BROADCAST engineering

November 1986/$3

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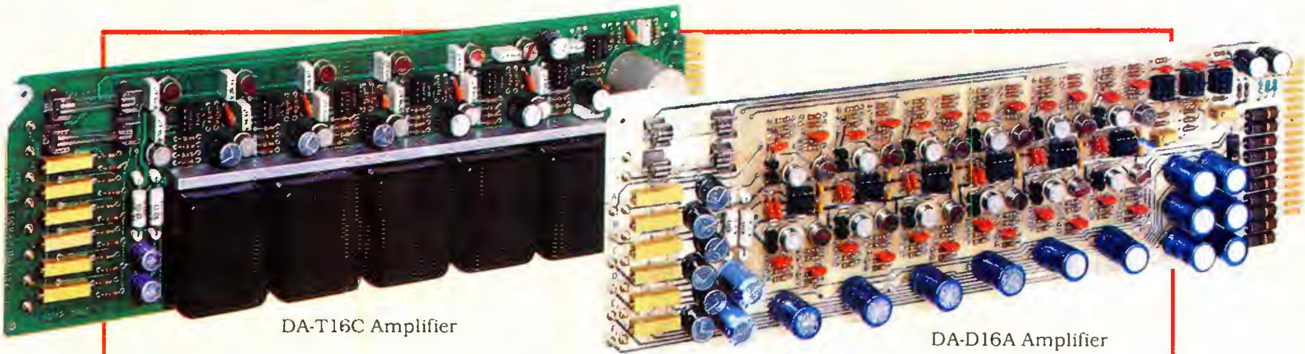

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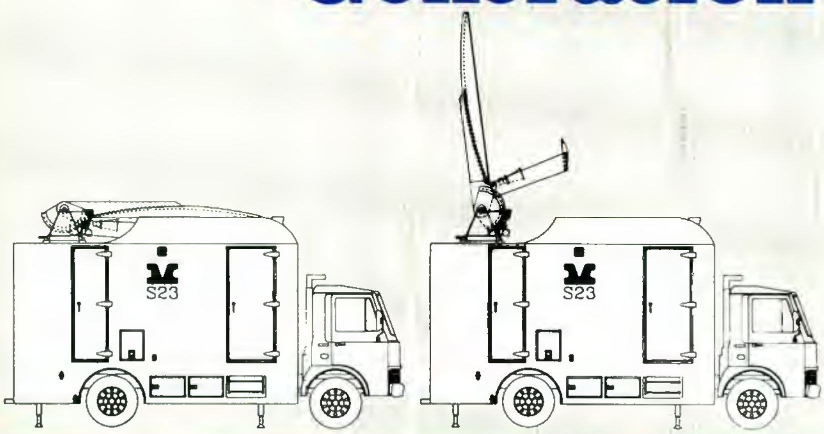

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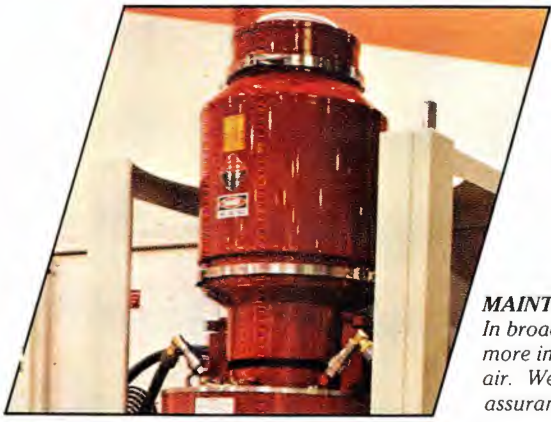

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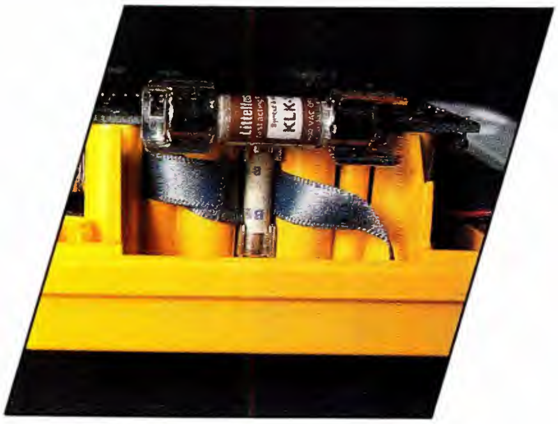
BROADCAST ENGINEERING

MAINTENANCE SPECIAL ISSUE:
In broadcasting, maintenance is job 1. There is no responsibility more important than keeping the equipment on-line and on the air. We examine critical areas of maintenance and quality assurance in our third annual Maintenance Special Issue.



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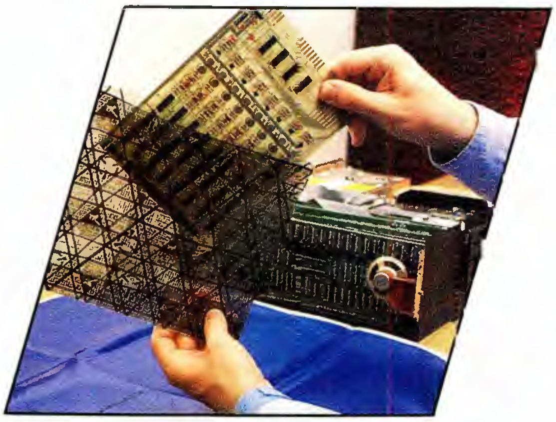

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ON THE COVER
Station maintenance is an ongoing commitment that every engineer faces on a daily basis. It is a requirement that is as old as broadcasting itself. This issue—our third annual *Station Maintenance Special Issue*—examines how to keep the equipment at radio and TV stations operating properly. Shown on the cover is a portion of a high-voltage rectifier stack from a 30kW FM transmitter. (Equipment courtesy of Broadcast Electronics.)

DEPARTMENTS

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SMPTE and SBE to form liaison

The Society of Motion Picture and Television Engineers and the Society of Broadcast Engineers have appointed liaison committees in an effort to establish a more formal and meaningful exchange of ideas.

Plans call for SMPTE and SBE to hold regular meetings, to exchange society literature and to promote the advantages of cross-membership.

M. Carlos Kennedy, SMPTE executive vice president, is chairman of the SMPTE liaison committee. Tom Weems, SBE director, will chair the SBE liaison committee.

The purposes of SMPTE and SBE are similar and parallel in their definitions and practices. The purpose of SMPTE, according to an excerpt from Article II of the society's constitution, is to "advance the engineering and technical aspects of the motion picture, television and the allied arts and sciences, and to gather, receive, prepare and disseminate scientific information concerning the motion picture, television and the allied arts and sciences." The purpose of SBE is "to diffuse and increase operational and scientific knowledge in broadcast engineering, and to promote and advance the science of broadcast engineering and its allied arts, in both theoretical and practical applications."

Although SMPTE has many members in the film industry, the society has become involved in TV-related engineering activities over the past several years. The SBE serves the whole broadcast industry. Broadcast television is the primary crossover discipline between the two organizations. Other common areas include video and audio, as well as new and developing technologies.

FCC receives request to review downgrade

The National Association of Broadcasters has asked the FCC to reassess its decision to reclassify or downgrade existing Class B and C FM stations that do not meet, or have not filed applications to meet, certain power and antenna height requirements by March 1, 1987.

In its filing, NAB said that without a rule change, these stations will be reclassified to achieve station diversity goals that are already being met and, in the process, the commission will have abandoned several of its own fundamental communications policies.

The NAB pointed out that the commission's goal of diversity and increased service can be met, without delay, even if stations are not reclassified. It said implementation of Docket 80-90 (which created more than 600 new allotments and adopted new allocations rules that have allowed the filing of petitions to create hundreds of additional FM stations) plus plans to improve and expand the AM band, will provide additional radio service without requiring FM station downgrading.

NAB also said the commission's reclassification rule will destroy service currently enjoyed by many listeners and ignores the fact that many stations face significant obstacles in their attempts to upgrade their facilities.

It recommended that the commission begin an expedited review of the matter and issue temporary waivers to those stations making a good faith effort to upgrade, which would give the FCC additional time to revisit the rule and assess the need for reclassification.

