurs in the remote-control system. *73.1410* ($300)
3. Failure to ensure correct calibration of remote antenna base, common point and extension meters, e.g. meter readings are grossly out of tolerance from licensed parameters. *73.57, 73.1550* ($300)
4. AM directional antenna systems tolerance, e.g. base and sample currents are grossly out of tolerance from licensed parameters. *73.62* ($600 to $1,500)
• Examples:
Discrepancy in AM directional parameters (as evidenced by more than 5% deviation of actual base and antenna monitor currents from licensed values) resulting from significant misreading of meters, e.g. wrong scale. ($600)
AM directional parameters grossly exceeding licensed values due to improper equipment installation. ($1,500)
5. Failure to make field strength measurements quarterly at the monitoring point locations for stations not having an approved sampling system. *73.61* ($600)
6. Terms of authorization, e.g. operating non-directional when directional is required, failure to change power at sunset and sunrise, for an extended period of time. *73.1745* ($1,000)
7. Station operating under post-sunset authority. *Docket No. 82-538*
• Examples:
Operating 50% over power. ($1,000)
Operating one-half hour or longer after the station was required to sign off under the post-sunset authority. ($1,000)

TABLE 3. ADMINISTRATIVE AND NON-TECHNICAL

1. Failure to maintain or have a complete public inspection file. *73.3526* ($300)
2. Failure to have a licensed operator on duty. *73.1860* ($200)
3. Willfully or repeatedly incorrect on entries, e.g. readings repetitively logged when the meter is defective. *73.1800* ($1,000)
4. The commission has reduced or eliminated the logging requirements detailed in a Report and Order dated August 12, 1983, Docket No. 82-537. However, it has maintained some logging requirements, and forfeitures will be imposed for failure to log the following:
• Tower lighting operation. *17.49, 73.1213* ($300)
• Experimental Broadcast Stations in Part 74. *74.181* ($300)
• AM broadcast stations operating without commission-approved antenna systems. *73.1820* ($600)
• Situations involving interference or deficient technical operation. FCC may require special technical records to be maintained, as necessary, to resolve special problems. *73.1835, 74.19* ($600)
• Tests of the emergency broadcast system. *73.1820* ($300)
5. Repeated failure to reply with assurance of correction/repair for violations listed on *notice of apparent liability. Section 308(b) of the Communications Act of 1934, as amended* ($1,000)
6. Failure to identify the station in the manner and at the times specified. *73.1201* ($500)
7. Minor technical, administrative and operation rules where the forfeiture penalty will result for repeated violation subsequent to initial violation where Form 790 notification occurred.
• Examples:
Failure to have available the EBS checklist. *73.908* ($300)
Failure to have available the EBS authenticator word list. *73.910* ($300)
Defective meters, improper scale/range, all powers. *73.1215* ($300)
Failure to have available a copy of the most recent antenna resistance or common point impedance. *73.1225* ($500)
Station and/or operator(s) license(s) not posted. *73.1230* ($200)
Failure to designate a chief operator (agreement not available or posted with operator license or in station records). *73.1870* ($500)

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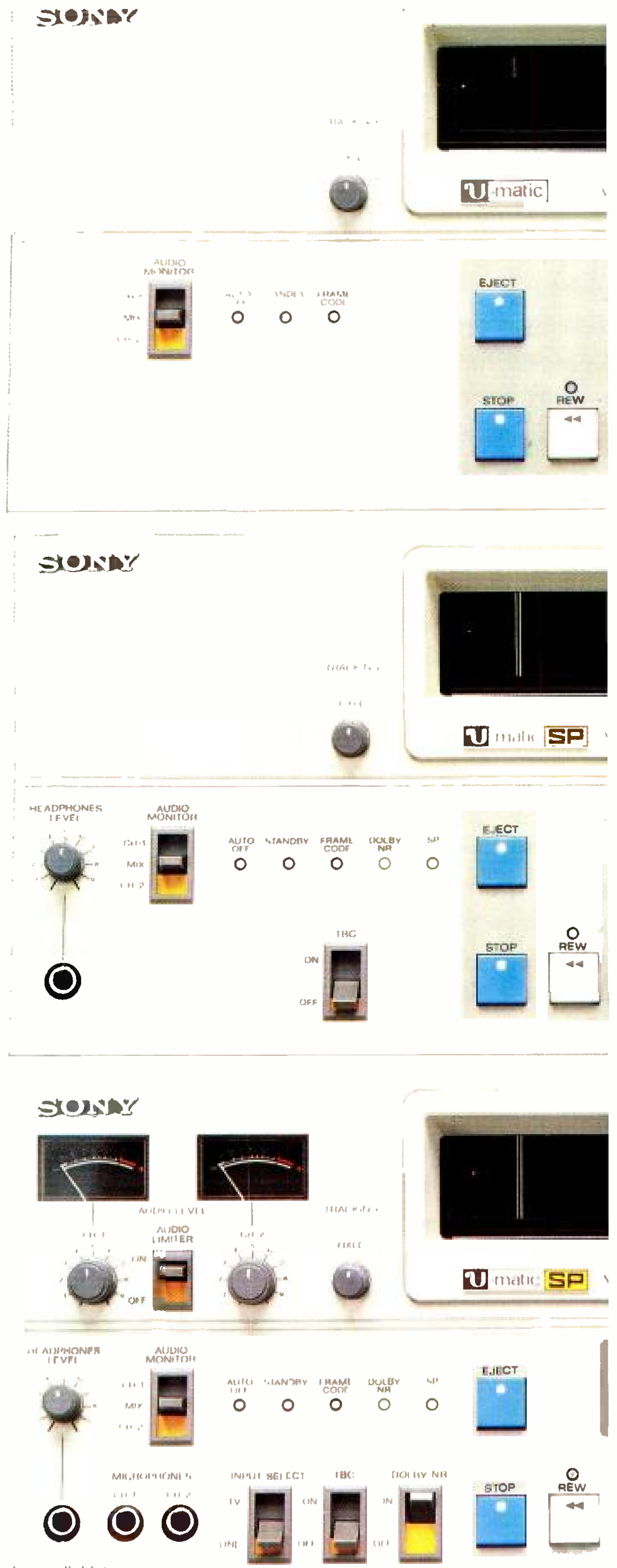

Some video experts would have you believe that the only way to upgrade your video equipment is to throw it all out and start over.

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In fact, with an RS-232C computer interface, you can preset your players and recorders to start and stop on certain frames or rewind and playback at certain times. So you can conveniently automate programming, insert commercials, or set up point-of-purchase displays.

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SONY

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TABLE 4. SERVICE QUALITY

1. TV pulse and reference levels. ($500)
2. FM stereo parameters. ($500)
3. SCA parameters. ($500)
4. AM audio performance requirements. ($500)
5. Excessive AM or FM modulation. ($500)

Continued from page 88

quite lengthy. If, upon inspection, the engineer in charge issues a NAL, the station has 30 days to respond to the notice. The NAL specifies the fine that could be levied for the cited violation.

The station can request a review of the NAL prior to the issuance of a *notice of forfeiture* (NOF). The field supervisor will review the NAL and inform the station of the determination. A higher-level review can be requested if a NOF is issued. At this point, the fine can be reduced or even canceled.

If a NOF is issued, the station has several options. The station can appeal the decision to the field engineer or chief of the field operations bureau. At this stage, if the NOF is judged to be correct, the station is ordered to pay the fine. If the station decides to pursue the matter, the commission may file a civil suit for collection of the fine. The process then passes to the courts. Both the FCC and the station present their cases before a U.S. District Court judge, who then issues a ruling. If the court rules against the station, an order for civil collection of the fine is issued.

Monetary fines are not always levied. Other administrative sanctions may be applied as deemed appropriate.

What's the cost?

Specific fines to be levied are listed in the FCC memorandum. Only in those cases involving mitigating circumstances may fines be adjusted by the field offices. However, the engineer in charge may increase or decrease the fine, with justification. The amount doubles for a second offense.

The listed violations are broken down into four categories: safety (see Table 1), interference-harm actual/potential (Table 2), administrative and non-technical areas (Table 3) and service quality (Table 4).

Each table lists specific rule violations, the applicable FCC regulation number for each and the fine to be levied. Some are further broken down with examples and appropriate fines. This material was taken from the December 1985 memorandum issued by the chief of the mass media bureau. BE

3

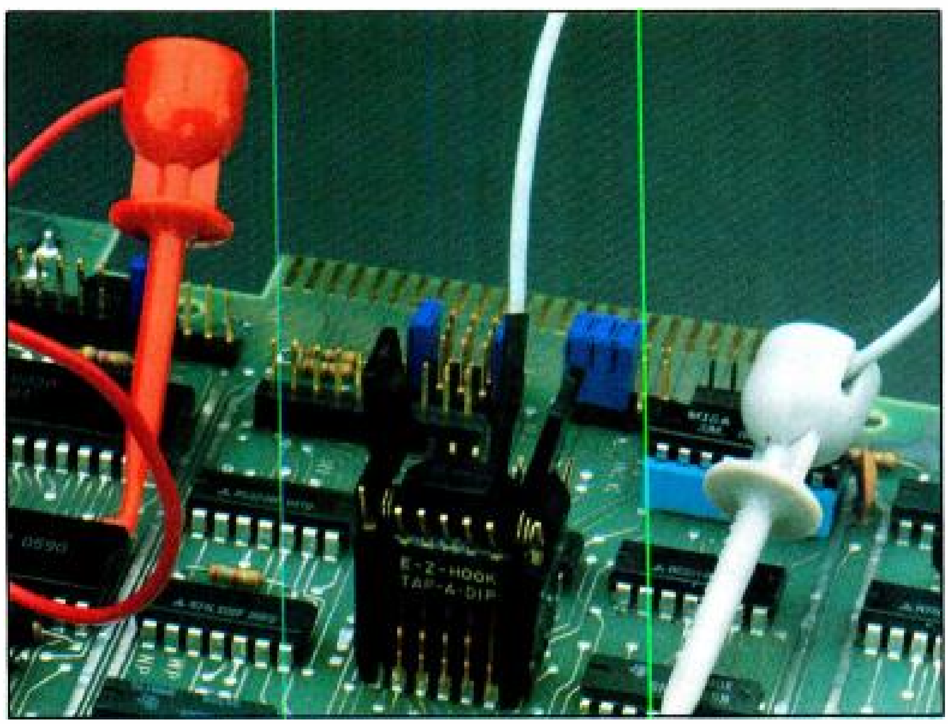
Using digital oscilloscopes

By Ed Caryl

Today's digital scopes can be powerful tools for the broadcast technician.

Maintaining the video and non-video circuits in a broadcast station today presents a wide range of technical challenges. Only a variety of test and measurement instruments can solve the problems a technician will face. Special needs require special instruments. Recent advancements in digital technology have made the digital oscilloscope a viable competitor with traditional analog scopes. Both types, however, have their strong points and weak points. The selection and use of a digital scope requires a full understanding of its operation and specifications.

Caryl is a technical communications manager with Tektronix, Beaverton, OR.



In a typical TV plant, maintenance work requires the following test and measurement equipment:

- A waveform monitor for making quick and easy video-signal level and timing measurements.
- A vectorscope for displaying, in familiar polar coordinates, video-signal phasing.
- An analog oscilloscope for displaying high-repetition-rate signals—video and non-video—in real time, in the studio or in a mobile unit.
- A digital scope for storing waveforms in local memory or sending them to another unit for analysis or comparison.

You probably are familiar with the many advantages of waveform monitors, vectorscopes and analog oscilloscopes. You may be less familiar with the advantages and unique features of new digital scopes for special video and non-video signal measurements. Figure 1 summarizes the advantages and capabilities of these four major waveform test and measurement tools for television.

All these tools are evolving. For exam-

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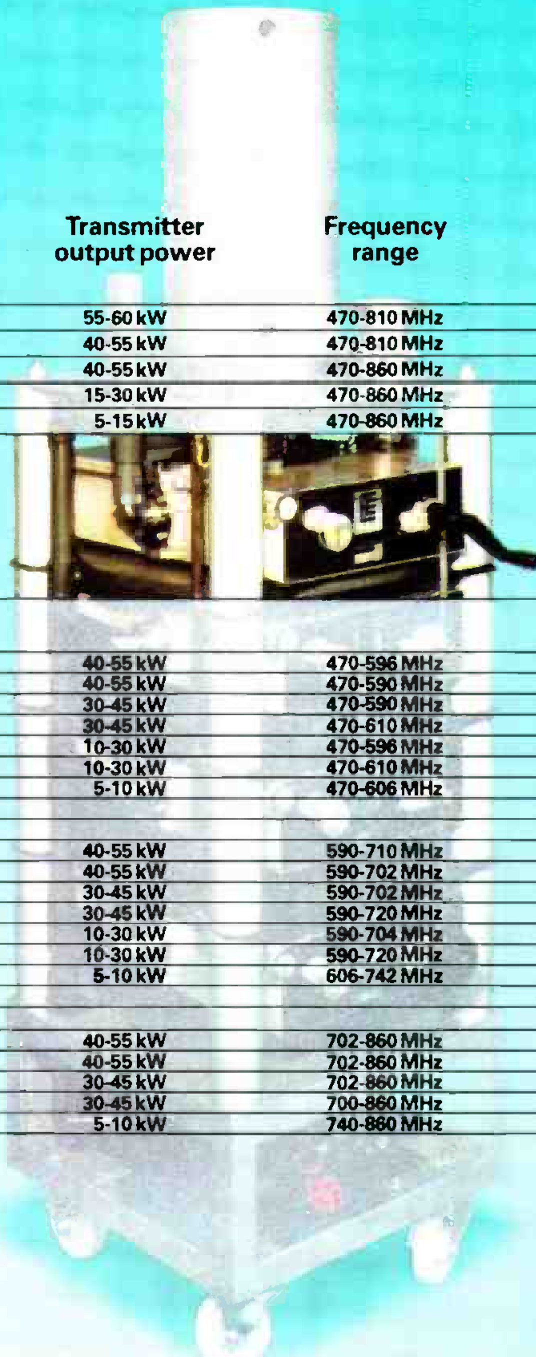

WIDEBAND SERIES	Transmitter output power	Frequency range	Typical Sync efficiency
K3672BCD	55-60 kW	470-810 MHz	44% to 48%
K3572BCD	40-55 kW	470-810 MHz	43% to 46%
K3272WBCD	40-55 kW	470-860 MHz	42% to 45%
K3271BCD	15-30 kW	470-860 MHz	42% to 47%
K3270BCD	5-15 kW	470-860 MHz	42% to 47%

STANDARD SERIES			
Low Band			
K3276HBCD	40-55 kW	470-596 MHz	38% to 43%
K3382BCD	40-55 kW	470-590 MHz	38% to 42%
K3217HBCD	30-45 kW	470-590 MHz	40% to 42%
K3282BCD	30-45 kW	470-610 MHz	30% to 40%
K3230BCD	10-30 kW	470-596 MHz	40% to 42%
K376L	10-30 kW	470-610 MHz	34% to 40%
K370/W series	5-10 kW	470-606 MHz	29% to 35%
Mid Band			
K3277HBCD	40-55 kW	590-710 MHz	38% to 43%
K3383BCD	40-55 kW	590-702 MHz	38% to 42%
K3218HBCD	30-45 kW	590-702 MHz	40% to 42%
K3283BCD	30-45 kW	590-720 MHz	30% to 40%
K3231BCD	10-30 kW	590-704 MHz	40% to 42%
K377L	10-30 kW	590-720 MHz	38% to 45%
K371/W series	5-10 kW	606-742 MHz	32% to 35%
High Band			
K3278HBCD	40-55 kW	702-860 MHz	38% to 43%
K3384BCD	40-55 kW	702-860 MHz	38% to 42%
K3219HBCD	30-45 kW	702-860 MHz	40% to 42%
K3284BCD	30-45 kW	700-860 MHz	30% to 40%
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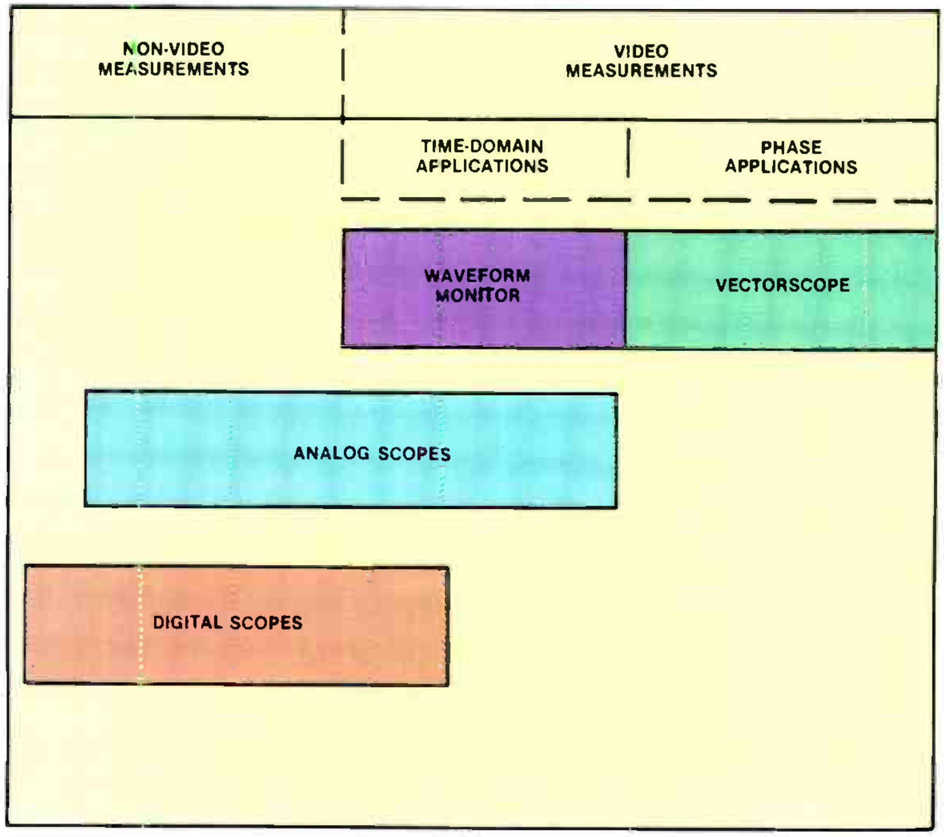
Figure 1. A quick comparison of TV studio test and measurement equipment (a), and a detailed look at the advantages and features of four major types of TV measurement equipment (b).



ple, vectorscopes and waveform monitors now are available in portable, even battery-powered, packages. Combined waveform monitors and vectorscopes also are available. Analog scopes are adding capabilities formerly found only in digital scopes, such as automatic amplitude and time measurement.

Digital scopes for special needs

New digital scopes offer advanced features that allow maintenance engineers to handle special problems that were difficult, or even impossible, to solve in the past. In the engineer's tool kit, digital scopes can be a welcome addition to the proven value of waveform monitors, vectorscopes and analog scopes. Figures 2 and 3 illustrate the major scope technologies.

After a digital scope has digitized a test signal, it can store the waveform in memory or send the waveform to another device. Local (in-scope) storage allows you to save a known-good waveform at one test site, acquire a possibly faulty waveform at another site and compare the two on-screen for a quick pass/fail test. With battery-backed memory, portable digital scopes can store a complete set of comparison waveforms for months. (See Figure 4.)

Digital scopes can make some special measurements that analog scopes cannot make unless they use *microchannel plate* (MCP) display technology. MCP is an electron-multiplier device located behind the screen phosphor. The MCP amplifies cathode ray tube (CRT) beam current, producing a high CRT writing rate.

A digital scope allows you to display—at full brightness—the waveform of a low-repetition-rate signal, such as single lines or parts of lines at the color field rate.