Continued on page 156

BROADCAST engineering

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BROADCAST ENGINEERING is edited for corporate management, engineers/technicians and other station management personnel at commercial and educational radio and TV stations, teleproduction studios, recording studios, CATV and CCTV facilities and government agencies. Qualified persons include consulting engineers and dealer/distributors of broadcast equipment.

SUBSCRIPTIONS: BROADCAST ENGINEERING is mailed free to qualified persons within the United States and Canada in occupations described above. Non-qualified persons may subscribe at the following rates: United States and Canada; one year, $25.00. Qualified and non-qualified persons in all other countries; one-year, $30.00 (surface mail); $108.00 (air mail). Back issue rates, $5, except for the Buyers' Guide/Spec Book, which is $20. Rates include postage. Adjustments necessitated by subscription termination at single copy rate. Allow 6-8 weeks for new subscriptions or for change of address. Second class postage paid at Shawnee Mission, KS.

BROADCAST ENGINEERING, Volume 28, No. 11 (USPS 338-130) is published monthly (except in the fall, when two issues are published) by Intertec Publishing Corporation, 9221 Quivira Road, P.O. Box 12901, Overland Park, KS 66212. Second Class Postage paid at Shawnee Mission, KS and additional mailing offices. POSTMASTER: Send address changes to BROADCAST ENGINEERING, P.O. Box 12983, Overland Park, KS 66212.

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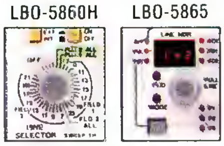

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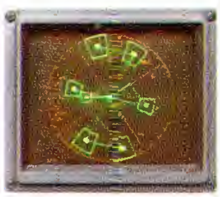

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Editorial

The fun is gone?

I see an era passing that I feel should not go unnoted. Others could chronical the event better than I, because they stood nearer the head of the line. They were the ones who taught me this business, and who have told me of those earlier days of broadcasting. This is in celebration of them.

A number of engineers across the United States charted the course of TV broadcasting. They ushered color, ENG, mobile units and studio automation to television as we know it today. They withstood the agonies of a fledgling industry, often keeping pictures on the air by sheer guts and ingenuity. Sometimes it was hair raising; at other times, gut wrenching; but it was fun.

These men arrived at work each morning, plagued with worries about cameras not firing up after the night's sojourn, about transmitters mysteriously failing, and about a million other major and minor catastrophies. These station basement inventors designed their own systems, with basic parts, often on shoestring budgets. These pioneers, with a drawing of the system burned into their minds, were on intimate terms with every piece of gear in the plant, having designed, modified, and/or installed it. They shared a common creed: *If it worked once, I'll make it work again.*

Dispatched to repair a unit with cryptic instructions to *make it work,* these jerry riggers found unparalleled satisfaction when the picture finally appeared. Each success was a chapter, and each chapter closed with the solving of the problem. Each day, challenging but hectic, was fun.

Perhaps the pioneering is done and the time has come for an MBA mentality to take over, to use the bottom line as its reference. Perhaps it's time to consider *will we still go on the air if we forego this?* Perhaps adequacy in a marketplace satisfied with the present product should supersede technical excellence. Perhaps television has progressed far enough and the harvest should begin.

Each industry undergoes a pioneering age when great strides are made by unlikely heroes. Chuck Yeager enveloped himself in the evolution of jet airplanes, finding his fun in breaking new ground and in the journey through the maze, but not in the final dissertation. He felt no yearning for automated space ships escorting him through the heavens, but rather, delighted in mastering his own fate.

Such were the TV titans, who designed and built the marvelous monstrosities that gave us pictures where none had been before. But could these creative minds elicit joy from pressing buttons or replacing chips? If they can't get their hands on it anymore, are they inclined to trace through a system mined with software and PROMs that render their tools ineffective? They begrudged few hardships and shrank from few challenges for the industry was tempered with their ideas of fun.

Times have changed the focus of their original commitment. Each day across this land a microprocessor will record one or more of these pioneers as they leave their stations. Some will be festooned with retirement gifts and gags; others will slip away silently, unceremoniously.

As the age of broadcast pioneers draws to a close, we must bid farewell to those who opened the Pandora's box of broadcast and set sail on a sea of microwaves. They leave behind mere specialists who know but parts of the system. (The early concepts have expanded beyond only the most imaginative of minds.) They (willingly?) bequeath the system to the minders of the money who feel secure that a picture will always arrive. After all, it was guaranteed by the signatures clearing the way to corporate possibilities, wasn't it?

Behind them, a redundancy of manufactured systems replaces one-of-a-kind fabrications. The evolutionary steps to modern television and the accompanying legacy of terrors (tales told by fireside) encountered, in blazing a trail through an electronic wilderness of valves and condensers, has given way to an advanced state-of-the-art (so they call it) industry. Hey, wait, you guys, don't take away all the fun!

Prepared by Bebe F. McClain, B.F. McClain Productions, Asheville, NC.

U.S./Mexican pact implemented

By Harry C. Martin

A new AM broadcasting agreement between the United States and Mexico was signed on Aug. 28, implementing the following long-awaited changes for daytimers:

- *Post-sunset authority:* All U.S. daytime-only AM stations that received post-sunset authority from the FCC last year now may operate for up to two hours past sunset with the power levels indicated in the FCC authorizations. No additional application or notification to the commission is necessary.
- *Use of Mexican clears:* The 300 stations that operated daytime-only on the Mexican clear channels now are authorized to operate on an unlimited time basis at the power levels indicated in show-cause orders sent to them by the commission last spring. Affected stations were required only to advise the commission in writing as to when nighttime operations would begin and to provide a brief technical description of how such operations would be conducted.

Use of the Mexican clears for new or improved facilities will be phased in over the next five years. For the next two years, until Aug. 27, 1988, the commission will accept applications for new full-time stations on the Mexican clear channels and for power increases by stations already operating on the Mexican clears. However, such applications filed prior to Aug. 27, 1991, may not specify nighttime power in excess of 500W and will not be afforded interference protection.

Beginning Aug. 28, 1988, the commission will accept applications by existing stations wishing to move to a Mexican clear if the applicant can show compliance with FCC interference standards. Therefore, stations operating on a Mexican clear channel that want to increase nighttime power should prepare and file their applications (for up to 500W) as soon as possible. Stations wishing to move to a Mexican clear will have to wait until August 1988 to apply.

Former daytime stations operating on the foreign clears, or stations seeking to move to a foreign clear after the conclusion of the 2-year moratorium, will not be afforded nighttime protection during the 5-year phase-in period.

After Aug. 27, 1991, increased nighttime power on the Mexican clears of up to 1kW will be available, provided protection is given to all stations, including former daytime-only stations operating with a power of 250W or more at night.

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

Fairness Doctrine scrutinized

In a decision involving the applicability of the Fairness Doctrine to teletext transmissions, the U.S. Court of Appeals for the District of Columbia Circuit ruled that the Fairness Doctrine is not mandated by Section 315 of the Communications Act (the "equal time" provision). This interpretation of Section 315 has long been advocated by broadcasters because of the authority it confers on the commission to exempt new technologies from the reach of the doctrine, or to repeal it altogether.

The Fairness Doctrine places an affirmative obligation on broadcasters to cover controversial issues of public importance in their communities and requires them to provide balanced treatment of such issues. Members of the commission, including Mark Fowler, chairman, have criticized the Fairness Doctrine on constitutional grounds. But the commission has stopped short of repealing the doctrine, in part because of the argument—now rejected by the court—that its enforcement is mandated by Congress.

In another case, the Court of Appeals heard arguments on Sept. 30 on the constitutionality of the Fairness Doctrine. The case involves appeals by broadcast news organizations of the commission's 1985 "Fairness Report," through which the commission announced it would continue to enforce the doctrine in spite of the agency's constitutional misgivings.

A court test of the constitutionality of the Fairness Doctrine may be delayed by Congress, however. An amendment to the commission's appropriations bill mandating reconsideration of the Fairness Doctrine came under Senate consideration in late September. Had the bill been passed with the reconsideration language included, the commission again would have had to deliberate before the fate of the Fairness Doctrine would be ready for court review.

In any event, it appears the Fairness Doctrine's days are numbered. The scarcity argument, which long has provided the underpinning for the distinction justifying different treatment of broadcast and print media under the First Amendment, has been eroded by the development of program delivery technologies.

VBI timetable eliminated

In early September, the commission eliminated its timetable for use of lines 10-14 for the transmission of teletext information using the TV vertical blanking interval (VBI).

The timetable was enacted in 1983 when there was concern that teletext signals could cause interference on some older TV receivers and was intended to allow for gradual replacement of such receivers. Having found that this purpose has been served, the commission eliminated its phasing-in procedure in order to satisfy the need for new and enhanced teletext services. This accelerates the time frame for full use of VBI by two years, and affords broadcasters greater flexibility in the use and development of teletext services.

The relaxation also applies to non-teletext uses of lines 10-14.

Compelling need relaxed

In addressing petitions for reconsideration in its "omnibus" FM-channel allocation proceeding, the commission has ruled that petitions for new or changed FM allocations may propose substitutions in the Docket 80-90 table as long as such substitutions involve allotments for which the application filing window already has closed.

Previously, substitutions for Docket 80-90 assignments were permitted only upon a showing of compelling need. Under the new procedure, rulemaking petitions involving substitutions will be accepted provided the channel being proposed as a substitute meets the spacing requirements for all applied-for sites at the time the petition is filed.

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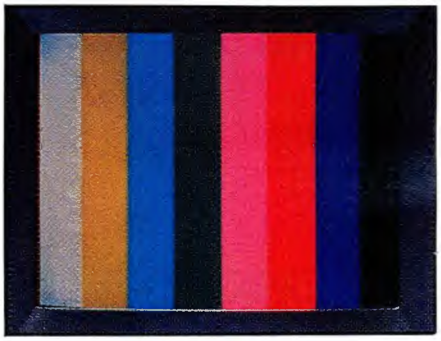
How to measure bandwidth

By Carl Bentz, special projects editor



Why was the bandwidth of U.S. TV channels limited to 6MHz? Several factors were involved. Sufficient information for a reasonably good image can be contained within 6MHz. More channels were possible by limiting the bandwidth rather than allotting a larger spectrum per channel. At the time NTSC was being defined, simultaneously controlling the gain over a 6MHz band, although not exact, was possible at a reasonable cost.

Investigations into higher-definition TV systems have shown the bandwidth of the NTSC channel to be a stumbling block. Image definition is directly related to the frequency spectrum of the signal. Large areas result from luminance components of less than 1kHz, but fine detail could extend beyond 4MHz. In NTSC, detail greater than 4.2MHz is lost in bandwidth restriction. Typical home receivers cut the frequency down even more with designs for mass production of televisions at an economical price.

Because you can never recover more than you start with, the transmitter, the final limiting factor of the TV station, must be adjusted for the maximum permissible frequency response. Response monitoring usually depends upon visual displays, such as waveform monitors, to observe how multiburst, color bars and swept-frequency test signals are handled.

The time-domain display of a waveform monitor allows observation of the signals on single or composite line or field basis. Response translates to variations of levels between the input signal that is applied to the transmitter and the relative reduction of any component through modulation, amplification and demodulation.

Pushing NTSC for increased detail requires a means to more accurately monitor response. Viewing the transmission channel with a spectrum analyzer is one popular method. The display is based upon the frequency domain, rather than a translation to time domain.

Traditionally a video-sweep generator provides the input test for performance assessment with a spectrum analyzer. A special signal, based upon mathematical functions, offers advantages over swept-frequency methods.

(Sin X)/X

Pulses and square wave signals with fast rise times are rich in harmonics. The horizontal sync pulse provides an excellent example. With a fundamental frequency of 15.734kHz, sync produces harmonics that extend upward from the visual carrier. Designed attenuation reduces harmonic interference with the aural carrier. Particular concern is necessary with stereo television, where harmonics can have a detrimental effect.

A new test for transmitter response uses the (Sin X)/X relationship. (See Figure 1.) The spectrum contains all harmonics of 15.734kHz sync to 4.75MHz. All harmonics are generated with the same amplitude and energy content. The pulse is presented as both positive- and negative-going. Beyond the 4.75MHz upper cutoff frequency, attenuation removes all significant energy.

Second, the test signal uses 1MHz markers in much the same format as a multiburst signal. Viewed on the spectrum analyzer, the markers quickly verify calibration of the display. Viewed on a waveform monitor, the markers produce a cursory display of system response.

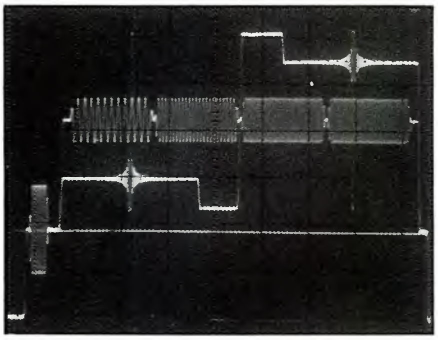


Figure 1. The (Sin X)/X pulse and marker waveform, as produced by the Leitch XTG-2500N transmitter test generator.

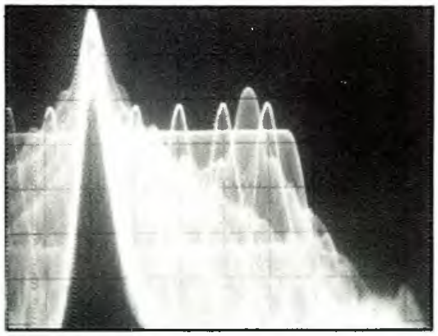


Figure 2. The spectrum analyzer display produced by the (Sin X)/X test signal.

The (Sin X)/X and 1MHz marker signal, connected directly to a spectrum analyzer, produces the display in Figure 2. Analyzer control settings of 1MHz/division and 300kHz resolution were used. A continuous coverage of the video band, a sharp rolloff above 4.75MHz and the visual carrier are clearly visible. The trace markers fall on each graticule marking, assuring the 1MHz/division setting.

Energy around the 3.58MHz color subcarrier is apparent, resulting from the presence of burst on the input waveform. More spillover from the subcarrier toward the aural carrier is apparent than from the luminance.

Figure 2 is a direct display. It is not obvious that the spectra produced by the positive- and negative-going (Sin X)/X pulses are shown. Under ideal conditions, both overlap perfectly. In real systems, gain-related non-linearity of the transmission system will cause the two spectra to diverge.

Using the signal

When out-of-service testing is possible, the equipment setup and procedure is simple. A full-field test signal is applied to the video signal input of the visual modulator. An output signal taken from a sampling point after the final amplifier is applied to the spectrum analyzer.

In-service testing can be achieved through the use of VITS. The test signal is inserted onto a VBI line of the program video. To view the signal, a sample is applied to a waveform monitor with line-select or line-strobe. The strobe output is used to unblank the spectrum analyzer during the desired line. RF from the transmitter sampling point is fed to the input of the analyzer.

Although the video sweep signal can be generated with marker birdies, it is not a continuous signal. However, the sweep rate can be set high enough that visually it appears continuous. The new form of test maintains a constant load on the transmitting system, because the fundamental and harmonics are constantly present.

Why spectrum analyzers? We'll answer that question next month as we look closer at the frequency domain.

Editor's note: Appreciation is expressed to Leitch Video for assistance in preparing this article.

FIELD PRODUCTION

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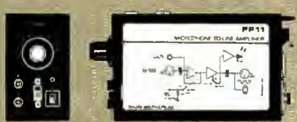
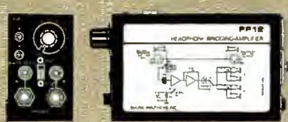


FP12



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Part 4

re: Radio

Learning the basics

By John Battison, P. E.

Many engineers know that an AM station with a directional antenna (DA) is required by the FCC to perform a complete proof-of-performance test after construction and before the license is issued. However, a non-directional (non-DA) station is under no FCC mandate to complete a set of field-strength tests. This is unfortunate because there are so many occasions when the information provided by a short proof completed after construction would be quite helpful.

There is no better example of when this information is needed than several years later, after the system begins to deteriorate. Typically, complaints (usually from the station manager) about poor signal coverage initiate an investigation by the engineer. If no records on the performance of the original antenna exist, it's difficult to establish whether the system is operating properly.