Video maintenance today typically includes checking many digital signals, such as digital effects, computer-generated video and digital video switching pulses. These operations use complex signals and single pulses that may occur only once per frame or once per color field. Pulses such as VCR servo control signals, which are a few nanoseconds wide and occur 15 to 30 times per second, are difficult to see on almost

TEST AND MEASUREMENT TOOL	MAJOR ADVANTAGES	EXAMPLE UNIQUE CAPABILITIES
WAVEFORM MONITOR	Allows quick, easy visual checks of video signals; dedicated to video measurements.	Front-panel and display graticule are optimized for specific TV measurements.
VECTORSCOPE	Provides a high-resolution vector display of chrominance phase and amplitude.	Demodulates color video, and displays phase and amplitude of chroma components.
ANALOG SCOPE	Measurement versatility provides a video and non-video general-purpose tool.	High display rate allows user to see infrequent changes in high-repetition-rate signals.
DIGITAL SCOPE	Can apply signal averaging to reduce signal noise for more exact measurements. Can display low-repetition-rate signals at normal brightness.	Captures, stores, and transfers waveforms. Envelope mode allows measuring peak-to-peak noise and chroma levels.

any analog scope. They can be viewed easily, however, on a digital scope.

Vertical interval test signal (VITS) and vertical interval reference signal (VIRS) waveforms occur at the frame rate. These signals are difficult to see on most analog scopes. (MCP analog scopes are the exception to this rule.) Triggering on individual lines in a field is another barrier for most scopes in video applications. However, an analog or digital scope with advanced TV triggering capabilities can use VITS and VIRS to troubleshoot or adjust video equipment using the broadcast video signal. Figure 5 shows an example waveform.

Some analog and digital scopes can trigger on a specific line in a specific field. The readouts at the top of the digital scope display of Figure 5 show that the scope is triggering on the horizontal sync pulse negative edge of line 70 in field 2.

A digital framing pulse occurs 29μs into line 70, field 2, so the user has delayed time base B by 29.3μs into line 70 to display the pulse for detailed examination. The upper trace (channel 1) shows a digital framing pulse. The user has set the cursors to measure the pulse width (73.500ns). Because of its low repetition rate, this narrow TTL pulse would not be visible on analog scopes that don't use MCP technology.

Digital scopes can end another headache—the need to continuously watch a display for an intermittent error or failure. You may need to watch a waveform for interference hits in the transmission system. You also may need to look for arcs within various stages of the transmitter, high-power filters, transmission line or broadcast antenna.

Consider the following example. You are using a scope that has a "babysitting" feature. First you display the normal waveform, then you build an envelope of limits around the target waveform. A spike on the test waveform or drift beyond the specified limits causes the scope to store the data in memory or to document it on a printer or plotter.

While the scope baby-sits the signal, you can attend to more challenging tasks or simply finish your work at a reasonable hour. Figure 6 shows a baby-sitting example. The screen display illustrates the horizontal sync pulse and the rising edge of the VITS on line 17, field 2. (To simplify the display, this example shows a black-and-white signal.) The envelope around the signal sets acceptable amplitude limits above and below the expected values. If the test signal exceeds the envelope, the scope captures the waveform, stores it and outputs it to a printer.

You have another choice, too. You can send a waveform from the scope to com-

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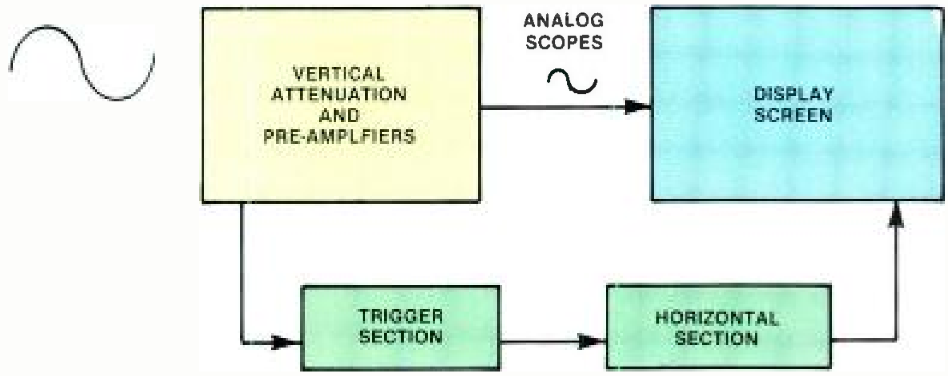


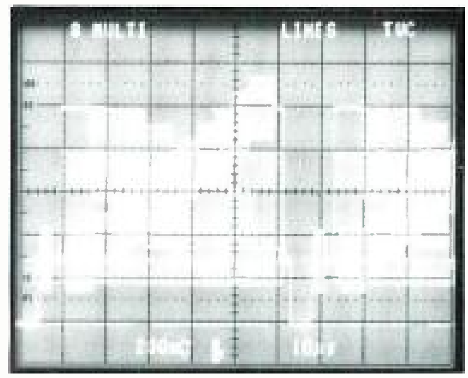
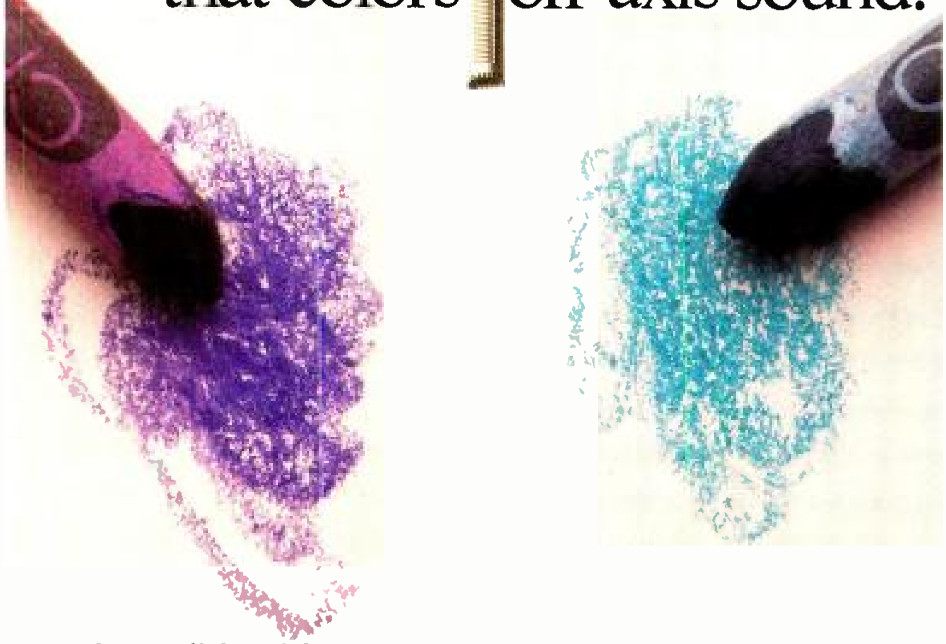


Figure 2. Simplified block diagram of an analog oscilloscope (a). The display shown in (b) is from an analog scope triggered on all TV lines. It illustrates three waveforms: color burst, a staircase and red bar. The photo demonstrates the analog scope's capability to display a waveform from any point in a TV system. (At the top of the screen, the readouts reveal that the front-panel setup for this display was saved in the eighth setup, the setup was named MULTI, the scope is triggering on all TV lines and the TV clamp is on.)



puter memory or to another peripheral device. At your leisure, you can recall the waveform for re-examination, comparison to other waveforms or identification of long-term performance trends.

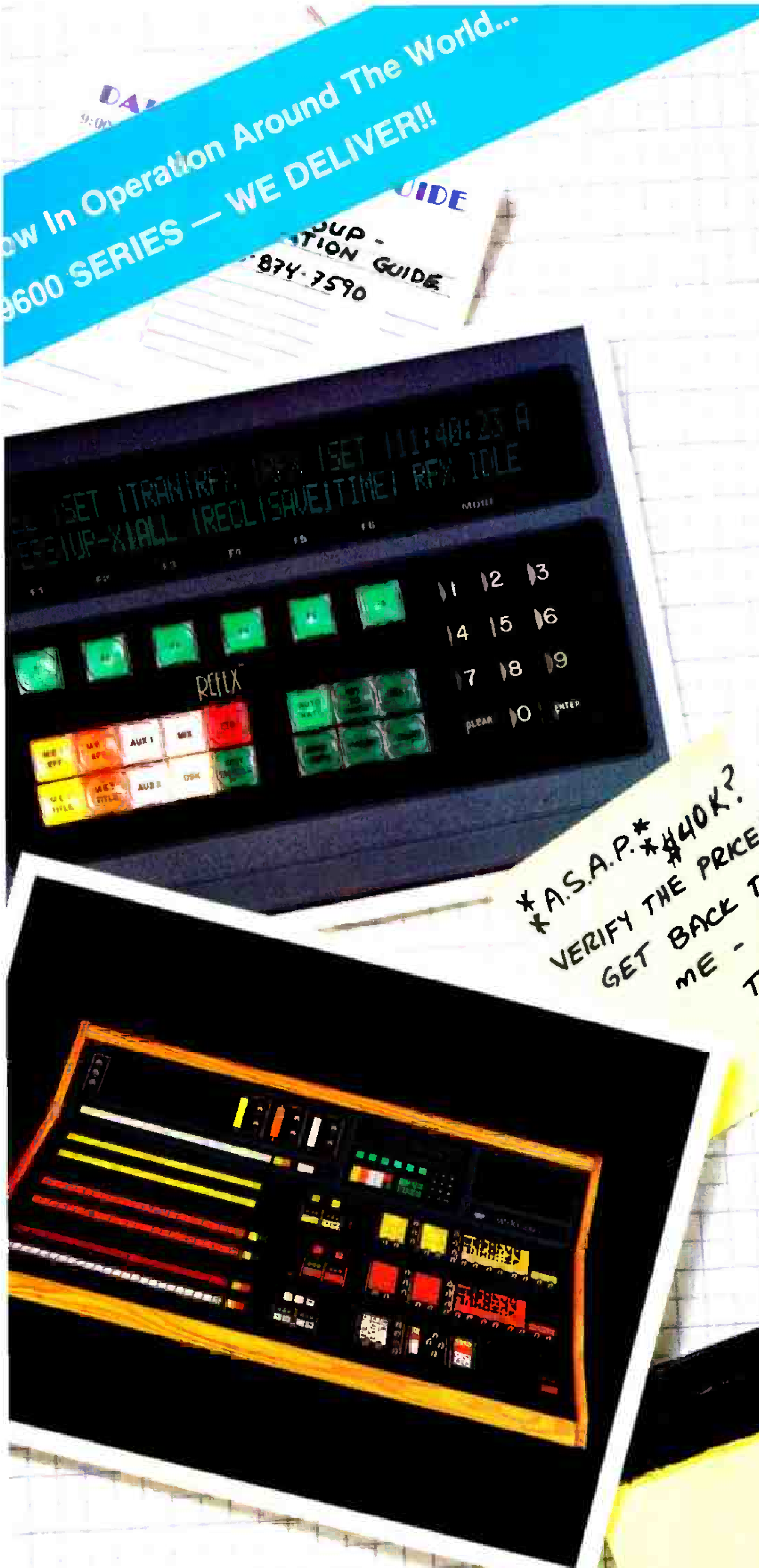
Automating test procedures

Programmable signal generators and digital scopes can be integrated into computer-controlled systems that automate and speed maintenance procedures. For example, a controller, scope and companion test-generator program allow maintenance engineers to generate—without writing any code—a test procedure for a wide variety of broadcast hardware, such as the servo section of a video recorder.

Such automated test procedures combine two sources of troubleshooting knowledge: the manufacturer's recommendations contained in the service manual and your own experience working with the equipment. With the proper test procedure stored on a PC (the controller), an engineer who is less experienced with a given piece of equipment can follow the troubleshooting routine step by step, attach the scope probes to the proper test points, and let the program make the pass/fail and branch decisions.

Still another dimension that digital scopes can add to automated test systems is the capability to transfer captured waveforms to the PC for display or analysis.

The most advanced digital (and analog) scopes allow you to create test sequences on the scope front panel. You don't need a controller, and you can store a large



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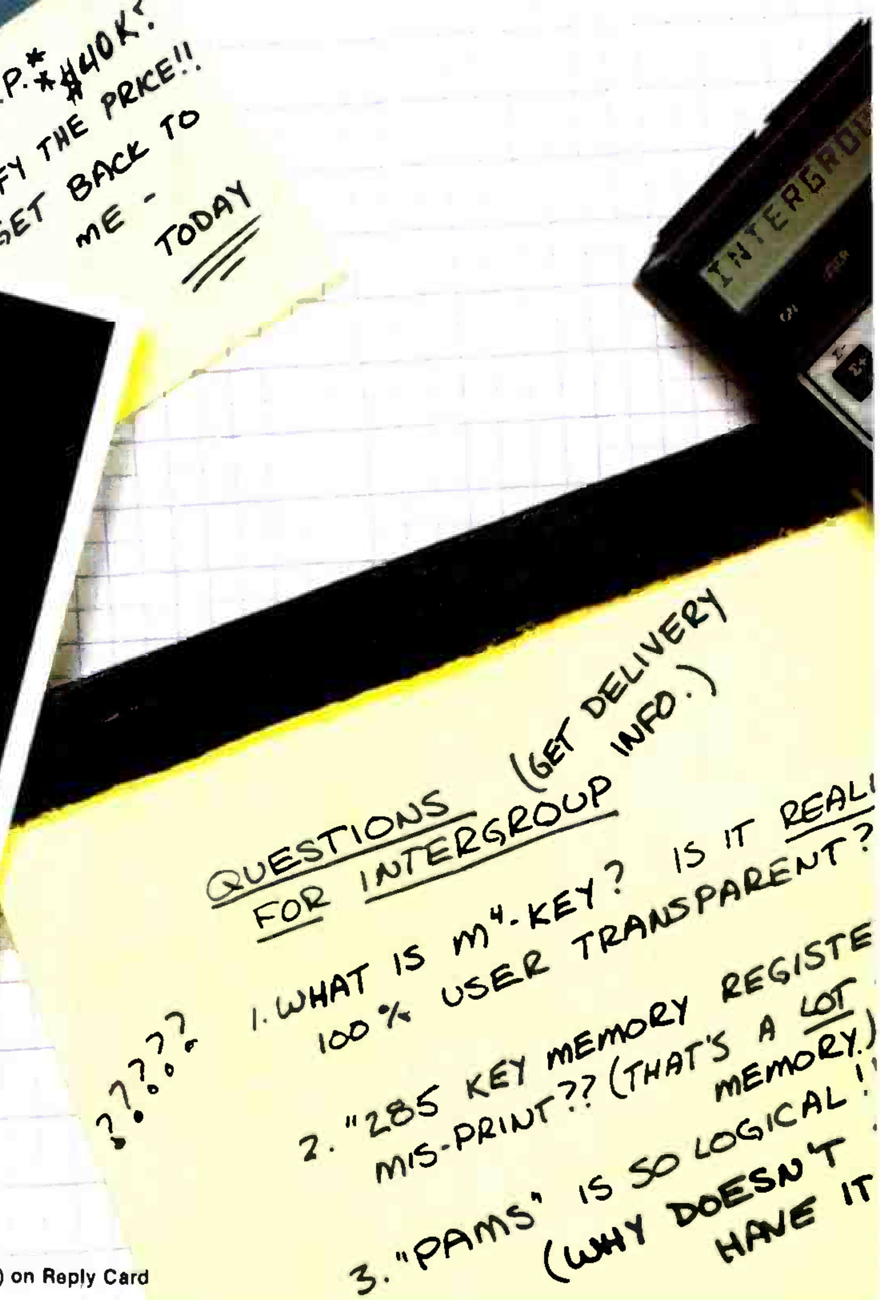

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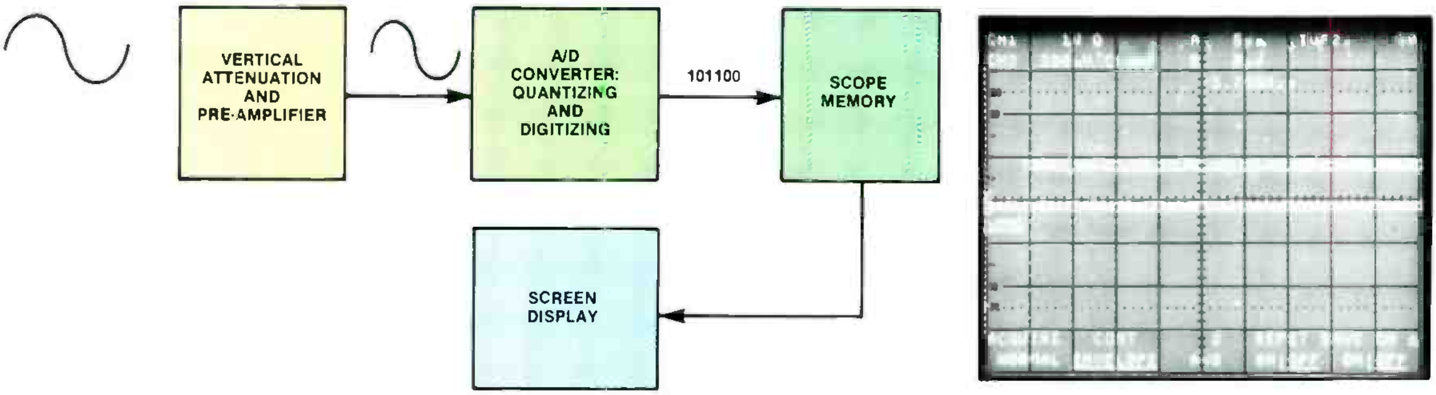

Figure 3. *Simplified block diagram of a digital oscilloscope (a). The display shown in (b) is from a digital scope set to measure part of line 70, field 2. The upper trace (channel 2) shows the video component of the signal. The lower trace (channel 1) reveals, in the scope's envelope mode, a digital framing pulse peak (lower center). A unique feature of digital scopes, this mode shows waveform maximum and minimum points (peaks).*

number of steps (up to 200 is not uncommon). Each step consists of a front-panel setup or scope action or both. The setup can be complete for a particular measurement, including presetting measurement cursors. The setup may include acquiring a waveform and sending it to a printer or plotter.

This level of automation improves throughput, increases repeatability, reduces drudgery and minimizes the potential for operator error. Figure 7 shows an example system designed using standard programmable video test and measurement instruments. An IEEE standard 488 GPIB (general-purpose interface bus) cable connects the instruments to the PC.

Limitations

In some digital scope applications, aliasing may occur. (See Figure 8.) Aliasing results from undersampling: the scope acquires too few sample points to accurately capture the signal being measured. Chroma bursts often are aliased in digital scope displays of video waveforms.

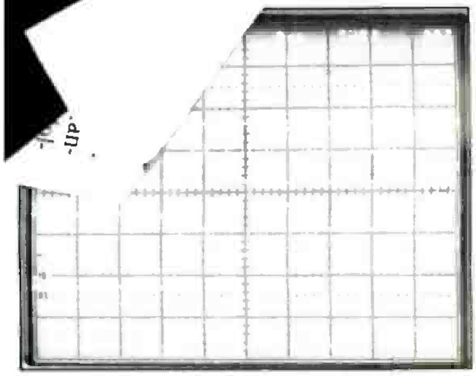

Figure 4. A digital scope has the capability to store and redisplay a waveform. The display shown here compared a stored reference waveform (REF 2) in the lower trace with a real-time sync and burst waveform from line 257, field 2, in the upper trace.

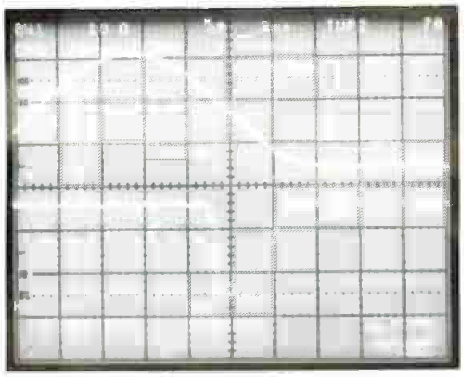

Figure 5. A digital scope display showing the capability of triggering on a specific line in a specific field. Note that the digital scope can display a waveform of low repetition rate at full brightness.

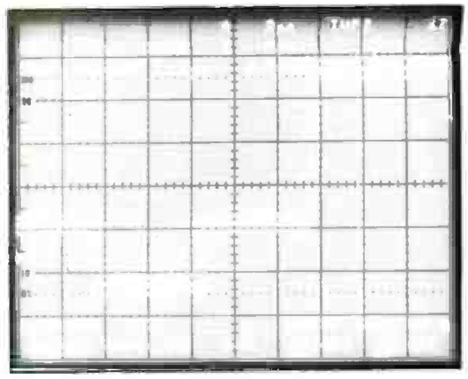

Figure 6. A display showing a user-defined envelope of test limits around a real-time waveform.

In some applications, the problem with aliasing is that the operator is unaware it is occurring. Scopes with advanced features offer an easy way to check for aliasing. In one approach, the *envelope mode* records the minimum and maximum values at each point, providing an outline of the true waveform. This information alerts the operator that aliasing is occurring on the displayed waveform.

Two techniques prevent aliasing. Digital scopes that use *vector* displays interpolate between sample points and connect them with straight lines (vectors). Increasing the scope sweep speed more directly reduces aliasing because more sample points are displayed.

Key digital scope specifications

Many of the key specifications for digital oscilloscopes are similar in nature to those for analog units. However, several of the following specs, unique to digital scopes, are important to consider during the selection process.

- *Bandwidth and sampling rate:* These two specifications are related.

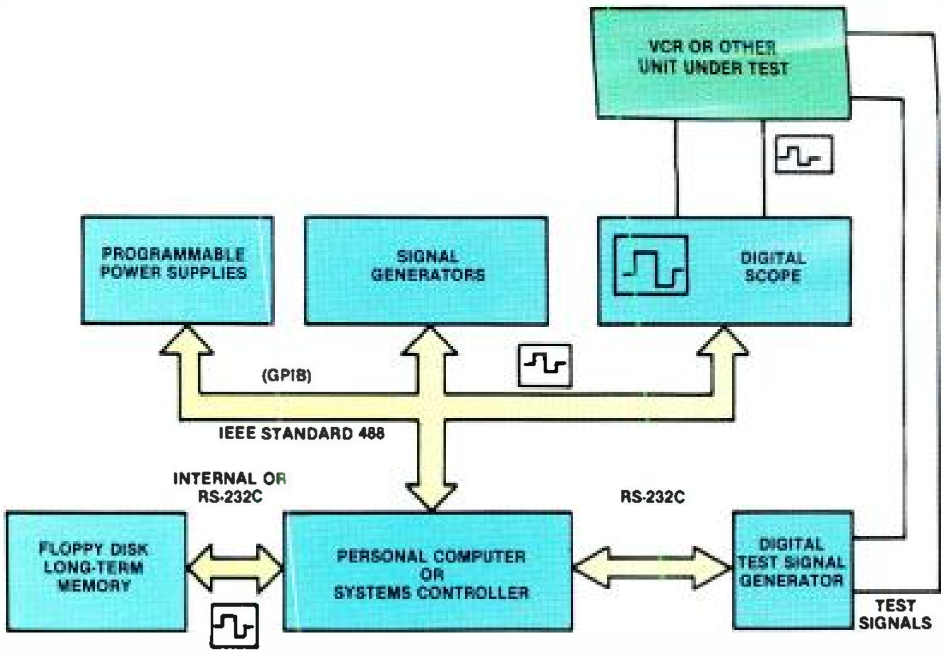

Figure 7. *A simplified block diagram of a PC-based, modular automated test system that uses a digital scope for waveform acquisition, processing and transfer.*

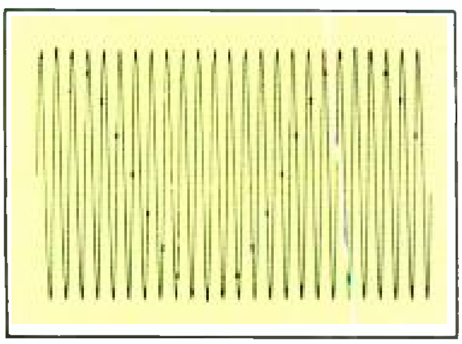

Figure 8. *An illustration of the problem of aliasing in digital oscilloscopes. Aliasing can be thought of as an optical illusion. If the scope takes too few samples to accurately define the applied signal frequency, the user can see a waveform that apparently has a lower frequency.*

but not identical, digital scope parameters. *Bandwidth* is the range of frequencies a scope can acquire and display with less than 3dB attenuation. Digital scope manufacturers specify bandwidths for two conditions, *repetitive* and *single-shot* (single-event) acquisitions.

For repetitive acquisitions, the bandwidth often is called *analog bandwidth* or *equivalent-time bandwidth*. This specification is the bandwidth of the scope's analog signal path.

Single-shot bandwidth is the bandwidth of the scope when it makes only one acquisition, whether the test signal is repetitive or single-event. This specification depends on three factors:

1. The sample rate of the instrument.
2. The type of interpolation used to reconstruct the signal.
3. The number of coefficients used to perform the interpolation.

- *Useful storage bandwidth* (USB):

USB is a valuable way to observe the capability of a digital scope to display sine waves. USB is the maximum digitizing rate divided by the number of samples the scope needs in order to properly display a sine wave.

The digitizing rate is the number of samples that the scope acquires per second (a common number is 100 megasamples/second). The number of samples needed to display a sine wave depends on the type of interpolator the scope uses. (An interpolator adds data words between the sample points.)

- *Averaging and smoothing:*

These two waveform processing techniques make signal viewing easier. Averaging works on multiple acquisitions of samples of the signal under test. This feature numerically averages the vertical (voltage) values for each time point on the waveform over the number of acquisitions chosen by the user. Averaging reduces random noise in repetitive signals and increases effective resolution.

Smoothing reduces noise on single-shot acquisitions of the signal under test. Smoothing firmware examines several points at once on an acquisition, then processes the set of values to reduce noise.

Selecting an oscilloscope

The selection of an oscilloscope—analog or digital—should be ... all of the pertinent facts ha... amined, and the cost vs. benefi... approach have been studied. When ... ning such a purchase, consider the ... lowing recommendations:

- *Define your application.* Digital scopes are appropriate for many non-video applications in a TV broadcast facility. They also are well-suited for some special video needs.
- *Examine your needs.* What kinds of non-video measurements will you be making? Single-shot or repetitive? At what frequencies? How faithfully do you need to reproduce the signal? What is the required accuracy and resolution?
- *Know whether the scope is user-friendly.* Capitalize on your familiarity with analog scopes. Some digital scopes have front-panel designs similar to popular analog units. Others combine analog (non-storage) and digital (storage) features in one unit. Find a unit that you are comfortable operating. Familiar operation can make your maintenance work more efficient.
- *Study the specs.* Take time to understand the key specifications of the units you are considering. For digital scopes, the terms sample (digitizing) rate and useful storage bandwidth may be new to you.
- *Look for easy-to-use features.* Digital or analog scopes with advanced features cut drudgery, save time and improve results simply because they are easier to use. For example, on some scopes, you can attach probes to a test point for an automatic display of several cycles of an unknown non-video signal. The scope sets itself up at the touch of one button. Another example is the capability to select specific measurements from an on-screen menu. The scope makes the measurements automatically and displays the numerical results alongside the waveform.
- *Consider the video applications.* Look for scopes designed to work with video. Some digital scopes have options that enhance the unit's performance when it displays a video waveform. An effective digital scope for video applications should include:

1. A sync separator capable of triggering the scope on any line in either field.
2. Backporch clamp circuitry.
3. The capability to work with traditional standards (NTSC, PAL and SECAM) and non-traditional video standards (HDTV, PC displays a... other non-standard displays).

The choice of an oscilloscope for maintenance work is one that you—and the other technicians in your facility—will have to live with for a long time. Make the selection carefully.

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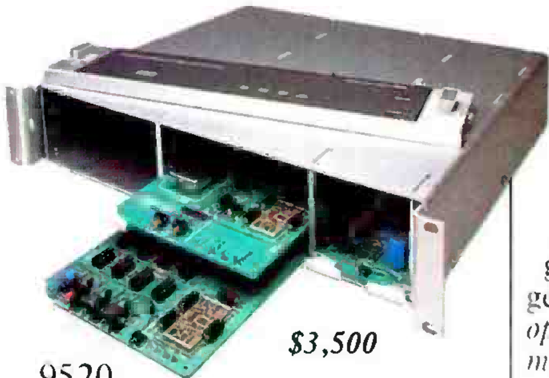

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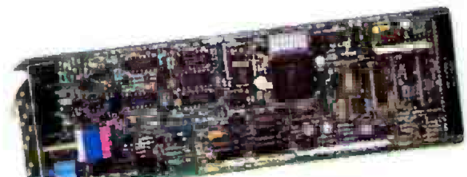

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4

Testing stereo audio for mono compatibility

By Mike Coleman

If you want to broadcast quality stereo TV, you need to know what your audio system is doing.

One of the most misunderstood problems with TV stereo audio is monaural compatibility. Producing a stereo program that is compatible with mono TV sets is critically important, because mono listeners greatly outnumber stereo listeners—and they will for many years to come.

Mono listeners hear the sum of the left and right channels. But a good mono sum results from good left and right audio only if both channels are processed identically. You can't check each channel in isolation and expect an acceptable mono sum to result.

Consider this example: Figures 1(a) and 1(b) show the frequency-response plots of a stereo audio system. Everything looks all right, and you might expect good mono. But look at Figure 1(c). It shows the frequency-response plot of the monaural sum of this system, which has a pronounced high-frequency rolloff. This particular problem is caused by a 30μs delay in the left channel. The frequency-response curve in Figure 1(c) was generated using common broadcast equipment, and it is typical of the problems broadcasters face with processing equipment in the audio chain.

You can observe and measure compatibility problems in two ways. Because the mono listener hears the sum of the left and right channels, you can add them in a test environment and make measurements directly on the resulting signal. This is easy to do and eliminates any guesswork. The other way is to indirectly monitor the mono sum by feeding the same signal to both channels and observing the phase relationship between the channels at the output. Each technique has its place in TV station operation.

The summing amplifier

Making measurements on mono frequency response is simple if you have a summing amplifier. You can either purchase one or use the circuit shown in Figure 2 to make one. The output of the summing amplifier is what the mono listener hears. The plot in Figure 1(c) was made by measuring the output of a summing amplifier while sweeping the frequency of the left and right audio channels.

Coleman is a hardware/software engineer with the TV division of Tektronix, Beaverton, OR.

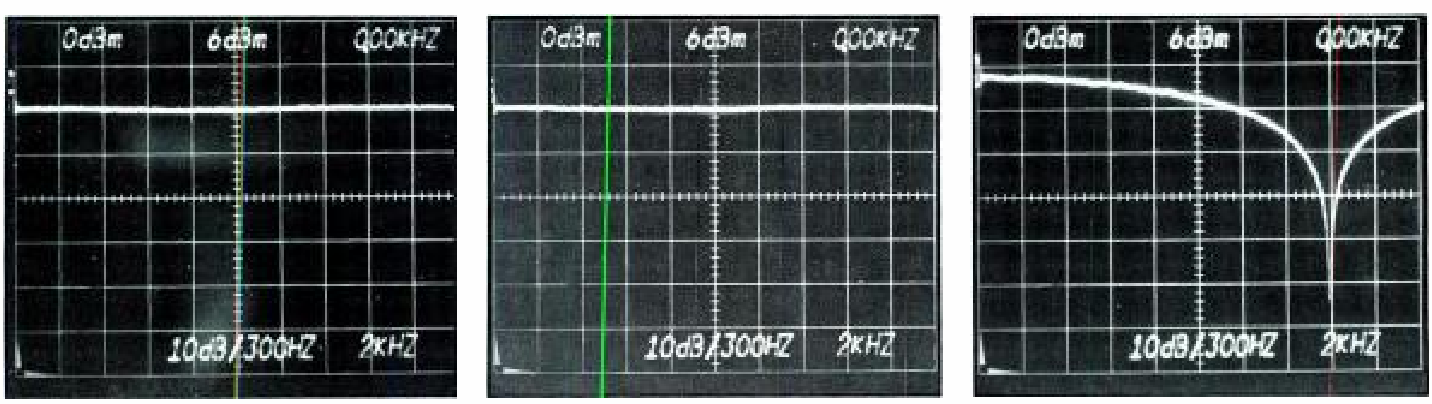

Figure 1. The frequency-response plots of a stereo audio system. Oscilloscope photo (a) shows left-channel amplitude vs. frequency. Photo (b) shows right-channel amplitude vs. frequency. Both plots seem perfect until the signals are summed to mono, shown in scope photo (c). Note the deep notch caused by a phase differential between the right and left channels. (Horizontal scale = 2kHz/div, beginning with 0kHz on the far left side of the display. Vertical scale = 10dB/div.)

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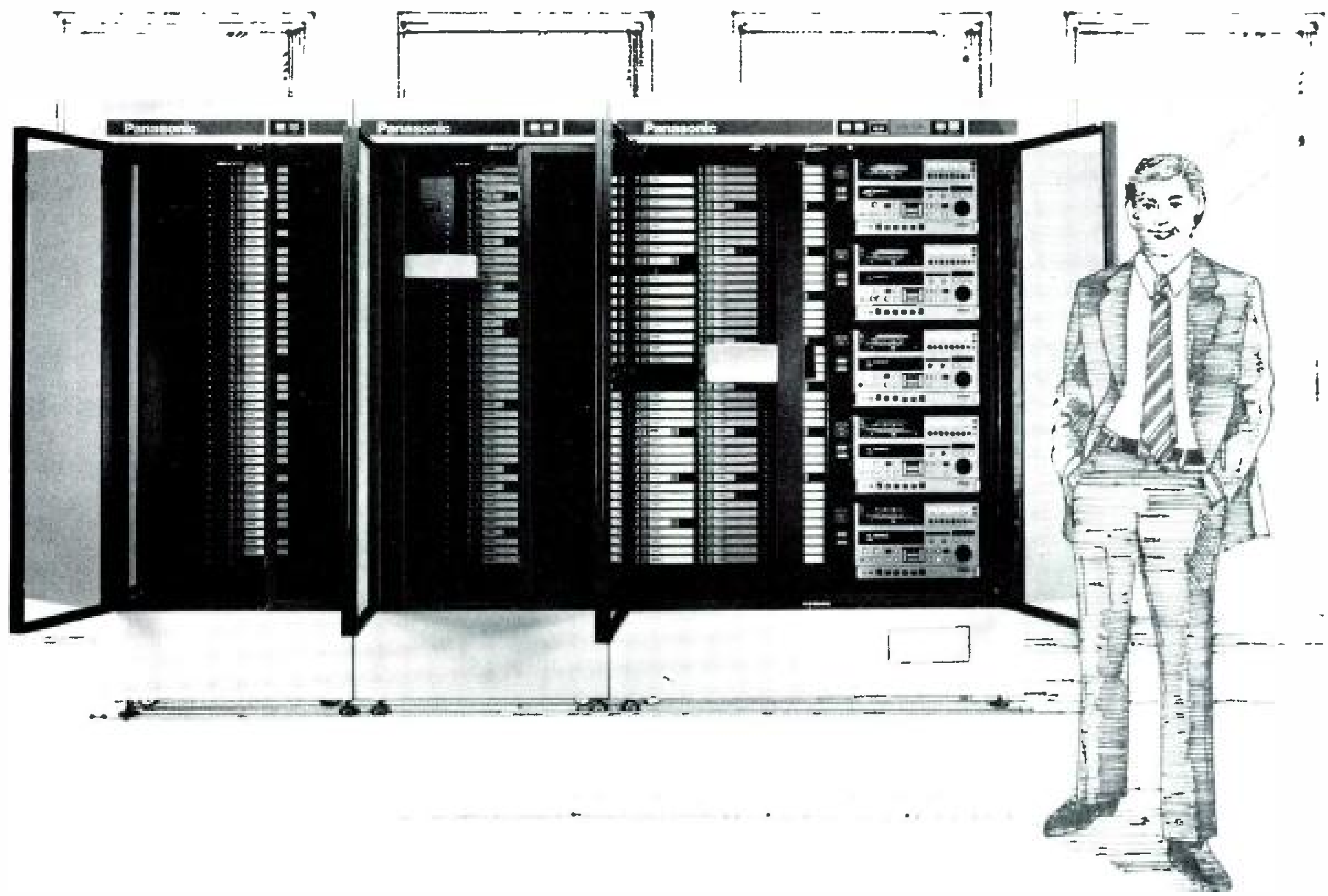

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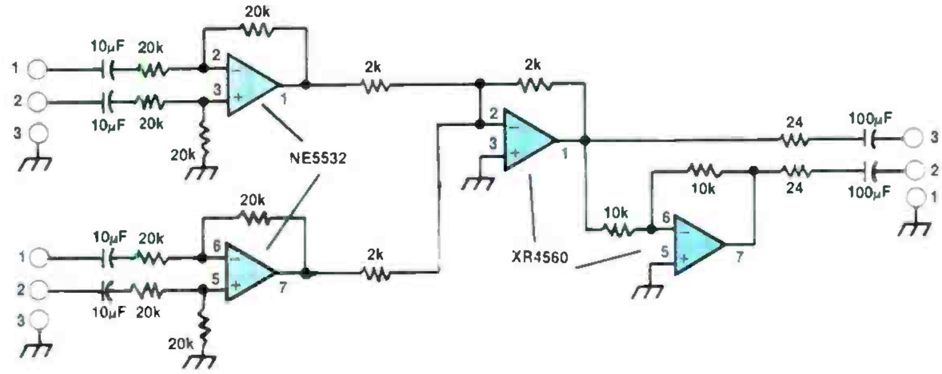

Figure 2. An active summing amplifier circuit used to check the mono compatibility of two audio channels.

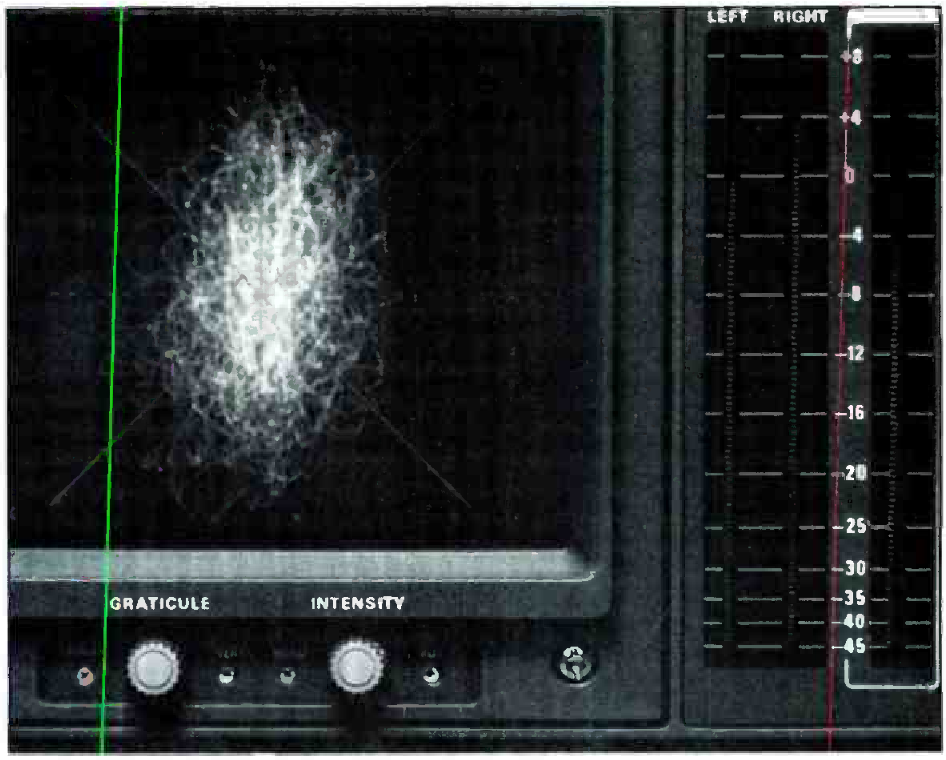

Figure 3. Front-panel controls and display for a stereo audio waveform monitor featuring left, right and sum amplitude readouts.