Defining the problem

The problem of assessing performance is particularly difficult for stations built before 1960. Their ground systems are probably deteriorating and the antennas and insulators may be rusting and cracking and covered with soot and other conductive substances. The transmission lines may be showing signs of age also, with loose fittings or physical damage. The old adage, "out of sight, out of mind," is an appropriate description of ground systems at many pre-1960 facilities. If you've ever worked for a small station, you may have had first-hand experience with this kind of situation.

Environmental elements also can affect a station's field strength. Construction near the tower can cause problems. There may now be houses and buildings where there used to be fields. This type of construction can alter the ground's conductivity.

Trees may be growing around the antenna. Many stations were built on scrub and forest lands. The bushes and trees that were originally cleared to make room for the ground system may have grown back around the antenna.

Ground systems can be damaged by root growth and flooding or heaving from yearly freeze/thaw cycles. Further deterioration is caused by unauthorized vehicular traffic across the site or by vandalism.

No matter what the cause of deterioration, you need a reference point. If field-strength measurements had been made when the station signed on, it would be relatively easy to make a comparison set of readings. If, on the other hand, you are not so lucky to have such a reference point, what can you do?

Check the impedance

After sign-off, measure the base operating impedance. If an in-line operating impedance bridge (OIB) is available, you can make the test while the station is on the air.

Connect the bridge across the jack on the antenna side of the network. Ensure that the bridge is properly set up and remove the jack plug. The impedance can now be read while the station is operating. If the base impedance has changed, it is possible to correct the network setting while still on the air.

If adjustments are necessary, it may be possible to reduce the power to 500W or 1,000W and make small adjustments while wearing a linesman glove. The shunt leg determines network input resistance. The series leg determines the reactance. An OIB eliminates the need for a signal generator and speeds the work.

Field-strength measurements

Assuming that the base resistance and current are correct, it will appear that the station is radiating its licensed power. At least it will appear that the transmitted power is going into the antenna. If the field strength is still not correct and the ground system is functioning properly, then the power is getting into the antenna system but not being radiated properly.

Using a field-strength meter, plot a radial through the areas where the signal strength is low and another where the signal strength is still good. Plot as many radials as necessary and use radials that cover similar ground. Measure the actual field strength along these radials and plot the results on groundwave paper.

Locate the 0.5mV/m point on each radial and plot each of these points on a suitable map. Connect the points, fairing or smoothing the curve to form the half-mil contour map.

Plot the radials showing low field strength on a topographic map. Examine the area between the transmitter and the 0.5mV/m points for new construction, buildings, concrete expanses, large power lines or tall towers built with continuously poured concrete and long reinforcing bars.

Also check for proper detuning on nearby FM or TV towers. There is at least one case in which the consulting engineer specified a detuning skirt for a new FM tower, but in the haste to complete construction, the skirt was not added.

The problem was discovered when the station owner complained that the signal strength became worse after the FM tower was built. Because no measurements were made on the AM station prior to constructing the FM tower, there was no way to be sure the new tower had not caused the problem. This example points to the need to make and record measurements whenever major changes are made to any antenna system.

This example was an easy case. Far too often, the causes are not obvious. If there is any kind of tall construction in the path of signal problems, take a field-strength meter and hold it near the object. If the object is affecting the AM signal, a strong reradiated signal will be observed. The problem then becomes how to detune it.

If the tower was built by an FCC-licensed organization, redress can usually be obtained by working with the FCC and having the offending tower detuned. This illustrates the importance of watching for proposed radio/TV construction near your tower site. The best information sources are FCC applications and proposals. If you don't have access to them, consider hiring a consulting engineer or attorney to perform this work.

Next month we'll take a look at tower detuning.

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

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Teleport—an earth station for all reasons

By Elmer Smalling III

A teleport is an earth station that is leased for public use as a common carrier. It is a multi-access transmit-and-receive facility for domestic and international applications. It also includes support hardware to facilitate communications of voice, data and video information. Depending on the number of customers it serves, a teleport may have from one to six or more 9.2m steerable C-band or Ku-band antennas. Each antenna must be capable of covering the full arc of U.S. communications satellites, from 60° to 143° west longitude.

At this time, there are approximately 45 teleports in operation in the United States, with 200 to 300 predicted by the end of the decade. The emergence of the teleport as a new, independent entity is the result of a number of factors.

Expense is one factor. Less obvious but important reasons range from local zoning restrictions regarding satellite dishes, space requirements and the necessity of locating dishes to access the full arc without obstructions (or future obstructions), or terrestrial RF interference. Although the number of satellite communications users is growing, private ownership of earth stations may be restricted by many factors beyond the users' control, regardless of budget. This creates the need for teleports.

Interconnection

Typical interconnection between the teleport and its customers may be by way of microwave, fiber optics or coaxial cable, which may be provided by the local phone company or the teleport. For some customers, the interconnection may be as simple as videotape. Most teleports have standard format VTRs online for such feeds. Some teleports may provide accommodations for a customer's antenna and support equipment.

Hard connections such as cable or fiber optics rate high in reliability, but are expensive. These costs will be intensified if trenches need to be dug or if special cable has to be pulled into buildings. The provider of hard connection services may also specify minimum use of the service to justify the cost of installation. Typically, the customer is charged for installation, but that charge may not preclude minimum use requirements.

Microwave interconnection can be simple and relatively inexpensive compared to hard connections. In large metropolitan areas, however, multihop links between the customer and the teleport's microwave system may be required due to line-of-sight blockage caused by buildings or terrain. Multihopping multiplies the costs of microwave interconnection, and should be compared to hard connection for overall costs of installation, operation and maintenance.

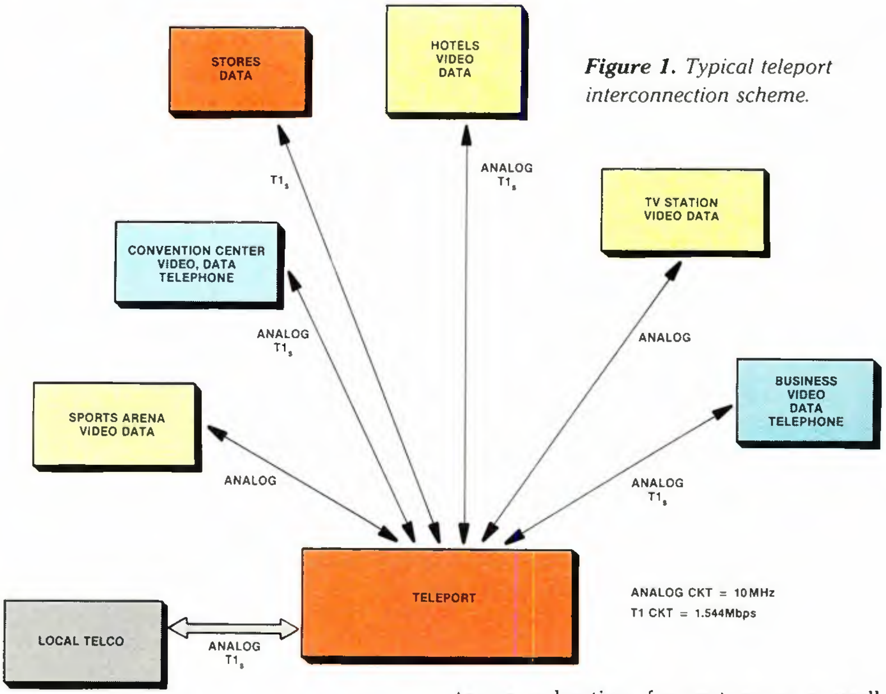


Figure 1. Typical teleport interconnection scheme.

The Dallas-Fort Worth Teleport

The Dallas-Fort Worth Teleport is a working example of a typical teleport that serves a large metropolitan area. It provides services for TV and cable networks, single-event TV feeds, and teleconferencing. The teleport has wideband communications with the local phone company via full duplex 6GHz microwave, with cable and fiber redundancy. The teleport also is interconnected with both major sports stadiums, the Dallas Communications Complex (a large, multifacility TV and film center), and several private businesses. Signals are imported via microwave.