Continued from page 106

The audio vectorscope

Probably the most important piece of TV stereo test equipment is the audio vectorscope. The display on the instrument is a *Lissajous pattern*. It relates the amplitude and phase of the left and right channels. With experience, you can learn much about audio signals at your plant just by observing the pattern on this instrument.

Some audio vectorscopes also have meters for left, right and sum or difference levels. This combination of metering and pattern display is useful for monitoring and locating compatibility problems quickly. See Figure 3.

Continued on page 114

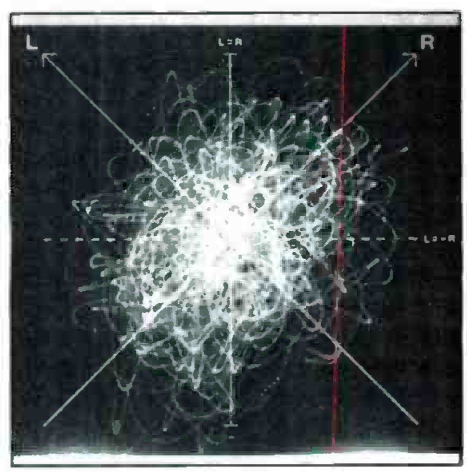

Figure 4. Audio vectorscope display for stereo programming of symphonic music. Note that little correlation exists between left and right audio channels.

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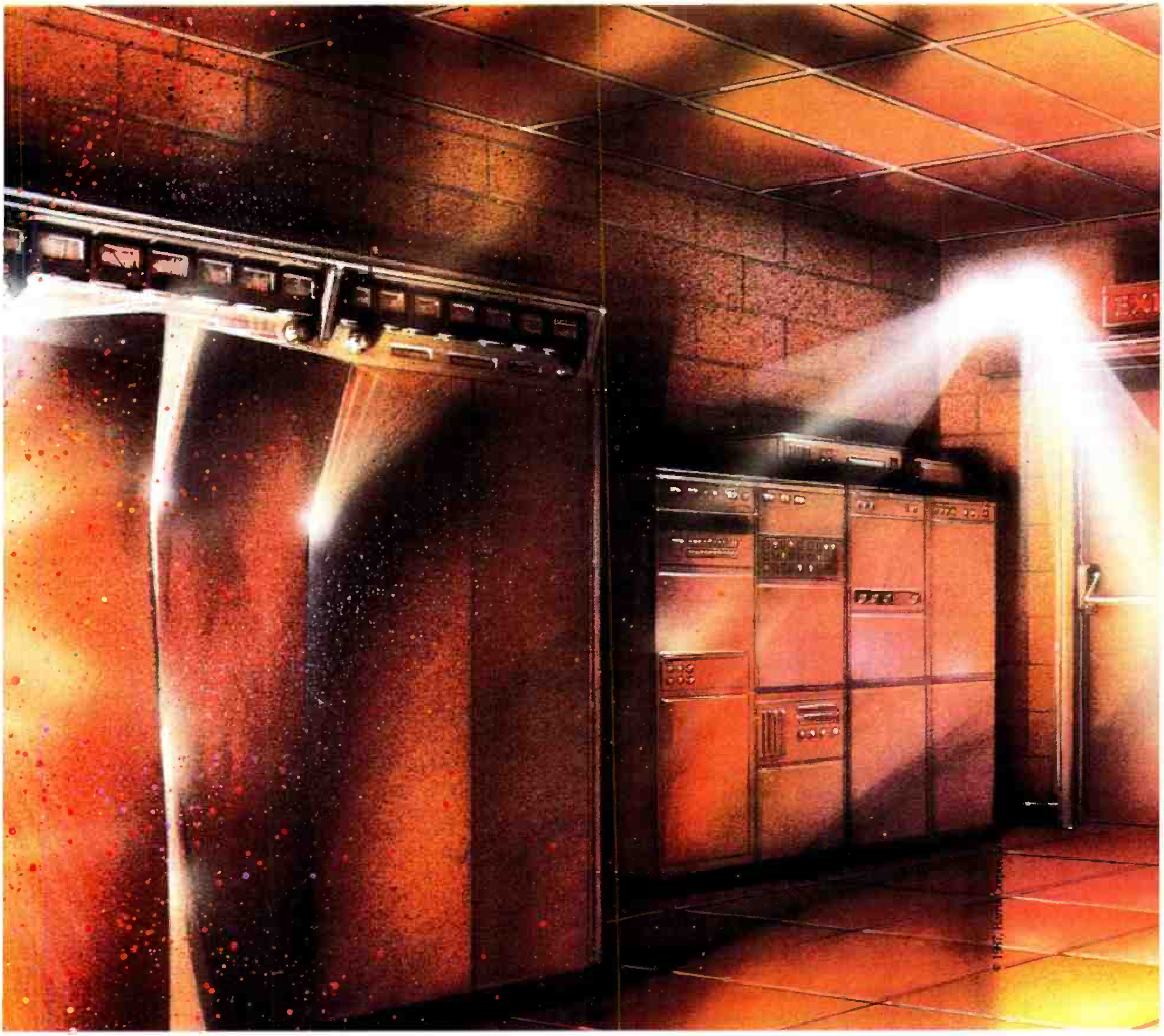

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Continued from page 110

The compatibility question

Now that you have a device for observing stereo audio, you can see more easily why TV stereo presents such a challenge for mono compatibility. Figure 4 shows a pattern typical of symphonic music. The pattern is almost circular, with little correlation between channels.

Figure 5 illustrates a pattern from a typical stereo entertainment program. Note that the stereo signal looks almost like mono. The channels are highly correlated. Most of the dialogue is in the center, and the music and sound effects have limited separation.

TV stereo audio is mixed this way to match the small size of the average TV screen. Your viewers don't want gunshots in the kitchen and car crashes in the bedroom! Because the material in both channels is so similar, any phase or delay errors result in some cancellation of the mono sum.

So the first rule of mono compatibility is this: Highly correlated stereo audio demands identical processing in eacl channel in order to sum to acceptabl mono.

Ensuring mono compatibility

The biggest potential problem facin broadcasters who are converting t stereo is wiring polarity error. If th polarity of one channel is reversed witl respect to the other anywhere along th audio chain, most of the correlate (center) audio information will disappea from the mono sum. Because a statio could have hundreds of audio wirin connection points, your plant probabl has some built-in polarity errors. Th penalty for inverted polarity was not to great in the monaural past, but that's no the case today.

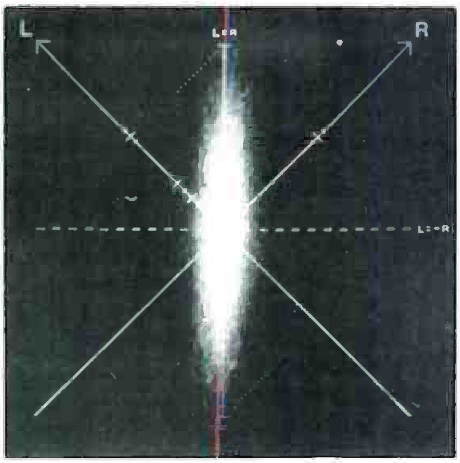


Figure 5. Audio vectorscope display configured as in Figure 4, but with programming typical of most stereo dramas or comedy shows. Note the high correlation between left and right audio channels.

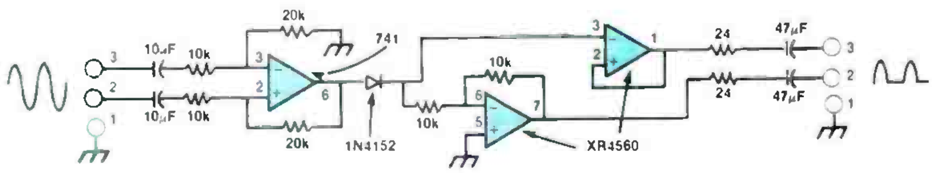


Figure 6. A sine-wave clipper circuit used to generate a test signal for checking polarity inversion in a stereo plant.

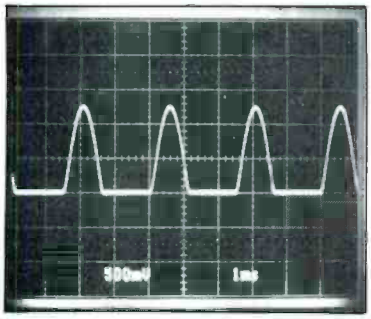


Figure 7. The output waveform of the sine-wave clipper circuit shown in Figure 6. When checking for polarity inversion in a stereo facility, keep in mind that two polarity inversions will yield a waveform that appears to be correct, but is not.

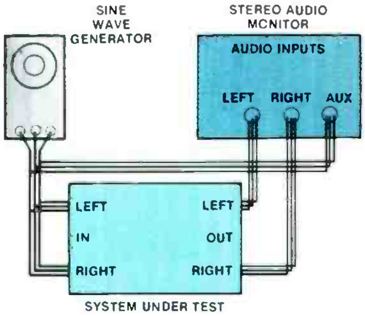


Figure 8. Test setup for checking the relative phase of two audio channels in a unit under test. Check for phase errors in all equipment through which the audio signals will pass.

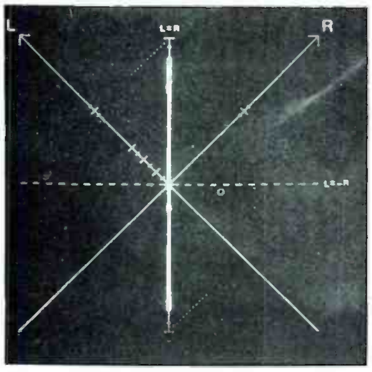
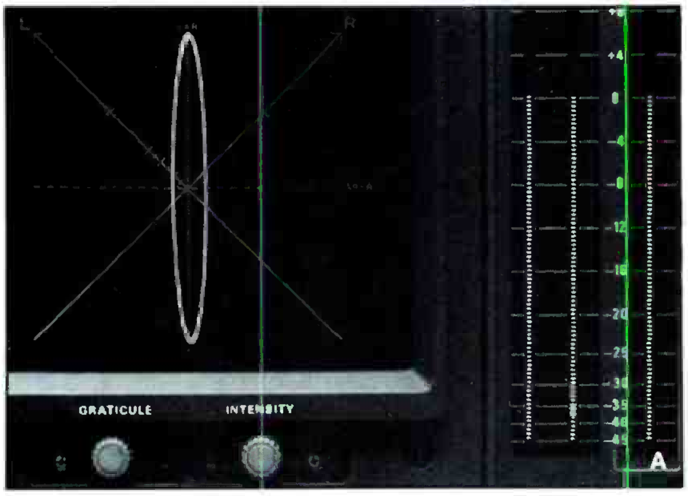


Figure 9. The ideal display from a relative-phase check of two audio channels, configured as described in Figure 8. The display is a vertical line indicating (on this type of monitor) two signals matched in amplitude and phase.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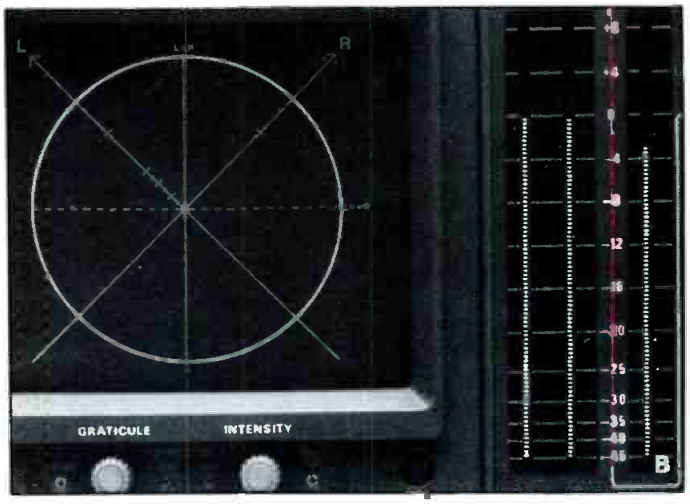
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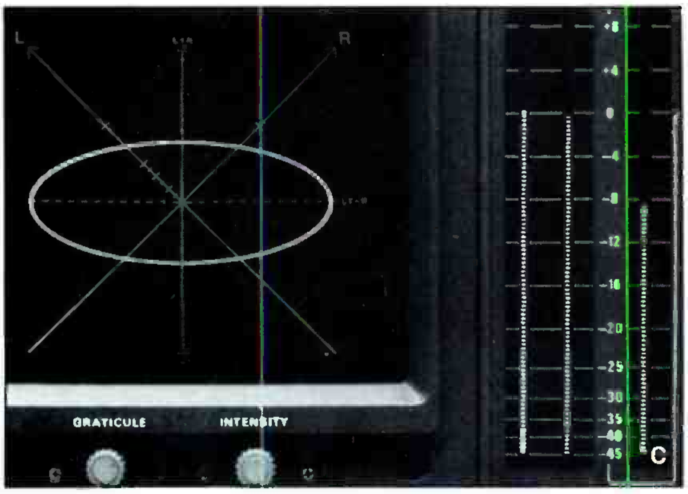
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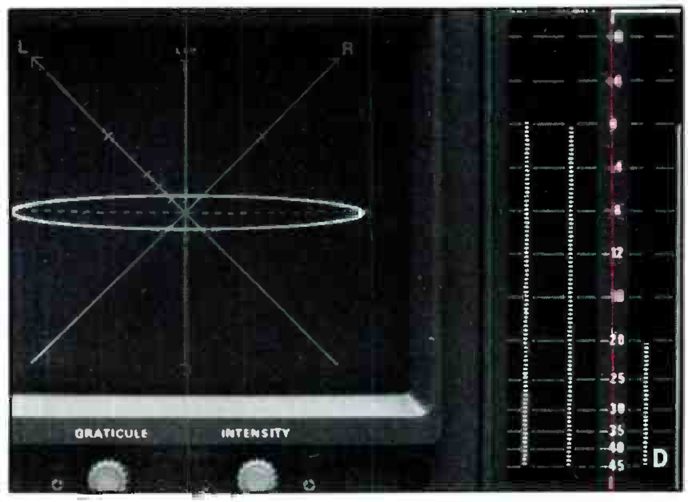
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Figure 10. Audio waveform displays for a stereo channel with varying degrees of relative-phase error. Photo (a) shows a phase differential of approximately 10°. Photo (b) shows a phase differential of approximately 45°, with sum-channel audio response down 3dB. Photo (c) shows a phase differential of approximately 135°, with sum-channel audio response down 9dB. Photo (d) shows a phase differential of approximately 190°, with sum-channel audio response down 21dB. Note that two audio signals perfectly matched in amplitude and 180° out of phase with respect to each other will result in cancellation when summed to mono.

Here's a technique for locating wiring polarity errors. Apply a clipped sine-wave test signal to the input of your system, one channel at a time. The circuit shown in Figure 6 will convert your house sine-wave tone into what you need. Figure 7 shows how the signal should appear on an oscilloscope. Use this signal to probe along both audio signal paths. With the scope connected to the positive phase of the line, the half sine wave should point up. If it points down, the polarity has been inverted.

It is important to check the wiring at any point where a new connection is made. Two polarity errors will cancel each other until a patch is made or until the audio system is modified (for whatever reason). Dual polarity errors compound the difficulty of preserving monophonic compatibility during the rapid pace of a typical broadcast day.

Some stations carry this testing procedure further and check (and rewire as necessary) all audio-processing equipment to eliminate input-to-output polarity inversion. When all polarity errors have been removed from the facility, you can be assured that the audio system will function properly when equipment is removed or replaced.

Phase errors

Now that you have found and corrected your polarity errors, let's turn to the second type of compatibility problem: phase errors. As illustrated in Figure 1, zero relative-phase error (ideally) is needed between the left and right channels in order to accomplish satisfactory mono TV sound.

Phase is simply a way of describing delay in other terms. When one channel has a bit more delay than the other, and the same signal is sent down both channels, the delay can be measured through observation of the relative phase of the audio at the other end.

This point is made so that you will consider all the possibilities for phase (delay) errors that might exist in your plant and

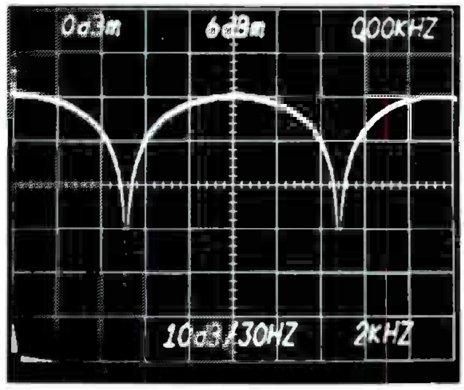

Figure 11. Audio spectrum-analyzer display of amplitude vs. swept frequency in a stereo audio system summed to mono. Note the deep cancellation that occurs at 5kHz and 15kHz. Discrete mono compatibility spot checks that did not include those frequencies could give a false indication that the system under test was operating properly. The notches shown were caused by a delay of approximately 100µs in one of the stereo channels. (Horizontal scale = 2kHz/div, beginning with 0kHz on the far left side of display. Vertical scale = 10dB/div.)

in the distribution system that delivers audio to your facility. Phase errors between stereo channels create errors in the mono frequency response.

Identifying phase errors

Detecting phase errors requires a high-quality audio generator and an audio vectorscope. Figure 8 shows how to connect the output of the audio generator to both channels of the system under test. You can observe the outputs on an audio vectorscope as you vary the frequency of the generator.

Ideally, the response at all frequencies will be similar to the display shown in Figure 9. The display should be a vertical line indicating equal and in-phase left and right signals. Any phase error will show up as an ellipse on the audio vectorscope. If your scope also has metering, you can watch the sum amplitude to make sure it stays constant throughout the audio range. Note that some audio vectorscopes display 0° differential phase by a straight line at a 45° angle relative to vertical. The vectorscope display used in this article has 0° differential phase referenced as shown in Figure 9.

Figures 10(a-d) tie all this together. The mono frequency response of a system is shown along with audio vectorscope photos taken at critical differences in relative phase. These displays clearly illustrate the relationship between phase errors and monaural frequency response. Note that the left and right audio-level bars show good amplitude response in their respective channels, but the sum bar is influenced significantly by the relative phase between channels.

For a quick check of your system or of a remote feed, supply a swept frequency to both channels at one end, and observe the maximum phase excursion at the other end. An even faster check can be accomplished with a pair of discrete frequencies. If you use this test, choose the frequencies with care. Consider the response shown in Figure 11. If your tones were at 400Hz and 7kHz, you would not notice the notches present at 5kHz and 15kHz.

Because these tests are simple, they should help you to quickly locate and observe the common stereo audio problems that affect mono compatibility. These techniques will put you well on your way toward producing good stereo *and* good mono sound.