Because the teleport is located in a new, planned business development away from downtown areas, its microwave system and microwave antennas are centrally located atop the Texas Commerce Bank building, and the InterFirst Plaza building. Interconnection between the microwave system and the teleport is accomplished using fiber optics.

Other support services

In addition to the hardware and engineering services found at any uplink facility, a teleport requires a support staff to handle the logistics and traffic scheduling required for successful satellite communications. The support staff can lease transponder time for customers, as well as arrange remote services for special applications. For example, to organize a teleconference, the support staff can make all the necessary arrangements not only for a studio, uplink and transponder, but also for facilities at the receiving end of the transmission. This includes contracting satellite reception, meeting rooms, display devices, seating arrangements and coffee and doughnuts if the customer requests.

The teleport has evolved into the "one-stop shop" for users of satellite communications in a broad spectrum of applications and services. BE

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

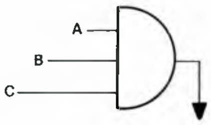
Examining logic gates

By Gerry Kaufhold II

Have you ever been working in the wee hours of the morning on routine transmitter maintenance, only to discover that when you think you're finished and ready to go home the transmitter won't come up? So you recheck the work you performed, since the transmitter was working before you started, and it still won't come up. Then it hits you. Check the safety interlocks. You check all the door switches and just about the time you thought you'd be crawling into bed, you find a bent lever on an interlock switch that just robbed you of a couple of hours of sleep. You may have just learned your first lesson in digital logic.

Digital AND gates

That sequence of switches that prevented high-voltage to be applied to the plates of your transmitter formed a basic circuit analogous to the digital AND gate. In a digital AND gate, all of the inputs must be HI before the output of the AND gate goes HI. If any single input is LO, the output of the AND gate will remain LO.



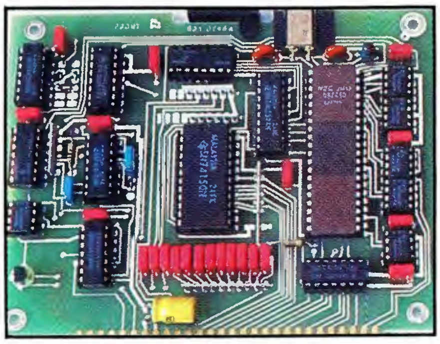
INPUTS A	B	C	OUTPUT
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

Figure 1. *Truth table and logic symbol for tri-input AND gate.*

Truth tables

A truth table is one method used by designers of digital circuits to express the various input and output possibilities of a digital circuit. This term is derived from the ancient study of philosophy where Plato used truth tables to analyze con-

Kaufhold is staff engineer for KAET-TV, Tempe, AZ.



cepts. The states of the inputs are tabularized, and the outputs that result can be easily seen.

The truth table for a tri-input AND gate is shown in Figure 1. Note that only when all inputs are HI does the output go HI. A typical method used to implement such a gate is the multiple-emitter transistor shown in Figure 2.

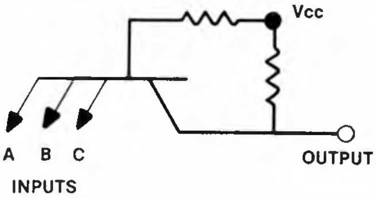
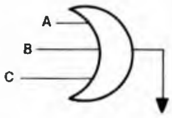


Figure 2. *Multiple-emitter transistor used as a simplified AND gate.*

OR gates

An OR gate has the truth table shown in Figure 3. In an OR gate, the output goes HI when a HI is applied to any input. This might be considered similar to a parallel analog circuit except with an OR gate, the signal that gets there first is passed to the output, and all other HI signals have no effect until the first HI signal goes away.

AND or OR gates are used to pass signals that go HI when they carry significant information. Such signals are called *active HI.*

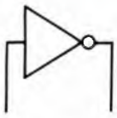


INPUTS A	B	C	OUTPUT
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

Figure 3. *Truth table of a tri-input OR gate and logic symbol.*

Inverters

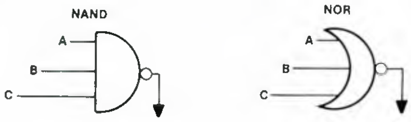
The truth table for an inverter circuit is shown in Figure 4, and is considered a special case and has a special notation. Whenever a signal is normally HI and is significant only when it goes LO, the signal name is specified with a horizontal bar over it, and is said to be *active LO.*



INPUT	OUTPUT
0	1
1	0

Figure 4. *Inverter truth table and logic symbol. The bubble on the output signifies the inverter portion of the circuit.*

Attaching an inverter to the output of an AND gate creates the NAND gate (not, AND). Similarly, using an inverter on the output of an OR gate creates a NOR gate (not, OR), as in Figure 5.



NAND

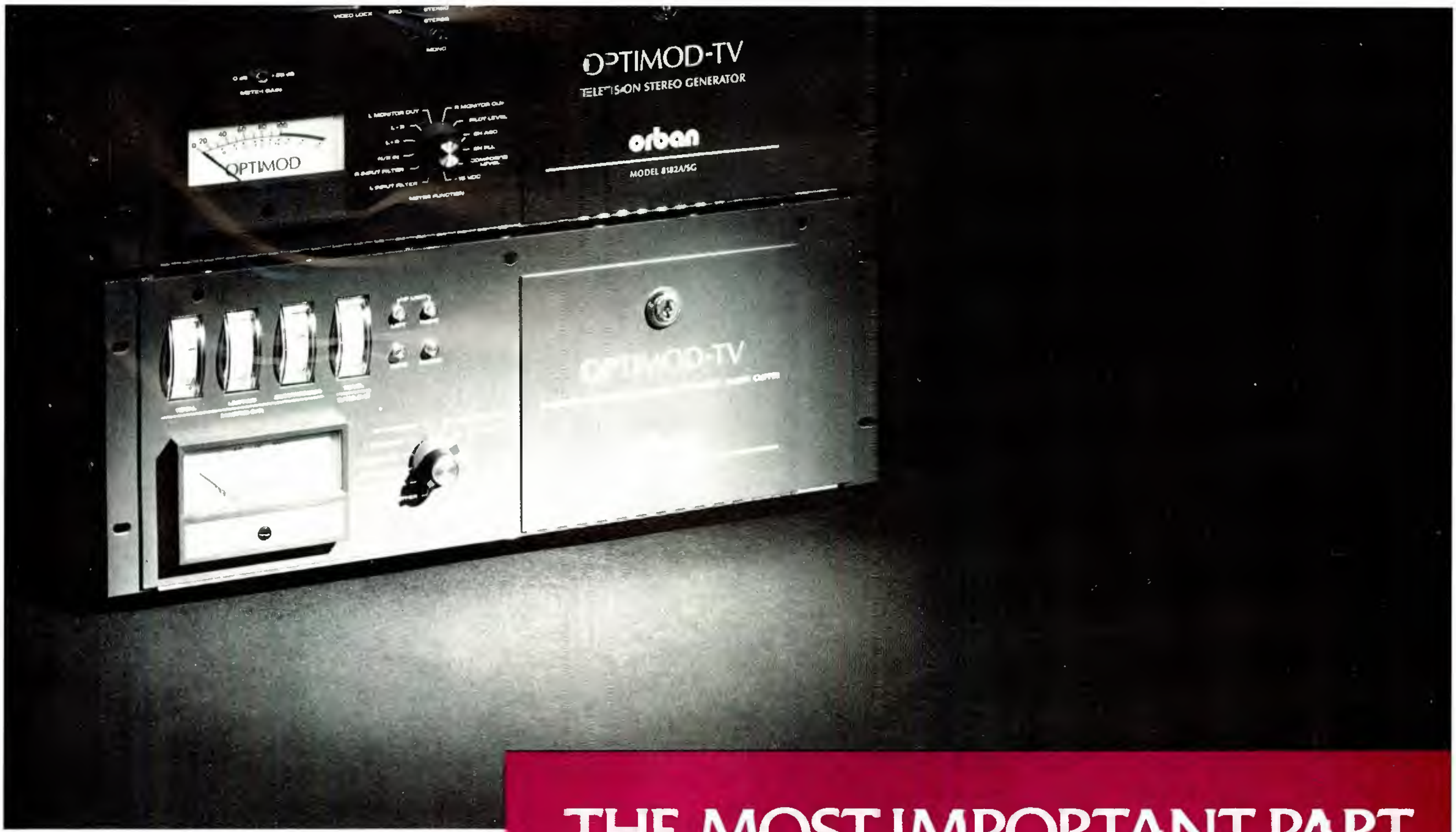
INPUTS A	B	C	OUTPUT
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

NOR

INPUTS A	B	C	OUTPUT
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

Figure 5. *Logic symbols and truth tables for NAND and NOR gates.*

Connecting several AND, OR, NAND, NOR and inverters together and trying to trace through the truth tables is complicated. Boolean Algebra is a form of designers' language used for testing the interconnection of gates. It was invented in the 1850s by George Boole as part of the mathematics of symbolic logic.