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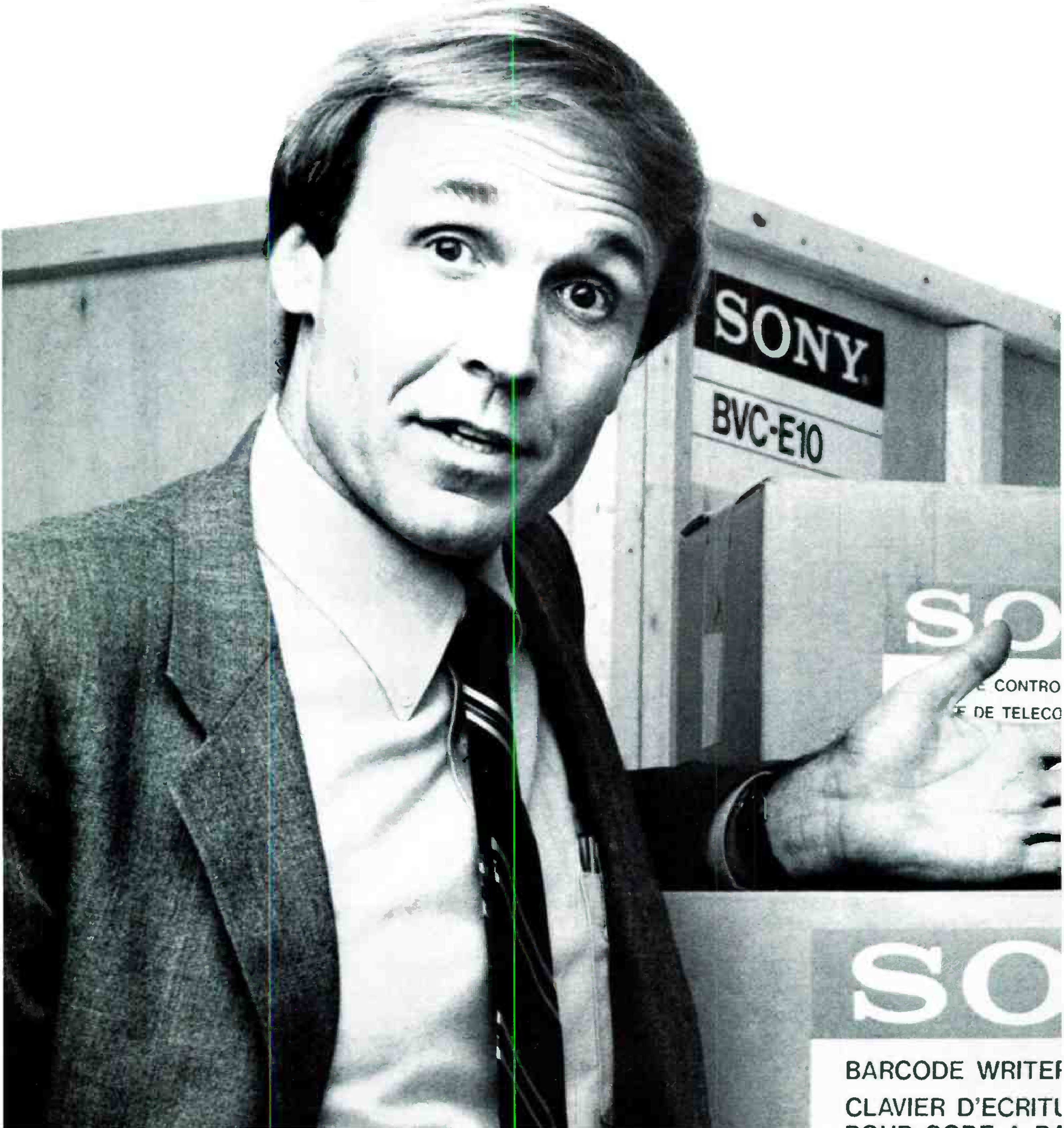

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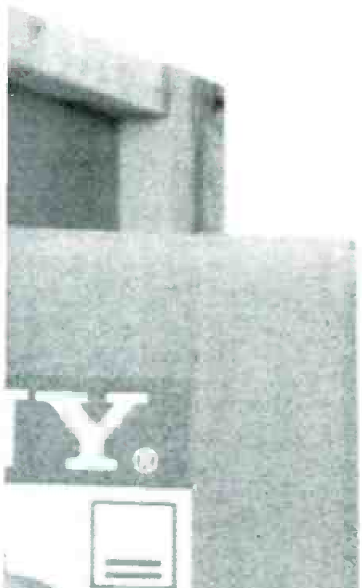
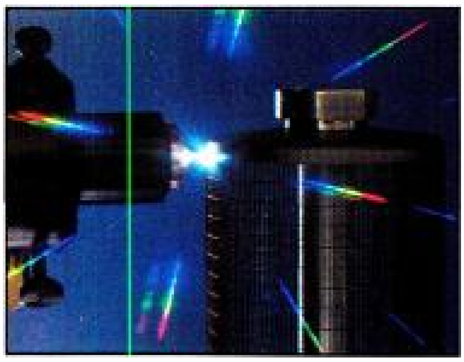


Binaural sound: Expanding on the image



By Claus Wittrock, M.Sc.E.E.

A variety of methods now exist for adding stereo sound transmissions to traditional terrestrial TV broadcasting around the world. These methods are influenced by a lack of bandwidth, by the amount and complexity of information carried in a TV transmission and by their compatibility with existing standards and norms. Consequently, all known stereo systems are compromises between the desire for improving audio performance and the limitations the terrestrial broadcast system imposes.

The key concerns are minimum disturbances of adjacent channels, minimum increases in stress on transmission equipment and no degradation of quality when existing monophonic TV receivers receive the signal. Stereo performance, therefore, has to be achieved either within the traditional sound system or by an additional sound carrier. Sound-in-sync methods, or other ways of carrying stereo information within the video signal, require either extended bandwidth or complex packing, which is based upon digital reduction of the information and is equivalent to a loss of compatibility with existing terrestrial broadcast systems.

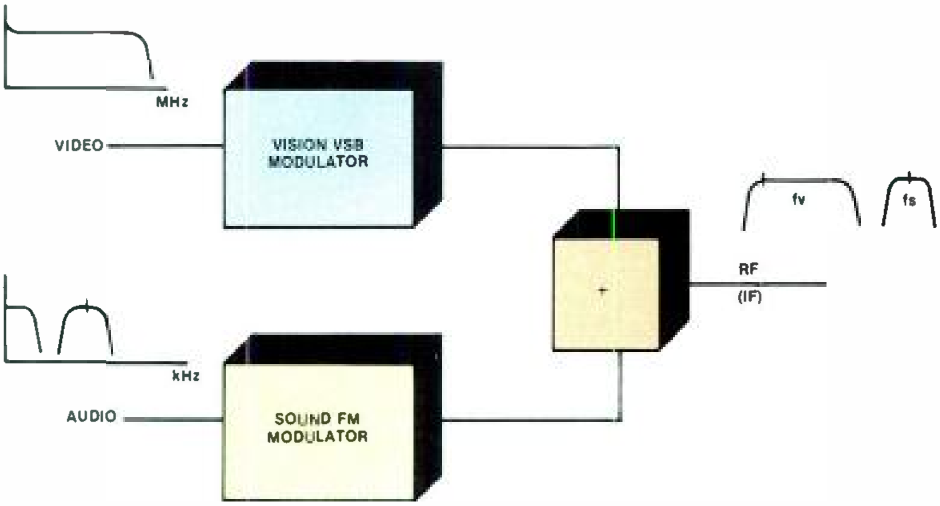


Figure 1. The general plan of single-sound carrier systems.

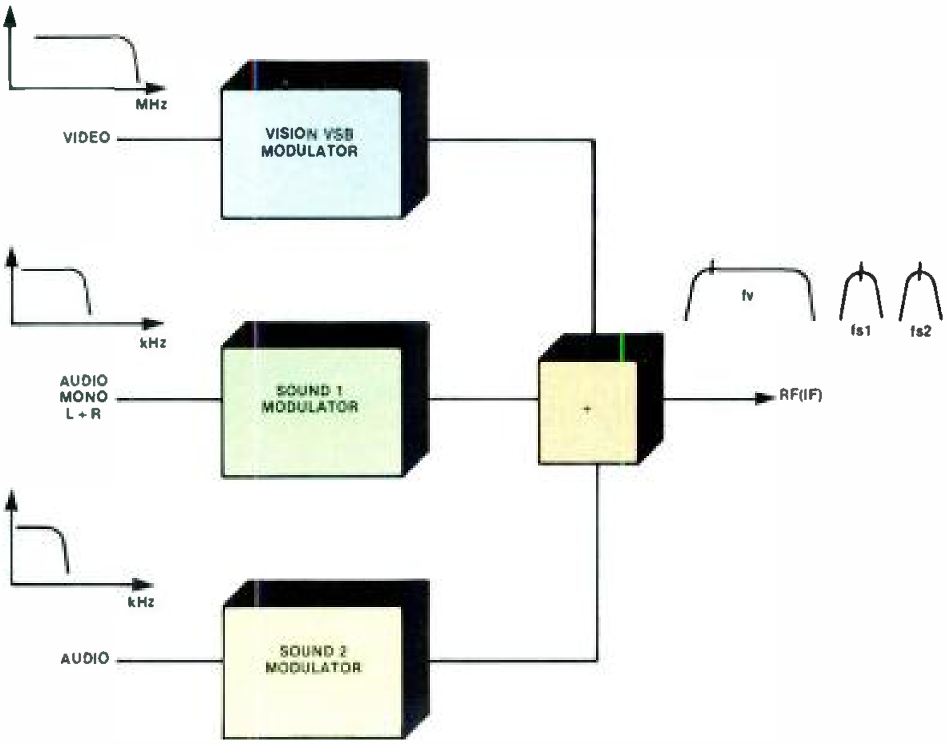


Figure 2. The general plan of dual-sound carrier systems.

Principles for stereo sound

In light of the constraints already noted, stereo quality must be obtained either through modification of the audio signal before transmission or by the addition of another carrier near one of the edges of the channel bandwidth allocated for the transmission. When analyzing the principles that have been described, we can classify them either as single-sound carrier (Figure 1) or dual-sound carrier (Figure 2) systems.

The first single-sound carrier BTSC variation is in operation in the United States and Canada. It features stereo and a second language and data transmission. The audio processing required in the transmitter and receiver is relatively complex (see Figure 3). The spectrum of the encoded audio signal is shown graphically in Figure 4. The BTSC companding scheme (compression during encoding, expansion in the receiver decoder) is based upon the Zenith/dbx processing circuit and makes use of both amplitude and frequency companding. The latter is implemented by using a level-controlled pre-emphasis curve.

Wittrock is development manager, RF TV products, Philips Professional Television, Copenhagen, Denmark.

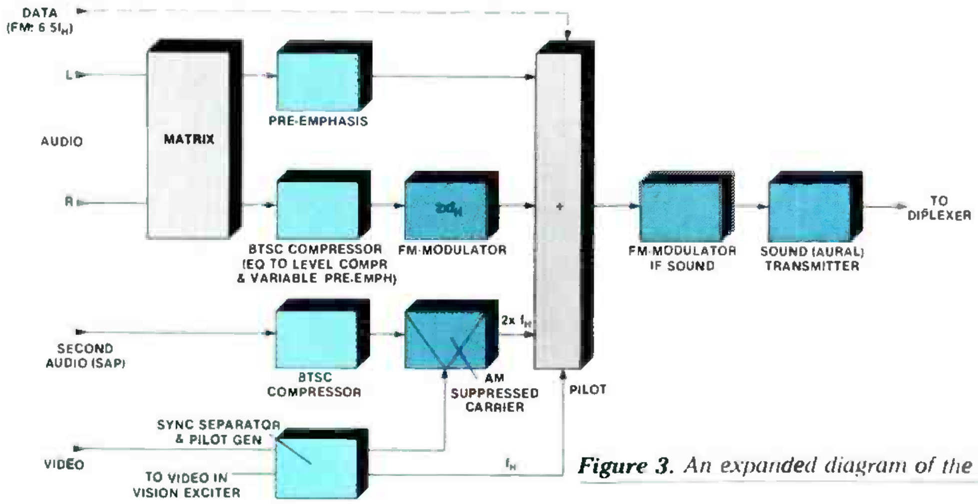


Figure 3. *An expanded diagram of the BTSC variation of the single carrier.*

A second variation of the single-sound channel approach is in use in Japan. (See Figure 5.) Although the FM-FM design has no direct facility for a second language, a low crosstalk level theoretically allows the left and right channels to carry two different languages.

Two basic principles also are found in the dual-carrier systems. The Institute fur Rundfunktechnik (IRT) developed an analog variation, while the British Broadcasting Corporation (BBC) moved to a digital approach. The IRT system is in use in Germany, Holland and Austria and is being considered for implementation in Australia and Korea. (See Figure 6.) An identification signal at 54kHz is AM-modulated with a low-frequency signal to indicate a mode of mono, stereo or independent 2-channel (language) transmission.

The BBC's system operates with a digitally converted audio signal that is companded, interleaved and quadrature phase-shift modulated on the second carrier. Developed originally for England, the BBC approach has been accepted in Finland, Denmark, Norway and Sweden, although some modifications have been made. (See Figure 7.) The Nordic alteration features VHF (CCIR system B) opertion, using an intercarrier frequency of 5.85MHz instead of 6MHz and other filters in the quadrature phase-shift keying (QPSK) modulator as a compromise between bandwidth and Eye height.

A closer look at QPSK

Of these systems, the BBC approach probably is the most difficult to understand, mainly because it is digital. Initially, the left and right signals are sampled at 32kHz. The resolution of the A/D conversion is 14-bit (maximum) digital word equal to an overload limit placed 12dB above the reference level, which indicates average peak program level. During baseband compression, the 14-bit word is reduced to 10 bits.

In this scheme, a group of 64 samples makes up a frame, while 32 samples comprise a block. Mono samples are placed in odd-numbered frames for language or channel 1, while those for language 2 are encoded into even-numbered frames.

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Frames are numbered in groups of eight with a control bit C_n. (See Figure 8.)

The compression process is implemented by finding the maximum sample value in a block. This value leads to one of five possible degrees of compression. A 3-bit scale factor word (R_2, R_1, R_0) is associated with each block carrying information for the expander in the receiver. Using 2's complement terminology for high-amplitude values, the bits (10 out of the 14) are taken from the most significant positions of the word. If the value is positive, it might be represented as *0, 1, x, x, x, x, x, x, x, x*. Thus, *1, 0, x, x, x, x, x, x, x, x* would indicate a negative value.

For stereo, one block of left samples and one block of right samples are mixed

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into one frame in such a manner that the samples follow one another successively. Naming the left samples A and the right samples B, we may represent the subgroup of 16 samples as:

$$A_1, B_1, A_2, B_2, \ldots, A_n, B_n, \ldots, A_{15}, B_{15}, A_{16}, B_{16},$$

where A_n (or B_n) consists of a representative group, such as $a_{n0}, a_{n1}, a_{n2}, \ldots, a_{n9}, P_n$, where n_0 is the least significant and n_9 is the most significant of the bits in the compressed data. P_n, at the end of the compressed form of the word, is a parity bit in principle, but, it is modified with the scale factor bits, following a specific pattern equal to (for sample number 1(+3n)): the parity bit modified with scale factor R_2, sample 2 with R_1, and

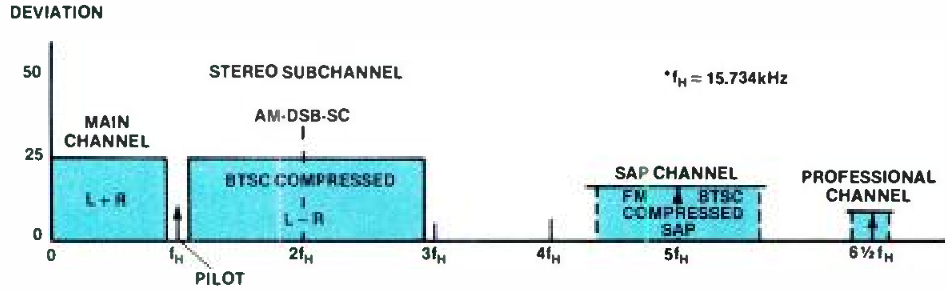

Figure 4. The energy spectrum of the BTSC audio signal.

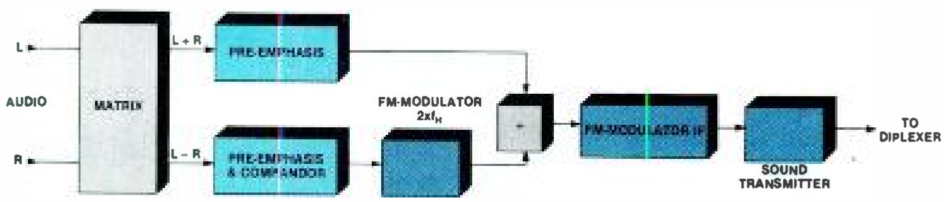

Figure 5. The FM-FM variation of the single-carrier system.

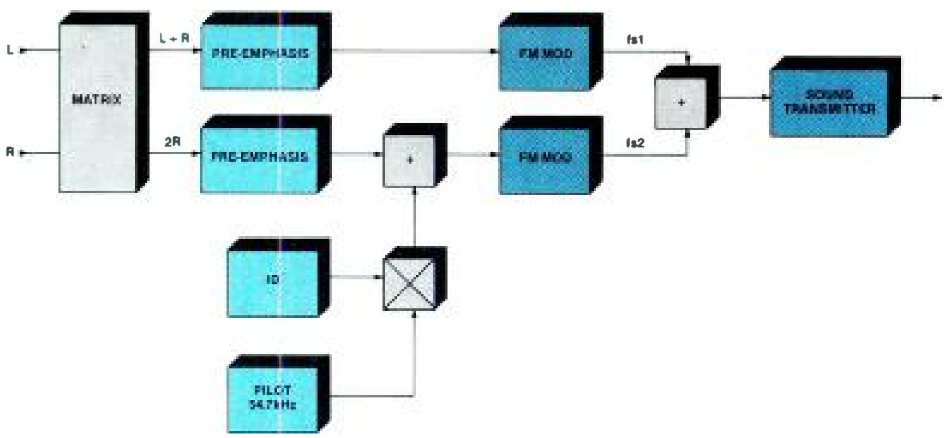

Figure 6. The analog dual-carrier sound system.

sample 3 with R_0, and so on, until sample 55 of the frame. Samples 55 to 64 carry only parity information in the P bit. The interleaving process is performed on every frame. A frame alignment word (FAW) is added plus a number of control bits and data channel information.

When all parts are assembled, the final frame can be represented by Figure 8. Transmission of the matrix begins with the first row, then the second row and so on. The method minimizes the effect of multiple-bit errors on the received signal.

Of the control bits, C_0 is 0 for the first eight frames and 1 for the next eight. The other C bits carry information about the audio mode—mono, stereo, dual

Continued on page 130

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There and Back With My Ikegami HL-79

By Ken Jobson, WTN Camerman

As a hardened cameraman of many years, I consider myself fortunate that UPITN/WTN has provided for my professional use, an Ikegami HL-79 video camera which produces quality images often under the most adverse conditions, is electronically reliable, robustly constructed and designed in such a way that it relates to the operator's body. The camera after all, is only a device which facilitates the recording of images seen by the human eye and therefore becomes an (electronic) extention of the human body.

I have very strong emotional feelings about all of 'my' electronic cameras — all Ikegami's.