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Several manufacturers make a stereo generator for television, Orban among them. How do you choose the best one?

Stereo generator design, while difficult, is a task whose goals are objectively defined by BTSC specifications and the EIA Recommended Practices. Such design is well within the grasp of competent engineers, and the success or failure of the design is readily measureable by instrument.

In contrast, a TV stereo audio processor must be evaluated by *subjective listening tests*. Measured performance tells you almost nothing about the sound of a given design. This point is crucial because the audio processor, more than any other element in the system, dictates the air-sound you get.

Orban spent four years fine-tuning and perfecting OPTIMOD-TV Model 8182A until it could gracefully handle even the most difficult and diverse program material. During the development cycle, sophisticated mathematical design techniques were always complemented by exhaustive listening tests.

Part of OPTIMOD-TV's superiority stems from its architecture: its patented multiband compressor usually acts like a wideband compressor to preserve frequency balances. But unlike the oversimplified wideband compressors found in some other TV audio processors, it also prevents the pumping of midrange sounds (like dialogue) by low-frequency sounds (like sound-effects with lots of bass energy). It also has a CBS Loudness Controller to prevent viewer complaints due to loud commercials.

Best of all, OPTIMOD-TV's adjustability makes it a processor that will serve you well now and in the future. Comprehensive setup controls determine the amount of dynamic range reduction that occurs, so you can operate OPTIMOD-TV to produce a consistent, uniform sound that is comfortably listenable on small sets, use it as a safety limiter, or split the difference. The choice is yours!

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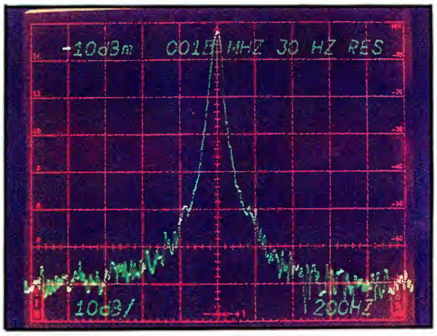
Repairing digital systems

By Ned A. Soseman, TV technical editor

In many applications, the digital storage oscilloscope (DSO) performs as well as its analog counterpart and offers several features that can be highly useful to today's broadcast maintenance engineer. The DSO is not without its limitations, however, which you should consider before trading or retiring your "old faithful" analog scope for a new DSO.



DSO sampling rate

Probably the weakest area of current DSO technology is the sampling rate. Top-of-the-line DSOs may be capable of 200 megasample/second rates, but many DSOs sample only every 20ns to perhaps 1μs. At a maximum speed of 200 megasamples/second, the input is sampled at intervals of 5ns. Without further processing, it will provide a resolution of $\pm$5ns. Given this fact, the analog oscilloscope retains the unique capability to measure rise and fall times in the subnanosecond range. Until digital sampling rates can be increased economically to several gigasamples/second, DSOs must rely on other methods to accurately interpolate timing points between samples.

The Nyquist theory

The Nyquist theory states that when a signal to be sampled is band-limited to one-half the sampling rate (the Nyquist frequency), the original sampled signal can be reconstructed completely and accurately. In fact, perfect bandpass cannot be achieved, and some high-frequency components of the signal leak through. These components are aliased, or transformed into low frequencies, similar to heterodyning. This limits the accuracy and repeatability of measurements taken by a digital sampling system.

Digital filtering

To improve accuracy beyond the $\pm$5ns resolution available from a 200 megasample/second rate, some DSOs use digital filtering that may offer a resolution with repeatability approaching 2ns for interpolation of timing points between samples. Before purchasing a DSO, find out the minimum resolution that can be observed with repeatability, and learn how the DSO resolves signals faster than one-half the sampling rate.

Random repetitive sampling

This technique, common to some DSOs, makes a number of enhanced DSO features possible, and it also tends to eliminate aliasing. Random repetitive sampling occurs independently of the phase or frequency of the input signal. The sampling timing is controlled by an internal crystal-referenced clock, and samples are taken at about every 25ns over many input cycles.

The technique is called *random*, but the samples aren't truly random in nature. The description comes from the fact that there is no correlation between the time the sample is taken and the input or trigger frequency or phase. The method is called repetitive because the process is used to build a waveform display from many randomly spaced samples that are repeated and superimposed on a single sweep.

Random repetitive sampling will not increase the resolution for 1-shot applications, but it does provide a distinct advantage. The crystal-referenced clock in the DSO is capable of an excellent time-base stability, with a short-term phase noise (jitter) of less than one-half part per million.

To illustrate the benefit of this degree of stability, consider jitter measurement of NTSC video. Not only can the jitter of any NTSC pixel be measured accurately, but the stability offers accuracy that can resolve the instability of any one pixel of a 1,000x1,000 line high-resolution graphics display in which one pixel represents only 1/1,000,000th of the total frame. This is several orders of magnitude greater than the time-base stability of typical analog oscilloscopes.

Negative time

Another advantage of the DSO is that it allows the user to look back in negative time, before a trigger pulse occurs. Random repetitive sampling may allow you to look back through thousands of screen diameters (one screen diameter represents the time/division times the number of divisions on the graticule). Other sampling methods may be limited to just one or two screen diameters. When you're troubleshooting an intermittent problem on a data bus or power supply, this feature can save you hours or days of watching and waiting for something to happen.

Some relevant DSO terms

Analog-to-digital (A/D) converter—*A device (usually an IC) that converts an analog level into a digital word. It is the speed of this conversion that limits the effective bandwidth of the DSO.*

Battery backup—*A battery is used to retain the content of the DSO memory when ac power is removed from the scope.*

Bubble memory—*A type of non-volatile memory, also allowing the DSO to be transported without the loss of memory content.*

Digital-to-analog (D/A) converter—*A device that converts a digital word into an analog level.*

Digital sampling rate—*The rate at which the A/D conversion takes place. It is automatically determined by the sweep speed selector switch.*

Memory size—*The number of bytes that the memory of the DSO can hold. Memory size is related to the horizontal resolution of the display.*

One-shot sampling—*The process of capturing a 1-time, non-recurring event. The maximum digital sampling rate of a DSO is related to the amount of detail that can be obtained for a 1-shot signal.*

Pre-trigger view—*This feature makes it possible to view the events that occur prior to the triggering point.*

Repetitive sampling—*A technique that takes successive samples of recurring waveform, giving the DSO a higher effective bandwidth on repetitive signals only.*

Roll mode—*In this mode, the sampling rate of the DSO is slowed down so that long-term variations of a signal may be observed. When in the roll mode, the display on the CRT looks like that of a strip chart recorder.*

Word size—*This is the size, in bits, of the words in the digital memory. A typical size would be eight or 12 bits. This specification relates to the vertical resolution. An 8-bit word means the signal is broken up into 256 levels (2^8=256).*

Look before you leap into a new job

By Brad Dick, radio technical editor

Athletes and actors are not the only ones who sometimes find themselves in a position to negotiate a higher salary and better working conditions. Someday, you might find yourself in the driver's seat for negotiating a "sweet deal" with a new employer.

Not all of you have, or will, experience the exhilaration of receiving a call or letter from a company that wants to hire you away from your present employer. If it comes, however, don't accept the offer without careful thought. If you want to make the best of what might be a good situation, consider all of the aspects.

The drawbacks

Suppose you get a call from a network or a large corporation across the country and they want you, right now. It would be a feather in your cap to step into that new position, wouldn't it? Maybe not.

Your salary is only one element of a job's total benefit package. What about your spouse's job? Will your spouse be able to find immediate and satisfactory employment? If your husband or wife works in a job that requires state licensing or credentials, he or she might have to go back to school to qualify for a similar position in another state.

What effect will the new job have on your current pension and retirement benefit programs? Consider the company's proposed hospital and sick leave benefits. All of these factors are important, especially if you are the head of a family.

Perhaps one of the most important considerations is the cost of living (COL) in the new location. For example, the COL in Buffalo, NY, is 97.3, and in South Bend, IN, it's 91.0. It would cost less to live in either of those cities than it would in a town with a COL of 100.0 (the average base cost of living in those cities reporting). If you receive an offer to work in New York, however, the salary had better be a big increase, because the COL there is 137.3, more than 37% higher than the national average.

Sometimes the COL can be misleading, because it refers to an *average* cost. If you own your home, for example, and you want to buy a house in the new location, consider the difference in house payments, including real estate prices, interest rates and taxes. Auto insurance rates also fluctuate markedly from area to area, and could be different by a factor of two or three compared with what you're used to paying.

Before you make a decision based solely on the virtues of a larger paycheck, try to develop an accurate budget for living in the new area and compare the difference in the amount of potential expendable income. Armed with COL information, you can calculate the real gain (or loss) in your purchasing power.

Call the shots

If a company comes to you, it's because someone recommended you. When you are the pursued, rather than the pursuer, you stand a far better chance of sitting in the driver's seat.

Suppose you have completed the initial interviews and both you and the company like what each sees. The salary would be a big increase for you, and perhaps the new duties are just what you've always wanted. Now, do you take the company's first offer?

Some experts say that if a company or headhunter contacts you for possible employment, you can use that aspect as leverage. Although you certainly can use this leverage to obtain the best possible salary, you might be able to negotiate more than that. In the long run, some *perks* may be more rewarding than a few more dollars in the paycheck.

One of those benefits worth negotiating for is a front-end bonus. In other words, the company may pay you a bonus to place your career on the line for its future. This is most likely to occur in new companies or in those with high-risk factors.

Some companies provide low-cost loans. These can be used to finance a new home, or even a car if it's required for the job. Also, there are certain tax advantages for both parties.

If your spouse is employed and you've been offered a position with a company in another city or state, it will mean your spouse must find a new job (unless one of you is willing to commute a long distance). The company may offer job counseling for your spouse or even guarantee that a position within the company will be available within a certain period of time. Large companies may be able to place both of you in the company right away. Smaller companies may limit their efforts to providing employment information and guidance.

Relocation costs are often covered, but suppose you can't find the kind of home you want in the new town? Don't just settle for moving costs. You might want to ask for a housing allowance to help offset the cost of an apartment until you can build a new home. After all, if you are living in an apartment, paying rent and not making mortgage payments, you can be losing equity and tax deductions.

More than one fish

Before you settle for one offer, consider that others may exist. After all, if one company has heard of you, it's possible that others have, too. Look around and see what else is out there. In many cases, job offers such as these come through professional search firms. If so, the firm may be able to help convince a prospective employer of your value. Because it's in the search firm's best interest to complete a deal, it may help put together an agreement.

Even if you can't come to terms with the first offer, don't give up. The fact that one company contacted you means that your services are valuable and recognized. If you haven't been actively looking for a job, maybe you should consider doing so. After all, the time to move on may be when things are running smoothly. In this case, you'll leave on a positive note.

Career planning

Whether you're looking for a new job or planning to stay where you are for a while, you should have a career plan. If you haven't developed a plan or considered where you'd like to be in five or ten years, give it some thought. You can't move forward if you don't know where you're going. Having a career plan will make it easier to decide whether to accept that wonderful offer that might arrive today. When it does arrive, consider all the possibilities.

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SBE opposes Docket 85-172

By Bob Van Buhler

The Society of Broadcast Engineers has filed comments in opposition to General Docket 85-172, *Further Sharing of the UHF TV Band by Private Land Mobile Radio Services.* SBE joins the NAB in opposing the FCC contention that permitting land mobile users to occupy unassigned UHF TV channels would have minimal impact on UHF TV reception.

Today's TV sets commonly employ frequency-synthesized tuning, a technology susceptible to interference from signals on second and even third adjacent channels. SBE points out that the commission failed to address that consideration in its proposed rulemaking. In concurrence with the NAB, SBE indicated that the proposals in the docket are contrary to the commission's long-term efforts to improve UHF service and mitigate the technical disadvantages that UHF broadcasters suffer.

Further opposition was based upon the proposal's guarantee of a "frustrating future of pernicious interference to fixed users." SBE pointed to the land mobile industry's inability to demonstrate that they are effectively self-regulatory.

The SBE urged the commission to insist on spectrum-efficient technology, prior frequency coordination and proper dissemination of user-identity information to co- and adjacent-channel licenses already on the air in the event of any allocations in the UHF TV channels.

SBE's comments reminded the commission of its commitment to the coordination process in the report and order on Docket 85-36. This action indicated that the commission will rely on licensee cooperation through a coordination process to decide on band implementation in specific areas.

The SBE also joined the NAB in seeking the separation of the idea of flexible spectrum use by existing and future full-service and low-power TV licensees of channels 50 to 59 from the other issues identified in Docket 85-172. Both organizations officially view flexible spectrum use as a step in the direction of eroding the commission's statutory obligation to allocate spectrum in the public interest.

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

SBE committees

Last month, we identified the members and functions of some SBE national committees. Let's continue our look at some of the current SBE national committees.

The education committee will be one of our most important in the coming years. SBE's primary focus in the future will be education, both for members and for those wanting to enter the field of broadcast engineering.

Jim Wulliman is the chairman, and members include: Brad Dick, SBE secretary; Wally Dudash, treasurer; and Mary Beth Leidman, Bill Harris and Jeff Baker as board members.

A committee priority is listing and disseminating information regarding schools that provide a serious broadcast engineering curriculum. Brad Dick will be receiving, evaluating and maintaining this information.

Stimulating interest in broadcast engineering within the educational arena is a related assignment. SBE believes that once students are introduced to the world of broadcast engineering they may want to pursue the field as a career. The committee will work to promote broadcast engineering as a profession through many activities throughout the next year.

The committee also will work with the SBE certification committee to integrate the proper entry level broadcast engineering course material into accredited schools. After the schools begin teaching the material, additional certified engineers should be available for SBE membership. These people also will have received the needed training to allow them to obtain employment in radio or TV stations.

The editorial committee, which is chaired by Jack McKain, vice president, is composed of Brad Dick and Roger Johnson, SBE past president. This committee manages the *SBE Signal* publication and works with the industry and public relations committee to promote the SBE and its activities.

The industry and public relations committee, also chaired by McKain, promotes the SBE activities and works to make the industry aware of the society's importance. Committee members include: Mary Beth Leidman, Robert Hardie, Joe Manning and Bob Van Buhler, all of whom are current board members. Other committee members include: Andy Butler, SBE executive director; and Chuck Morris and Jerry Whitaker.

The committee maintains lists of qualified SBE speakers available to address state association meetings, trade gatherings and other professional society meetings at the local, state and national level. The committee also can assist in developing complete technical presentations for such events.

A sizable amount of information is required for magazine columns, such as this, the *SBE Signal* and society press releases. The committee develops much of this material through solicitation from other committees, board members and SBE members. The assembled information is then routed to Bob Van Buhler, press release coordinator, who issues SBE press releases to a large number of newspapers, magazines and industry organizations.

The FCC liaison and technical advisory committee is responsible for identifying issues and interests regarding broadcast technology and regulations. If the committee determines that the SBE should respond to pending FCC or industry association action, comments are prepared and submitted to Chris Imlay, SBE counsel, for review, final preparation and filing. President Richard Rudman is acting chairman. Other committee members include: Ed Gordon, Gerry Dalton, Larry Will, Joe Snelson, John Serafin, Merrill Weiss, John Kean, Glenn Lahman, Jeanne Smith, Neil Smith and Mark Durenburger.

The committee's goal is to permit the SBE to speak authoritatively to the industry and the FCC on technical issues that may arise. To date, the committee has been effective in making the SBE's position well known throughout the industry and with the FCC.