Using Ikegami cameras has given me tremendous professional satisfaction and, I hope, established my reputation as a cameraman who will go to extreme lengths in order to capture 'the shot'. My Iky's have been taken from me at gunpoint, survived several car crashes, travelled in helicopters, tanks, armored cars, innumerable jeeps, fire engines, on camels, rowing boats to battleships, have been stolen, have boiled in midday sun in the Sudanese desert and chilled on the ski slopes of Lebanon, have witnessed the most appalling degrees of human inspired destruction, a fighter falling to the ground one meter in front of the camera as he was hit in the stomach by a sniper's bullet, glamorous fashion models on the catwalk, the Prince who loves playing polo, a famous parrot now alas no longer with us reknowned for his voluntary impressions of incoming shelling, hundreds of correspondent standuppers, the happiness at weddings and the sorrow of bereaved relatives, the innocent child at play and another innocent child staring into infinity from his hospital bed wondering why that phosphorous bomb exploded in his house. My Iky's have never let me down on any of these shoots. But one incident, which demonstrates the remarkable characteristics of Ikegami cameras, will remain firmly in my mind forever.

Location: Main street in Bhamdoun (pronounced without the 'B') an attractive mountain town in central Lebanon on a sunny afternoon. We had just finished taping the totally deserted street (or so we thought) and locked up shop fronts, when the distinct crackle of automatic gunfire could be heard breaking the eery silence. It took perhaps five to ten seconds for us to realize those bullets were coming at us. As my soundman and I both took independent evasive action, the Ikegami HL-79 and video recorder both fell from our shoulders onto the pavement. The Iky laying on its side (and as I realized minutes later, my finger had touched the roll button as it fell out of my hand) was now happily recording the sound of incoming bullets hitting the surrounding shop fronts. Our cries in Arabic that we were press and the gunmans order in English "Get out, get out,' were followed by another burst of gunfire.
Carefully, I crawled across the pavement and uprighted the still rolling Iky, pointing it in the direction of its crew who were to be seen crouching behind a sand heap for shelter. Minutes later, thinking our ordeal was over, I bent down to press the stop button, when an M-16 bullet tore through my right neck muscle. It was only the sudden feeling of wetness down my back that made me aware that something was seriously wrong. I was hit. Once again I flung myself down behind the gravel pile, as the gunman fired at least another twenty bullets at us. The firing then ceased, and I was put into the back of a car and taken to an Israeli medical unit, who treated the wound, gave me a pain killer injection and hot coffee. Later at the American University Hospital in Beirut, doctors gave me a local anesthetic, cleaned the wound internally (very painful), x-rayed, took blood pressure, etc.

The bullet which miraculously missed my spinal cord by two millimeters has left two holes three inches apart in the back of my neck. Subsequent viewing of the video reveals twenty five recorded gun shots at us before I was hit. Plus approximately twenty shots as I lay bleeding. I was very happy not to be going home as a waybill number. And today while the memories linger; my work as it must, goes on.

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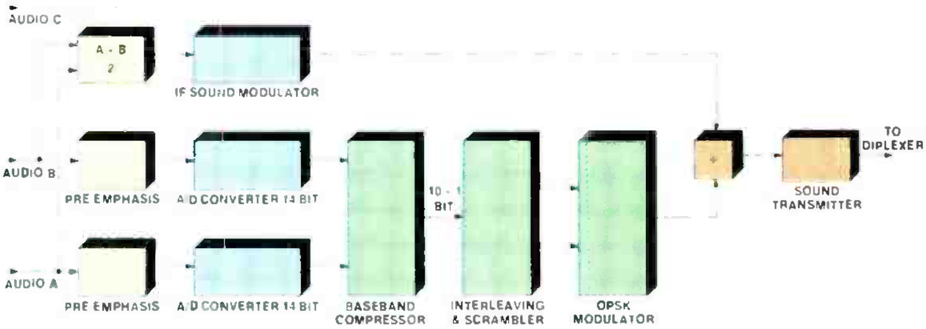

Figure 7. The sound transmitter side of a digital dual-carrier system.

Continued from page 126

language, data or the digital-system second channel carries an audio signal different from carrier 1.

The interleaved frame is finally scrambled by a specific bit sequence that is easily removed during reception. Nonetheless, a dispersed energy pattern is ensured for all levels. With this principle, the carrier of sound carrier 2 is always modulated, and cross modulation patterns in video are less visible. The QPSK modulator places the bit sequence on the carrier, taking two bits at a time. (See Figure 9.)

The principle in the modulation is differential phase-shift encoding. Information is carried by the value of a shift in carrier phase relative to the last stable condition. For example, 00 indicates no phase shift, while 01 is 90° shift. The rise time of phase transients is determined by low-pass filters in the QPSK modulator to set the necessary bandwidth limitation.

System performance

Evaluating the stereo performance must include the reception portion of the system. A typical standard receiver is illustrated in Figure 10. An intercarrier design is used to suppress phase noise from its own front-end. A quasi-split carrier system is used to obtain maximum quality despite video modulation. The notch between vision and sound carriers suppresses video frequencies at subharmonics to the intercarrier.

All of the stereo implementations described here must pass such a receiver system. Consequently, the behavior of the vision part of the transmitter plays an important role. Because intercarrier frequency f_i is $[f_{vision} - f_{sound}]$, the sound quality will depend accordingly upon phase stability of the vision modulator and the vision transmitter. A real split-carrier receiver is realizable, but would be too costly for a commercial TV receiver.

Tests and measurements

The existence of a number of different stereo aural TV systems places special demands upon test equipment to determine the performance of the systems. For the engineers who must make the performance measurements, the ideal

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			26, 70, 114 686
			27, 71, 115 687
		44 BITS (4 x 11 BIT COMPANDED SAMPLES)	28, 72, 116 688
			— — — .... —
			— — — .... —
			— — — .... —
			68, 112, 156 .... —

Figure 8. *The digital frame structure of the BBC/Nordic system.*

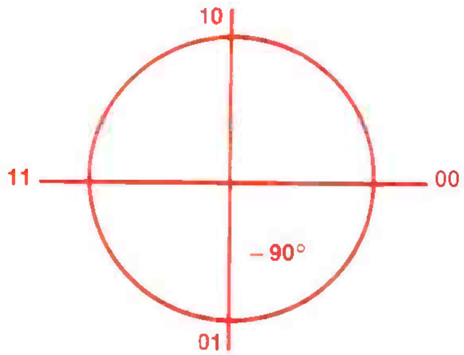
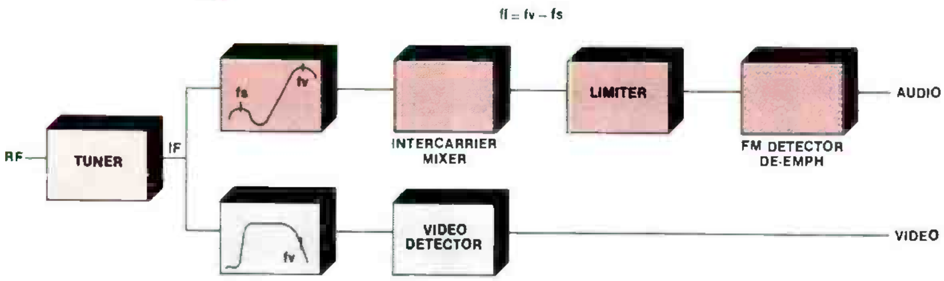


Figure 9. *QPSK modulation phase-shift diagram.*

Figure 10. *The general plan of a quasi-split-carrier receiver.*



test setup will involve as few pieces of equipment as possible. For the manufacturer of the test equipment, a flexible, multistandard, modular approach is desirable. The following description outlines a number of factors for consideration in the design of a stereo system test unit.

At the heart of the test system is a TV-IF modulator that can be adjusted to meet the various CCIR standards basic frequencies and parameters (See Figure 11.) In principle, all single-carrier systems can be supported by providing an audio input capable of 150kHz bandwidth. This modulator includes all signal processing, such as modulation and bandpass profiling, for stereo systems designed around the principles of Figure 1 and Figure 2.

To implement a dual-sound carrier operation, a plug-in module with a combiner network on the main sound channel is the practical solution to additional bandwidth. In the case of an analog dual-carrier system, the module contains all encoding circuitry. Although vision and sound are dealt with separately, both combined and separate outputs are provided.

The additional requirements of the digital dual aural carrier TV system, such as the BBC and Nordic methods, requires that a QPSK modulator with digital input is provided for carrier 2. The QPSK module can be provided with a 2-wire

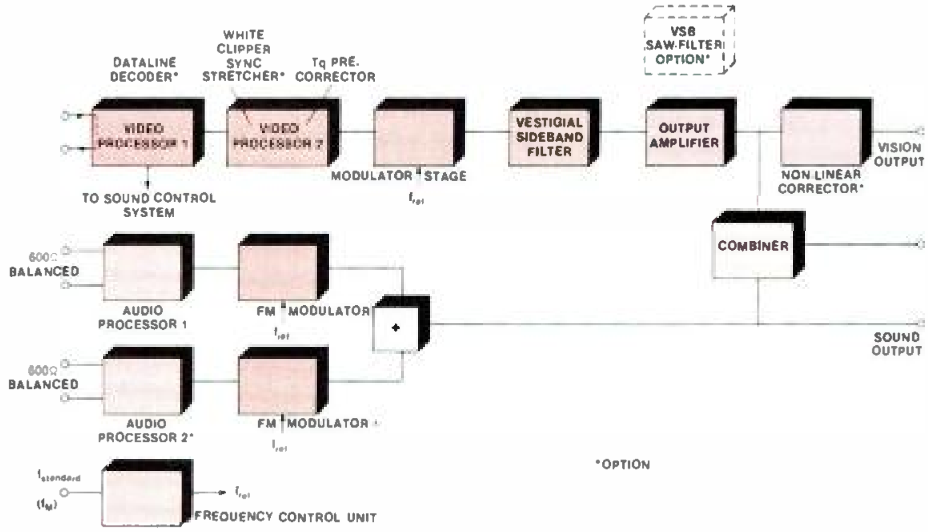


Figure 11. A block diagram of the stereo audio TV-IF modulator.

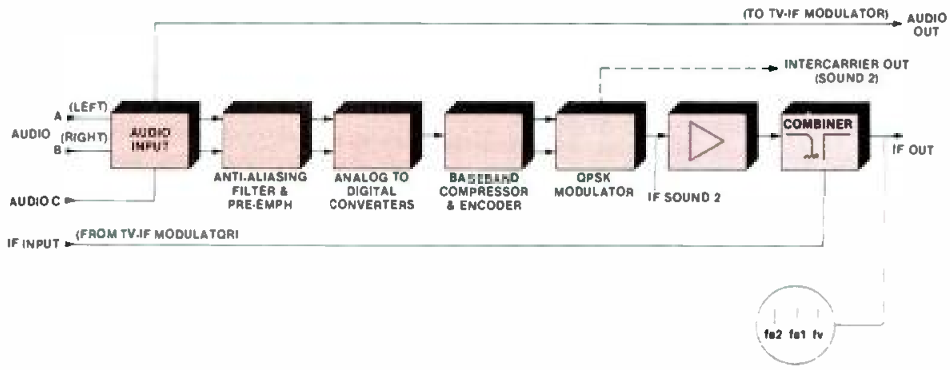


Figure 12. A block diagram of the digital sound modulator.

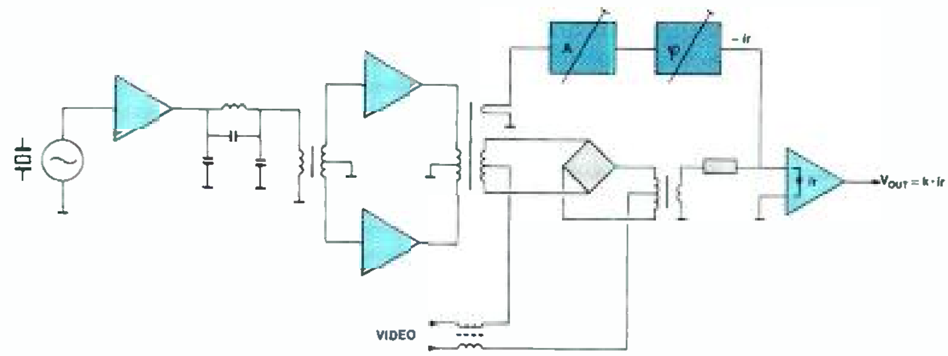


Figure 13. The plan of a vision modulator stage for low ICPM, residual carrier and spurious response.

signal from an external digital sound modulator that includes the complex digital-encoding circuitry, such as all analog-to-digital conversion, companding, interleaving and scrambling.

Another approach to the test system would be to include the QPSK module in the digital sound-modulator package, all as a separate package from the TV IF modulator. (See Figure 12.) If this design is followed, the combining of the carrier 2 with Vision+Sound 1 or just Sound 1 is handled on an IF basis through a transformer coupler in the digital unit. Certain flexibilities of operation are provided by the separated-units approach, including stand-alone use. When required for specific tests, a synthesizer circuit in the digital sound modulator provides an intercarrier frequency output.

In the visual portion of the TV IF modulator, special consideration should be given to incidental carrier phase modulation (ICPM), as this factor is a primary area of concern in stereo operation. Ideally, the modulator unit will produce no measurable ICPM values. Balanced amplifiers in all filter networks can alleviate much of the distortion despite complex load impedances. (See Figure 13.)

Mixing stages often are characterized by excessive residual carrier. By using a balance to the mixer with amplitude and phase compensation summed into the mixer output, remnants of the residual carrier can be kept low. Low-pass filtering in the driving circuit suppresses any high-order harmonics from the frequency source.

Ideal filters for shaping and bandpass profiling are unrealistic, even today. Through computer-aided design, however, it is possible to develop filter networks with optimum amplitude and group delay characteristics in terms of pulse response. This approach should be used in functions such as the vestigial sideband filter. The design found from computer optimization will include LC techniques as well as surface acoustic wave (SAW) filters, combined with balanced mixer methods to produce the least possible low ripple and tilting in frequency amplitude and group delay.

Finally, the multichannel conversion portion of the test unit must be able to develop any possible output frequency within common TV transmission bands. In order to do this without the introduction of significant spurious signals, particularly within VHF, UHF and typical CATV spectra, a multiple (triple) conversion is practical and recommended.

Metering growing demands

Transmissions of television with multiple audio channels have received favorable viewer responses with all four current system types. One reason for this is that the psychoacoustical phenomenon of the spatially enlarged audio field places the viewer more within the action. Another reason is that equipment required for stereo operation is all quite new and has not been excessively readjusted or ignored. A third reason is that stations beginning stereo operation logically will have performed an audio proof of performance on the transmission system. Fourth, by and large, the stereo audio sound with the program typically will have been produced on new generation equipment.

If stereo and multiple channel is to remain a favored transmission mode, engineers must be aware of how these systems work, and they must be given the tools to maintain the system at a peak performance level.

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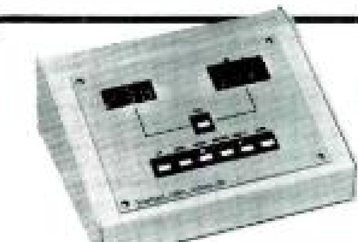
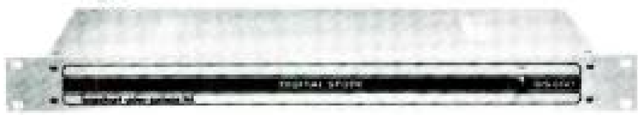
Editor's note: The test modulator system described in this article is based upon design criteria used by Philips Elektronik Industri A/S, Copenhagen, in developing the PM 5680 TV-IF modulator, the PM 5690 multichannel converter and the PM 5687 digital sound coder.





JVC CR-850U videocassette recorder

By Jay Ankeney

The JVC CR-850U frontloading ¾-inch videocassette editing recorder represents the company's commitment to the future of the ¾-inch videotape medium. The VCR offers several technical innovations that should make it a serious competitor for this segment of the market.

Construction

The deck is built on a diecast chassis and can be rack-mounted. The machine is quiet, partly because the deck's operation is controlled by direct-drive mechanisms, which eliminate much of the mechanical noise. The machine's direct-drive system eliminates all belts and tension arms that control the transport system. Once the U-matic arm has wrapped the tape around the upper tape drum, the direct-drive transport keeps the capstan constantly engaged while in play, search, jog and still modes. Electronic, rather than mechanical, stress sensors maintain constant tape tension. Even the skew adjustment is electronic, instead of manual.

Primary motion and tape controls are located in the center of the front panel. Large, illuminated buttons are used to direct the machine's operation. A large, bidirectional, variable-speed search control dial is located to the right of the motion controls. The editing controls are located to the left of the motion control knobs.

A dual-purpose meter, located in the upper left corner displays both tracking and video levels. During playback it displays the RF-tracking level, and in the record mode it measures the incoming video level. The front panel also contains two audio VU meters. Concentric level-control knobs allow the operator to adjust both record and playback levels.

The VCR provides two composite video inputs and one Y-688 input. A similar complement of outputs is provided on the back panel.

Selectable features

Switches mounted along the lower front panel provide access to other user

Ankeney is a videotape editor at KTTV-TV, Los Angeles.

Performance at a glance

- *Luminance response: 260 TVL color mode*
- *S/N ratio: 49dB L/47dB C*
- *Video headswitch in: vertical interval*
- *Search speeds: 20× rev/15× fwd*
- *Audio response: 50Hz-15kHz*
- *Audio: −20/+4dBs, 10kΩ*
- *Audio S/N: 48dB*

features. One switch provides a choice of line or dub inputs, another switch allows the machine to be used as a miniswitcher between the A and B video inputs.

For ease in maintenance, several test points are accessible without having to remove the VCR from the rack. These test points include: drum pulse, RF and video levels and both audio channels.

A unique feature is the deck's 7-position Y-frequency response control, which permits the incremental boost or attenuation of luminance detail in the 3MHz range.

The remainder of the lower panel houses switches that control several optional features: video AGC, color or monochrome input processing, audio limiters, frame servo control, sync source and memory control.

LED display

Centered on the front panel is an 8-digit LED display that shows hours, minutes, seconds and frames. The data is normally obtained from the CTL pulse. An independent timer also is available so edit points can be determined by duration.

When coupled with optional SA-K11 time-code reader/generator and character inserter, the address track is displayed on the front-panel display. The optional reader/generator also allows the No. 2 video output to provide convenient burned-in window time code. In addition, when blacking tapes, the desired time-code starting numbers can be loaded from the front panel. Or, the time-code generator can be used to assemble edits in the *jam sync* mode. The SA-K11 time-code reader/generator can even work with user bits, which makes the reader/generator the one major option I recommend for use with the deck.

The right side of the LED panel contains a diagnostic warning panel. Microprocessors inside the VCR continually monitor the various circuits. If any problems are detected, warning lights are illuminated on the front panel. Monitored circuits include: servo lock, horizontal phase, lack of control track and presence of address-track time code. When an internal circuit error is detected, a 2-digit diagnostic code is displayed on the diagnostic panel. The service manual lists the error codes and probable causes. Such information makes resolving a problem much easier.

Signal processing

The VCR provides several video noise-reduction circuits, both for luminance and chrominance signals. The luminance signal benefits from a correlating noise-cancelling circuit, which delays the video signal by one line and compares it to the original. This helps eliminate random noise. The luminance signal also passes through a dropout compensation circuit. This circuit detects the transient signal dips in the FM-circuitry area and corrects them after demodulation in the video section. This means there is virtually no delay in the DOC process.

Signal linearity is crucial to proper video processing. To address this need, the VCR uses low-distortion FM amplifiers. In addition, each video head is provided with an independent amplifier and equalization signal, which is custom matched for that channel.

A direct automatic-phase control circuit (APC) compensates for unavoidable mechanically induced phase errors. See Figure 1. The circuit uses a horizontal discriminator that compares the jitter on the horizontal sync and shakes or tracks the 4.27MHz oscillator to eliminate velocity errors and stabilize the chroma signal.

Head switching occurs in the vertical interval at 2H before vertical sync. Through line replacement, the resulting noise is removed from the picture. Other

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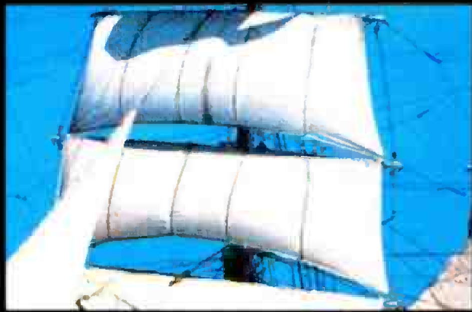

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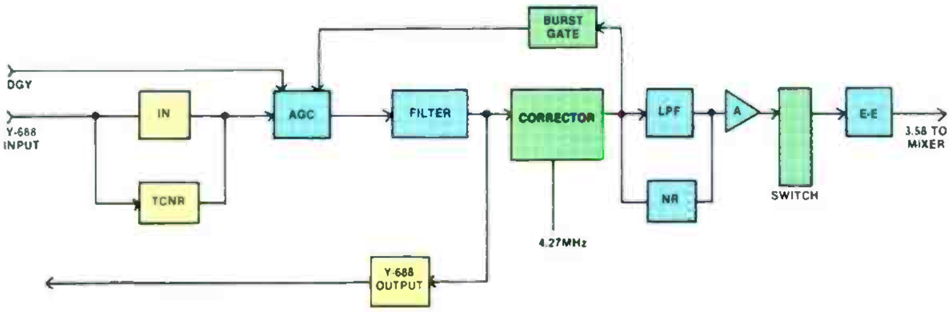


Figure 1. The automatic phase-control circuit maintains the correct phase during both playback and record by tracking the 4.27MHz oscillator with the horizontal sync jitter.

chroma noise, which may be added by the address-track time code is removed by additional noise-canceling circuitry.

To eliminate luminance/chrominance delay, individual record, playback and E-to-E adjustments permit the color to be precisely aligned with the Y signal. In the dub mode, (with Y-688 signals) a 75Ω input impedance is used for improved signal-to-noise ratio. This impedance can be changed if desired through an internal dip switch.

The video output is not bandlimited. The composite video signal contains as much high-frequency information as the unlimited RF output. This aspect may allow some newer TBCs to provide better performance without having the extra cost of adding a Y-688 input.

Versatile interfacing

One of the machine's more important features is the ease with which it can be interfaced with numerous editing systems. At this year's NAB, the CR-850U was successfully interfaced to 11 different editing systems.

Much of the flexibility is due to sophisticated control software. The software can be customized by setting dip switches within the machine. This feature allows the VCR to be programmed to meet the requirements of outboard systems.

Edit-timing dip switches allow the machine to set offsets of +2 to −1 frames for the requirements of different edit controllers. Another dip switch permits setting preroll times to 3, 5, 7 or 10 seconds. The VCR also can be programmed to abort an edit when the control track is not present on the tape during video inserts.

The timer can be programmed to count up or down to meet the need of auxiliary equipment. In the ON position, timer one always counts in positive numbers, as required by many equipment manufacturers. When the switch is set to the OFF position, negative numbering is used, as required for some JVC equipment.

The video record/play and Y/C processor boards provide several user-settable dip switches. One switch permits

In the rack-mount configuration, the CR-850U is easy to locate in almost any setting.

changing the nominal 75Ω input impedance to match the requirements of some TBCs. Other switches allow selecting several noise-canceling circuits.

The interface board contains a switch that allows the VCR to send out its own internal ID command through the RS-422 port to determine the ballistics default on individual edit controllers.

The software contained within the machine can be easily updated to accommodate new equipment. This feature, in conjunction with the user-settable control switches, allows the machine to work with a wide variety of equipment. Because the software is contained within a ROM, which can be changed by the user, the machine can be reprogrammed to meet the demands of tomorrow's equipment.

Comments

I found the machine performed well when interfaced to both the CMX and Videomedia editing systems. It was responsive and capable of locking up within the first few seconds of preroll. When coupled with the optional SA-K11 time-code reader/generator and character inserter, the machine's second video output provides the editor with easily readable tape locations.

My checks indicate that the video path lives up to the deck's specifications, with clean vertical interval switching and a 47dB color S/N.

I have used the JVC CR-850U for many hours and find it to be a welcome addition to my work. It is quiet and provides excellent tape-handling and signal processing. The machine is certainly worth considering for those instances where top-quality ¾-inch production is needed.

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 firm.

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, whether positive or negative. No report should be considered an endorsement or disapproval by **Broadcast Engineering** magazine.

News
Continued from page 4
movies shot at 24 frames per second. A reduction in flicker, screen granularity and stroboscopic effects were observed. The films also were shown to audiences who concurred that the 30-frame-per-second productions were better quality.

Some technical considerations involved in a large-scale conversion to the higher frame rate were addressed, namely the need to alter motion-picture cameras, projectors and some post-production equipment. However, the group concluded that all modern cameras are capable of operating at the 30-frame-per-second rate in crystal sync. With regard to projectors, advanced technology has made them capable of being operated at the higher frame rate.

NRSC announces AM standards proposal

Additional voluntary standards to further reduce interference on the AM band were proposed by the National Radio Systems Committee (NRSC), at the Radio '87 Conference.

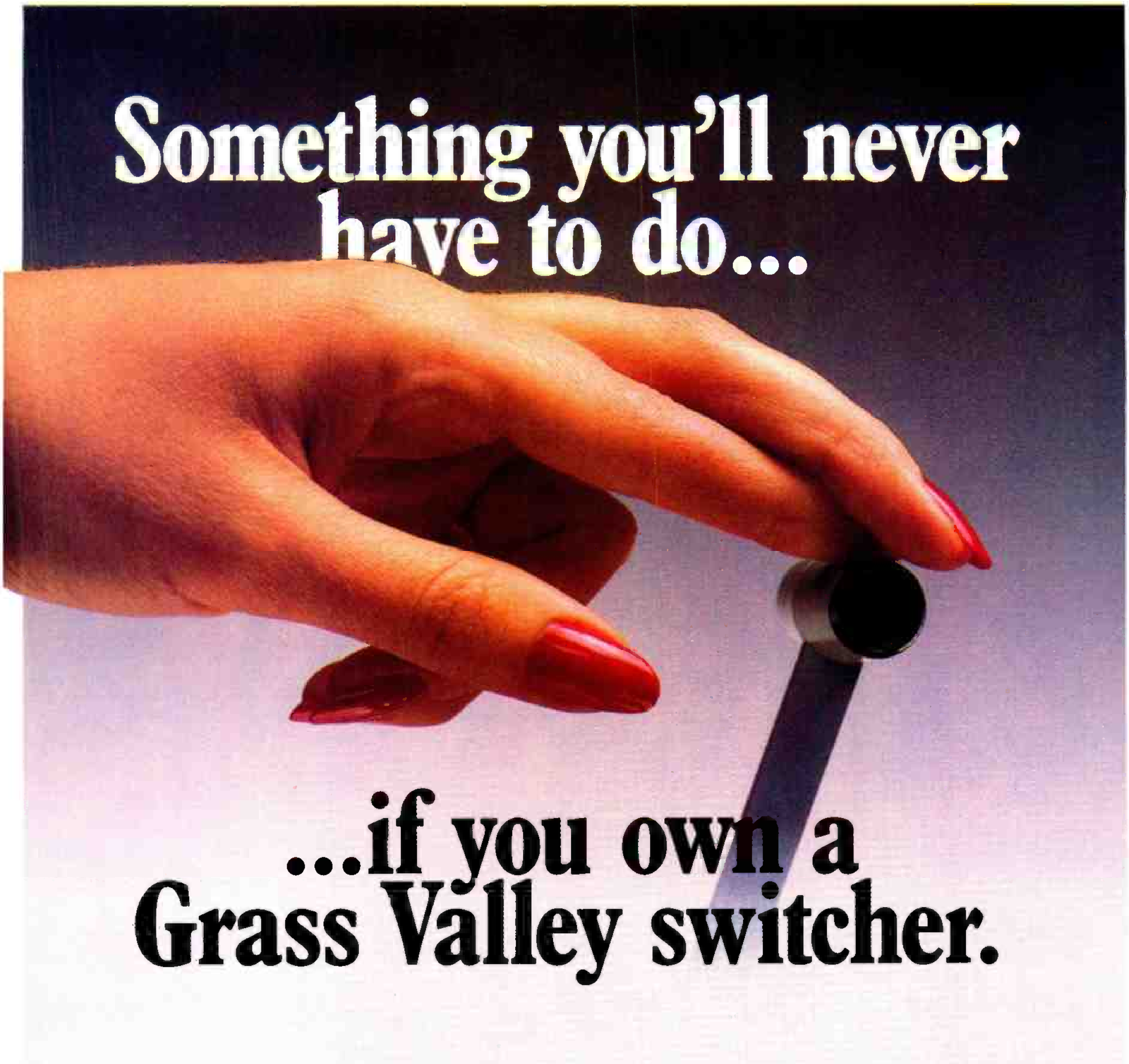
The standards would mask unwanted radio-frequency emissions and complement the NRSC standards being implemented by AM stations to improve their audio and adhere to a uniform 10kHz bandwidth. Currently, undesired RF emissions from AM stations can cause interference to other stations on nearby frequencies. However, stations that implement and properly operate with NRSC's current audio and bandwidth standards are likely to be in compliance with the new proposed RF standards without making further modifications.

Citing a 1986 NAB technical report on AM overmodulation showing that "meeting Federal Communications Commission overmodulation limits is no guarantee of a clean signal," the NRSC proposal tightens out-of-band emission limitations for AM stations and assures an absence of "splatter" AM interference. The NRSC has established a 6-month public comment period.

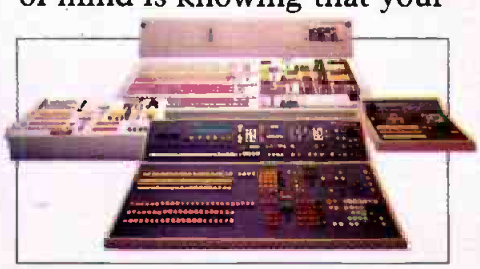
NATAS honors award winners

Emmy statuettes for outstanding achievement in engineering development were presented by John Cannon, NATAS president, at the 10th annual National Academy of Television Arts and Sciences' Engineering and Scientific Awards Ceremony held in September.

The winners included:
- *Color Systems Technology* in recognition of its engineering contributions to the development of the technology for the conversion on videotape of original black-and-white images into color.
- *Colorization* in recognition of its engineering contributions to the development of the technology for the conversion on videotape of original black-and-white images into color.
- *Dubner Computer Systems* in recognition of its engineering contributions to the development of the technology for the conversion on videotape of original black-and-white images into color.
- *National Aeronautic and Space Administration* for its pioneering efforts in research of the application of Ku-band satellites for terrestrial communication.
- *Public Broadcasting Service* for its leadership and contributions in helping to develop more efficient UHF transmitter technology.
- *Society of Motion Picture and Television Engineers* for its recognition of the need for a component digital videotape recording standard, development of a recording system based on the worldwide standard for digital component sampling and cooperation with the EBU to provide the basis for a world standard for digital component videotape recording.



Whether you are in a live or post production environment, the moment of truth comes when the lever arm is finally moved. Peace of mind is knowing that your



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Coordination software now available

By Bob Van Buhler

The latest version of the SBE's national coordinator software is now available for use by coordinators. The latest edition, version 1.01, incorporates several corrections and additions the committee felt were necessary. The software is available on disk to the national frequency coordinating council (NFCC) recognized frequency coordinators.

If you are interested in obtaining a copy, it can be downloaded in XMODEM BINARY format from CompuServe. Look for file NFCC2.ARC/binary. All previous versions of the Clipper dBASE compiler, provided by the NFCC, should be replaced with this new version.

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

After entering CompuServe, type: (user responses in italics)

go BPForum

BPForum
FUNCTIONS

1	(L)	Leave a message
2	(R)	Read messages
3	(CO)	Conference mode
4	(DL)	Data libraries
5	(B)	Bulletins
6	(MD)	Member directory
7	(OP)	User options
8	(IN)	Instructions

Enter choice !*DL7* (you can also enter 4 and CR)

DL 7 - SBENET

1	(DES)	Description of data library
2	(BRO)	Browse through files
3	(DIR)	Directory of files
4	(UPL)	Upload a new file
5	(DOW)	Download a file
6	(DL)	Change data library
7	(T)	Return to function menu
8	(I)	Instructions

Enter choice !*read DL7.CAT*

The system will then scroll though the file, providing information on each of the programs/files available in this data library.

***Table 1.** The above table shows what your computer terminal will display on CompuServe once you issue the command:* go BPForum.

Gerry Dalton, national coordination chairman, and the NFCC subcommittee developed this software for the all-industry committee as a part of the society's contribution to the project. Members also are writing and editing a coordination manual for the NFCC. The NAB has agreed to print the publication, which should be ready in 1988.

The NAB has hosted all of the council's meetings, either at its Washington headquarters or by providing meeting rooms at the NAB convention each spring. The NFCC meets at least three times a year and comprises many broadcast companies and those individuals interested in spectrum management.

A well-coordinated papal visit

Coordinators across the country worked long and hard to assure effective spectrum management during the Pope's visit. An enterprising group from Chapter 53 spent many hours planning for his Miami visit. This event probably received more national attention because it was the first major event in his U.S. tour.

Tom Beauchamp, chief engineer of WTVJ-TV, Miami, worked from June until the visit, putting together an on-line frequency coordination database and keeping the files updated. The result of his continual calling and coaxing to many users and nearby stations was a complete frequency listing, which helped produce a successful visit.

Ralph Beaver, Tampa, FL, coordinator, and Don Anglin, combined the information with their own frequency-coordination data, which assured that local conflicts did not result. The final spectrum usage plan was published on CompuServe, Sept. 2, by Henry M. Seiden.

Check in on CompuServe

The CompuServe Broadcast Professional Forum (BPForum) is a potential source of valuable information for all engineers. A recent check of the files revealed the text changes of the society's FCC filings, copious amounts of frequency-coordination data and the new Clipper compiler for frequency coordination. Some other interesting files include chapter newsletters for Milwaukee, Seattle and Little Rock, AR.

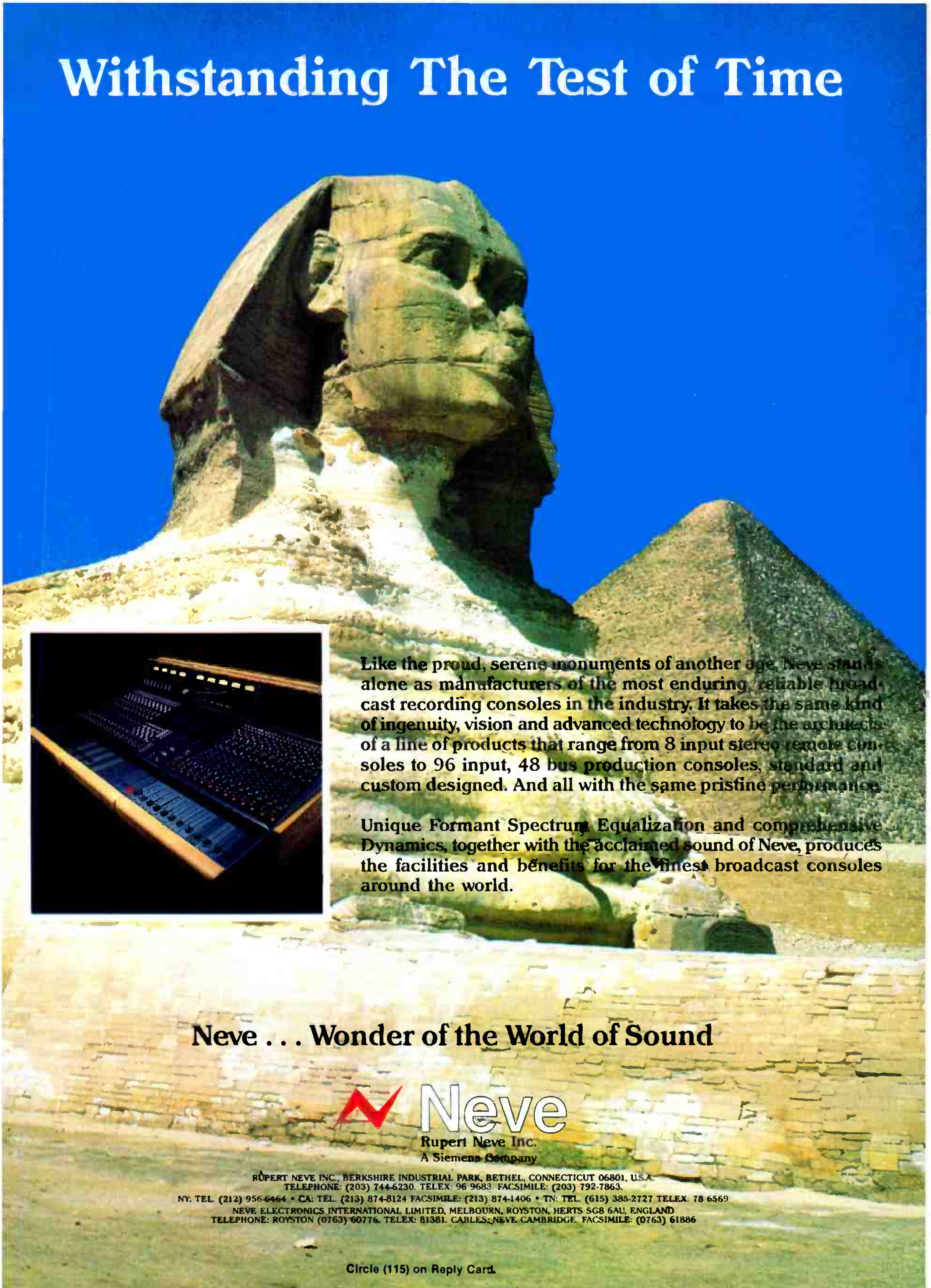
Communication within the society would be enhanced greatly if all chapters uploaded their monthly newsletters and meeting announcements. Some chapters find it difficult to come up with interesting programs. Being able to access other chapter newsletters could be a great source of programs and program sources. BPForum also is a good place to post information concerning the availability of manufacturers who provide programs, and to what areas they might be able to travel.

The NFCC's national frequency coordinator's list also is published on the BPForum. Because the list is updated regularly, you know the file you download is the most recent (and correct) version.

The national board of directors often uses the BPForum as a means of communicating with the membership. Richard Rudman, past president, often has filed informative texts concerning SBE positions and responses on a variety of topics. A good example is his reply to a magazine editorial, which criticized the SBE certification program.

The procedure for downloading or browsing through the data libraries is simple. The process is menu-driven, so just select the desired action from the available options. Table 1 lists the menus and response used for a typical computer.

Give it a try. There is a lot of useful information in the SBE area. The forum provides a convenient way to communicate with other broadcast engineers and to receive up-to-date information on a wide variety of topics.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Like the proud, serene monuments of another age, Neve stands alone as manufacturers of the most enduring, reliable broadcast recording consoles in the industry. It takes the same kind of ingenuity, vision and advanced technology to be the architects of a line of products that range from 8 input stereo remote consoles to 96 input, 48 bus production consoles, standard and custom designed. And all with the same pristine performance.
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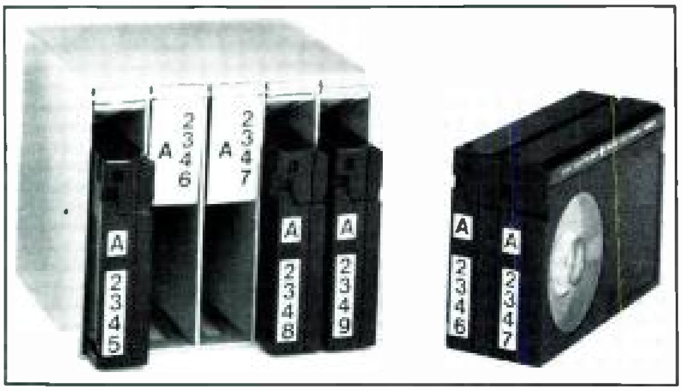
Circle (115) on Reply Card.

New products

Storage system, video center and videotape truck

The *Winsted Corporation* has introduced the following products:

- The TapeCube videotape storage system can store any brand of ½-inch Beta-size tape cassettes without covers in less space, in any cabinet or open wall area. The system is an injection-molded ABS plastic cube that accommodates five ½-inch Beta cassettes. The cube attaches to an aluminum extrusion hanger bar that fastens to any open wall space, or can be added to an existing hanger system. Pressure-sensitive vinyl labels on both the cube and cassettes provide identification.
- A/V carts are available in 34-inch heights with two or three shelves, and in 54-inch heights with three or four shelves. It is constructed of welded steel. It is finished in shadow gray baked enamel with chrome legs. All models feature 4-inch swivel casters (two locking).
- A programming videotape truck is equipped with eight aluminum hanger bars to accommodate the TapeCubes, ½-inch and ¾-inch tape shelves, and hanger cases for Sony, Ampex and 3M tapes. A stand-up work surface is provided, with adjustable height in 1-inch increments. The truck moves on 4-inch dual wheel casters.



TapeCube storage system

Circle (350) on Reply Card

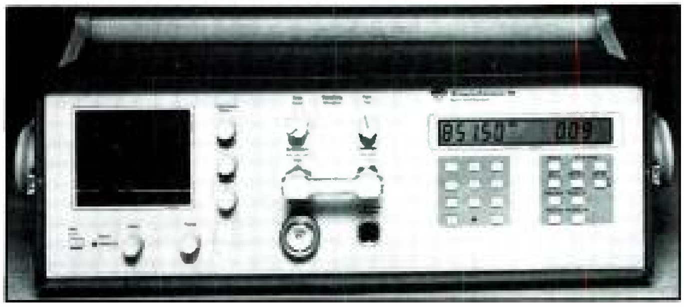
Fiber-optic repair kit

Jensen Tools has introduced the JTK-63, a comprehensive tool kit for work with fiber optics. It contains all the tools and materials needed to repair and terminate high-quality, ready-to-use fiber cable. The kit is recommended for use with SMA Amphenol 905- and 906-type connectors or other compatible SMA styles and for terminating a wide variety of single and bundled optical fiber cable. It contains tools and supplies for cleaving, stripping, polishing, buffing, crimping and inspection, plus heat gun, lapping film, epoxy, wash bottles, beakers, tissue wipes and an instruction guide. The tools and supplies are foam-protected within a polyethylene case.

Circle (351) on Reply Card

RF pulse reflectometer

TLH Heucke has announced the model 858 selective RF pulse reflectometer. It locates and measures reflections in transmitter antennas. The instrument is portable and can be used for the checking and aligning of (stacked) VHF/UHF sound and TV antenna systems and receiving-antenna networks. The distance to and reflection from each reflection point are shown on an LCD. The reflectometer is based on the transmitted pulse-modulated RF carrier signal and the selective receiver for time-domain measuring of the reflections. The selective measurement technique with the limited spectrum of the short (100ns) $\cos^2$-shaped RF pulses and low VSWR of the built-in wideband directional coupler enable precise attenuation and return loss measurements up to 42dB. A high amplitude of minimal +19dBm of the RF pulses eliminates problems with interference signals. Both the reflections and the transmitted pulse are simultaneously shown on a CRT screen. Features include a zero-setting, XY-recorder output, ac and 12Vdc-20Vdc supply.



Circle (352) on Reply Card

Wireless microphone series

HM Electronics has announced the 50 series of wireless microphones. The series features a dual-frequency body-pac and a switching-diversity receiver. The NRX-II noise-reduction system is optimized for wireless mic applications. Other features of the wireless mic series include mic-mute and power-switch lockouts and operator selectable RF frequency selection on the body-pac system.

Circle (353) on Reply Card

Time base corrector

Broadcast Systems Design has introduced the TBC501, a new design for time base correction, incorporating after-the-fact white balance, horizontal enhancement and pixel-by-pixel dropout compensation. Based on its sampling rate, the product offers increased bandwidth, low residual error and eliminates chroma shimmer. The dub in/out capability makes it suitable for Super VHS applications.

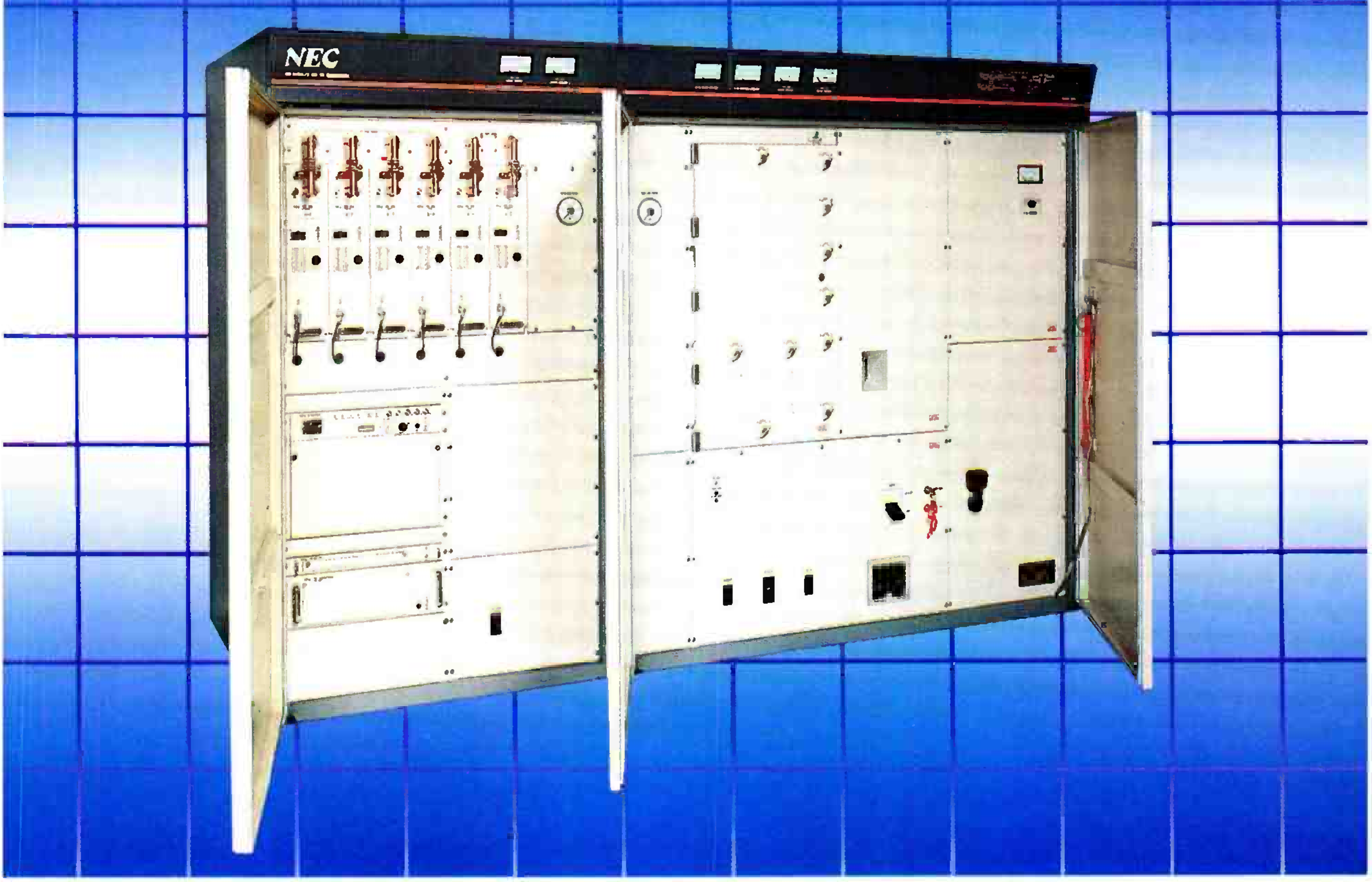
Circle (354) on Reply Card

Transponder selector

Designer Electronics has introduced the SA-257A transponder selector. It is designed for the Scientific-Atlanta DAT-32 digital audio receiver. The transponder crystal switch turns the DAT-32 into a dual transponder receiver with electronic switching control. The selector plugs directly into the downconverter. The user need only to wire 15V from the back of the downconverter and to supply a control voltage to switch from one network to another on different transponders.

Circle (355) on Reply Card

The new standard of dependability: VHF TV transmitters from NEC.



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NEC America, Inc.
Broadcast Equipment Division,
1255 Michael Drive, Wood Dale, Illinois 60191
Tel:312-860-7600.

C&C
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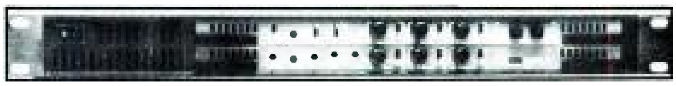
Circle (116) on Reply Card

Time base corrector and color corrector

Fortel has introduced the following products:

- The Turbo 2 time base corrector for PAL format for use with ¾-inch video recorders uses dub processing and is compatible with Sony SP machines as well as other ¾-inch machines. It accepts highband or lowband inputs, automatically detecting and switching for either. The unit also will handle dynamic tracking signals to allow DT play and provides pictures during high-speed shuttle. Other features include noise reduction, infinite window TBC, field or frame freeze with interpolation and horizontal enhancement.
- The WORKLINE series DHP 625 time base corrector provides signal processing for ½-inch and ¾-inch PAL composite video signals. It features infinite window correction, field and frame freeze, dropout compensation, high-speed shuttle, horizontal enhancement and noise reduction.
- The CC-2 color corrector provides broadcast-quality control of video color in all common component formats. Component operation is provided for RGB or Y, R−Y, B−Y for use with Beta and M-II formats. Plug-in PC boards permit reconfiguration for either 525 or 625 standards. The unit includes black, white and gray color-balance adjustment, black-and-white gamma control, standard proc-amp controls and independent hue, saturation and luma adjustments for each of the six color derivative vectors.



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RCA COLOR TELECINE SYSTEM, New/unused. To include: TK-66, color camera, TP-66, 16mm telecine projector, TP-7, 35mm slide projector, TP-55B, camera multiplexer. Write to: P.O. Box 23555-273, San Diego, CA 92123. 1-86-tfn

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SEALED BIDS WILL BE RECEIVED until 9:00 A.M., Thursday, December 3, 1987 for the "Sale of Used G.E. TV Transmitter". For more information contact Mr. Jim Moore, KOMU-TV Station, Highway 63 South, telephone (314) 442-1122, University of Missouri—Columbia, Columbia, Missouri 65211. 10-87-2t

TEKTRONIX TEST EQUIPMENT 521A Pal Vectorscope $3000, 1481R Pal WFM $3000, 1430 Random Noise $1500, 1480C WFM $3000. (818) 352-6619. 10-87-2t

COPPER!#8 & #10 ground radials; 2, 3, 4, 6, 8" strap; flyscreen; ground screen. 317-962-8596. Ask for copper sales. 11-87-6t

Routing switcher

Adrienne Electronics has introduced the AEC-1, a 10x1 wideband video and stereo audio routing switcher. Standard features include 30MHz video bandwidth, dc restored video, two audio channels, breakaway switching, crosspoint memory and broadcast-quality specifications. Options include a third audio channel for SAP or time code, remote-control panels, a serial interface, RGB/component switching, input expansion to 100x1 and output cable equalization and customization.

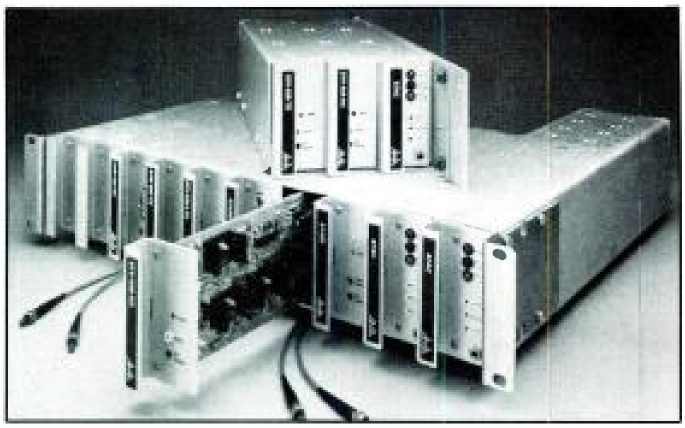
Circle (357) on Reply Card

Computerized audio console

Richmond Sound Design has introduced the Command/Cue 4096 computerized audio console. The console may be configured into many sizes of theater sound effects matrix systems. It may be used in conjunction with live P.A. mixers running mics while the computer is running taped effects and presetting levels. The console is a modular card frame system that is controlled by software specially designed on the Amiga computer system. The DCA-8 card is used for the level matrix and has eight digitally controlled attenuators with 60 1.5dB steps. The DMF-8 card is used for master input levels and is identical to the DCA-8, but with 240 0.395dB steps. Each card has a signal noise ratio of more than 100dB and total harmonic distortion of less than 0.03%. The DAP-8 card has eight patented digital auto pans. The pans will fade up, down or crossfade levels.

Circle (358) on Reply Card

Fiber-optic transmission system and teleproduction unit



87 EZ-LINK transmission system

Grass Valley Group has introduced the following products:

- The Series 87 EZ-LINK fiber-optic transmission system for distribution of video and audio signals features LED and laser transmitters for distribution up to 8km. An FM square wave carrier eliminates video distortion due to optical system non-linearities and delivers signal-to-noise performance of 60dB. Frequency response of 10MHz provides compatibility with standard NTSC or PAL baseband video. The system can be configured in an 8-module rack-mount tray or a 2-module wall-mount version.
- The IPS-100 full-capability teleproduction unit accommodates four VTRs via RS-422 serial control. It features JOG-PAD, a touch-pad for editor control. Other features include an edit controller, a model 100 production switcher, an AMX-170 audio mixer and sync and pulse generators with test signal—all incorporated into a single chassis.

Circle (361) on Reply Card

Satellite news van

DALSAT has announced the Roadrunner, a small, lightweight satellite news van. It features an Andrew 2.3 meter antenna. The air-transportable vehicle measures 21 feet long and 8 feet 6 inches tall. It can be equipped with redundant satellite electronics, communications, video and audio processing, edit and microwave systems.

Circle (362) on Reply Card

Laser video system

Artel Communications has introduced an addition to its SL3000 broadcast video system. The T3065 is a low-power laser transmission system. It is designed to transmit EIA 250B standard audio-video signals up to 25km over a single mode fiber. The unit uses a low-power 1,300nm laser as its optical source. The system is designed to make broadcast video available for medium distances on single mode fiber.

Circle (363) on Reply Card

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CHIEF ENGINEER needed for Miami Christian UHF Station. Strong on transmitters. Contact Ben Miller, Vice President, Engineering, Trinity Broadcasting Network, 714-665-2145. E.O.E. 11-87-4t

HELP WANTED (CONT.)

RADIO ENGINEERING MAINTENANCE SUPERVISOR FOR RAPIDLY EXPANDING Christian Science Monitor international broadcasting operation. Will supervise staff, maintain equipment and inventory; participate in design, purchase and installation of new equipment. Requires degree in Electrical Engineering or equivalent level of work experience. Must be motivated to get things done by building a quality maintenance team. Send resume to Maria Parrott, Christian Science Publishing Society P-818, One Norway St., Boston, MA 02115. 11-87-1t

TELEVISION MAINTENANCE ENGINEER to participate in the international growth of The Christian Science Monitor television operation. Will ensure efficient, quality production readiness with emphasis on audio systems and equipment; offer maintenance, installation and technical operations support; maintain inventory; and recommend purchase of new equipment. Must have 2-year technical degree and 3-4 years experience. Send resume to Maria Parrott, Christian Science Publishing Society P-818, One Norway St., Boston, MA 02115. 11-87-1t

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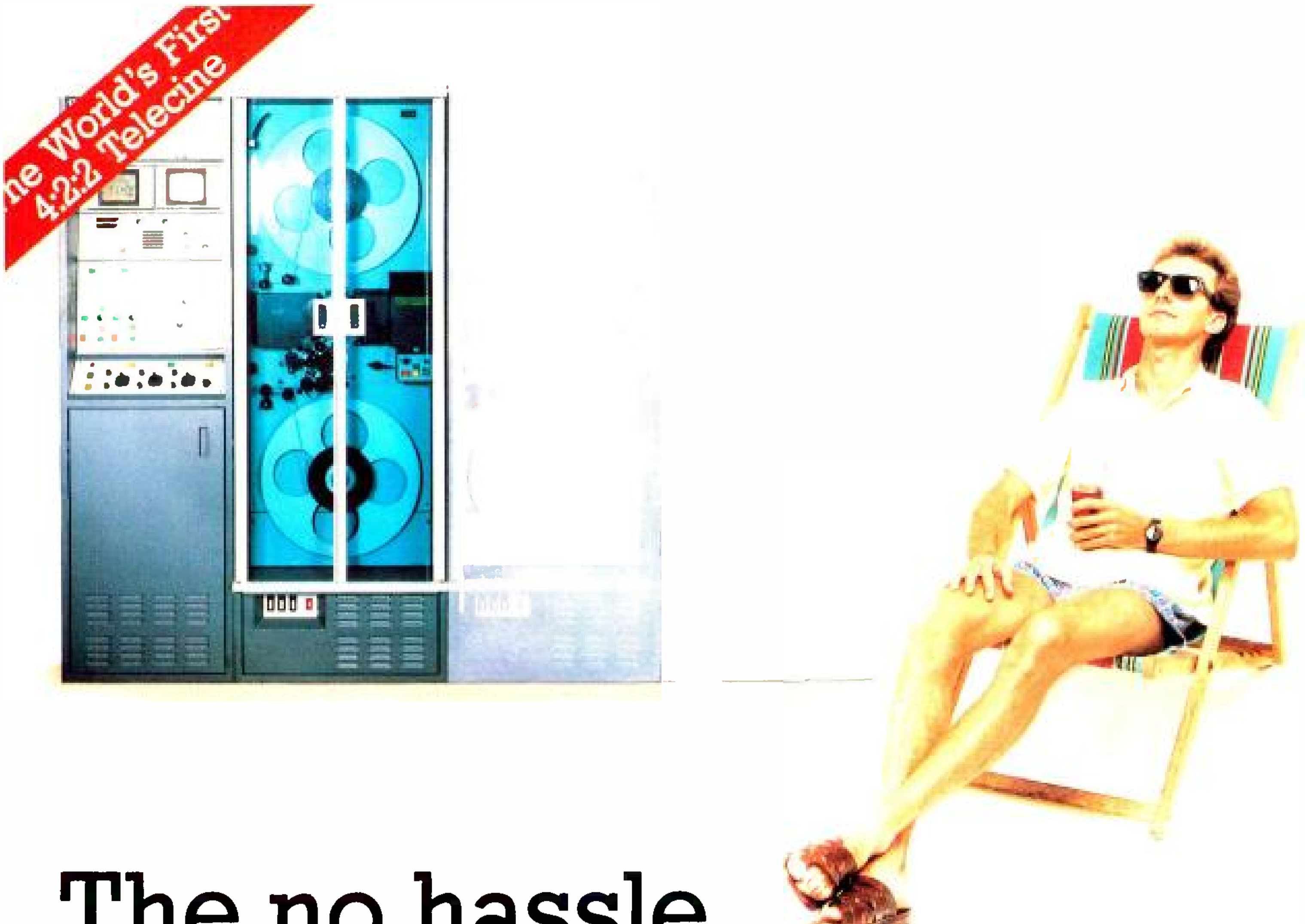

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