1986 has been a busy year for the society. With the progressive goals set forth by the president and the board of directors, the SBE should see even more growth and activity in 1987. Stay tuned for a great tomorrow in broadcast engineering.

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Preventing transmitter failures

There is no job more important to a broadcast engineer than maintenance of transmission equipment.

By Jerry Whitaker, editorial director

Without a doubt, the most frightening event at a radio or TV station is a transmitter failure that takes you off the air. You know the feeling. That sudden burst of noise on the air monitor speakers and/or a splash of snow on the video monitors. It's something you feel as an ache inside. The reasoning mind then takes over and brings forth a long list of possible causes for the problem that place blame squarely on somebody else. Do these sound familiar?

- "It's probably just a power failure at the transmitter site. Damn the utility company anyway!"
- "Maybe it's only a problem with the air monitor here at the studio. I bet we're *really* still on the air." (The eternal optimist.)
- "No cause for alarm. We just had a power surge. It'll be back up in a second or two." (If you say that confidently enough, people will believe you.)
- "Who's on duty at master control? I bet it's operator error."
- "Telco must have lost our line to the transmitter. It's not our problem. Damn the phone company anyway!"

The list can go on and on, particularly if it's the middle of the night. At 3 a.m. you can come up with a whole laundry list of system anomalies that can be corrected from your bed. And while we're on the topic, have you noticed that nobody ever calls an engineer at home with good news? When was the last time an operator called at 10:30 p.m. to say that everything was working just fine?

Anyway, if you're lucky, one of the easy solutions that every engineer prays for will be at the root of the failure. Many times, however, the problem is not so easy to solve. Such is life.

Editor's note: Information on UHF TV transmitter maintenance provided by Andrew Whiteside, engineering manager at Comark Communications, Southwick, MA. Information on first aid treatment provided by Harris Corporation, Quincy, IL.

Back to reality

An equipment failure at a radio or TV station causes an instant crisis. All gear in the transmission system, from the cameras, cart machines and microphones to the antenna, must work 24 hours a day, seven days a week, without fail. Every link in the broadcast chain is important, but the transmitter itself is most important. Studio equipment may occasionally fail—and the operators will complain loudly about it—but you can usually circumvent the problem with backup gear. The greatest concern on the part of most engineering personnel is keeping the transmission system, particularly the transmitter, in good working order.

Unfortunately, the heart of the broadcast station's technical plant is often located apart from the studio, on some out-of-the-way tract of land or on a mountain top that takes half a day to reach. It becomes too easy to ignore the transmission gear until a problem occurs. The weekly transmitter inspection visits allow the engineer to give the system a quick *once-over* look, but there's no substitute for walking past *the box* every day, if possible.

Engineers who have worked on a particular piece of transmission equipment for any length of time acquire a feeling for how well the unit is working. They know what the blowers should sound like and what meter readings are normal—not by reading the meters individually, but glancing at the front panel. They know when the PA tube needs replacement, and when there's still some life left in it. They know when the transmitter needs retuning, and when to leave well enough alone. They know the unit's strong and weak points.

The only way to gain this knowledge is to know the transmitter and instruction manual forward and backward, and to work with the equipment on a regular basis. This translates into a thorough maintenance program. Such an effort can be expensive and time-consuming, but the rewards outweigh the cost.

The importance of maintenance

The transmitter is usually the most expensive single piece of equipment at a broadcast station, and one of the most vulnerable to damage, as well. Whether or not a station has a standby transmitter, the importance of regular, proper maintenance cannot be emphasized too strongly. Many stations unwisely skimp on transmitter maintenance efforts, reasoning, "If it breaks, we can always use the standby." But will the standby work? Moreover, how much extra downtime and expense will the minimum-maintenance policy cause?

Maintaining a broadcast transmitter is a predictable, necessary expense that all stations must include in their operating budgets. Tubes have to be replaced no matter what the engineer does; components fail every now and then; and time must be allocated for cleaning and adjustments. By planning for these expenses each month, many unpleasant surprises can be avoided.

Although the reason generally given for minimum transmitter maintenance is a lack of money, the cost of such a policy can be deceptively high. Problems that could be solved for a few dollars may, if left unattended, result in considerable damage to the transmitter and a large repair bill. A standby transmitter in the back room often can be a lifesaver. However, its usefulness sometimes is overrated. The best standby transmitter in the world is a *main transmitter* in good working order.

Contrary to popular belief, equipment failures are not solely dependent on the power company and divine providence. Many failures are preventable. Through accurate observation of the transmission system, degradation of the air product can be avoided.

Routine maintenance

If you look for problems, you can find them...and prevent them.

Most failures in a transmitter can be prevented through regular cleaning and inspection, and close observation. The history of the unit also is important in a thorough maintenance program so that trends can be identified and analyzed.

Logging practices

The front panel can tell a great deal about what is going on inside of a transmitter. Record all front-panel meter readings, as well as the positions of critical tuning controls, on a regular basis in the station maintenance log. (See Figure 1.) This information provides a history of the transmitter and can be a valuable tool in noting problems at an early stage. The most obvious application of this logging is to spot failing tubes, but any changes occurring in components can be found as well.

For example, consider the case of an IPA and PA stage in an AM transmitter that has lost neutralization. (See Figure 2.) Neutralization adjustment is made by moving taps on a coil, and none have been changed. The history of the transmitter (as it is recorded in the maintenance record) reveals, however, that the PA grid tuning adjustment has, over the past two years, been moving slowly into the higher readings. An examination of Figure 2 leads to the conclusion that C-601 is the problem.

The tuning change of the stage was so gradual that it was not thought significant until an examination of the transmitter's history revealed that continual retuning in one direction only was necessary to achieve maximum PA grid drive. Without a record of the history of the unit, time could have been wasted in substituting capacitors in the circuit, one at a time (each costing a couple hundred dollars). Worse yet, the engineer might have changed the tap on coil L-601 to achieve neutralization, further hiding the real cause of the problem.

Clean and inspect the transmitter as often as required. A comprehensive maintenance program will result in a reliable system and keep the unit looking brand new for years.

An example of the importance of accurately logging meter information for a UHF transmitter involves the body-current monitoring system. A typical reading with average picture content is 50mA. Suppose that over a 4-week period the reading dropped gradually to 30mA. No other parameters showed any deviation from normal. Yet, the decrease in the reading indicated an alternate path (besides the normal body-current circuitry) by which electrons were returning to the beam power supply. (See Figure 3.) Several factors could cause the body-current variation. Eventually, each could have disastrous consequences, if allowed to run their course.

Water leaking into the body-to-collector insulation of the klystron causes partial bypassing of the body-current circuitry. In time, this water can corrode the klystron envelope. Such corrosion may lead to a loss of vacuum and obvious klystron failure.

The body-current circuit is one of the more important protection systems in the transmitter. It is essential that the circuit functions normally at all times and at full sensitivity in order to detect change when a fault condition occurs. Regular logging of important transmitter parameters will ensure that any developing problems are caught early.

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pressure for pressurized transmission lines helps identify line or antenna problems. After the regulator is set for the desired line pressure, record the tank and line readings each week and chart the data. If possible, make the observations at the same time of day each week.

Ambient temperature can have a significant effect on line pressure, so note any temperature extremes in the transmission line log when the pressure is recorded. The transmission line pressure usually will change slightly between carrier-on and carrier-off (depending on the power level). The presence of RF can heat the inner conductor of the line, causing the pressure to increase.

After a few months of charting the gradual loss of tank pressure, a pattern should become obvious. Investigate any deviation from the normal amount of tank pressure loss over a given period.

Whenever a problem occurs with the transmitter, make a complete entry describing the failure in the station maintenance log. Include in the log a description of all maintenance activities required to keep the transmitter operational. Make all entries complete and clear. Include the following information for each entry:

- A description of the nature of the malfunction, including all observable symptoms as well as performance characteristics.
- A description of the actions taken to return the transmitter to a serviceable condition.
- A complete list of the components replaced or repaired, including the device schematic number and part number.
- The total system downtime due to the failure.
- The name of the engineer who made the repairs.

Visual inspection

A complete visual inspection of the transmitter on a regular basis is an important part of any preventive maintenance program. Component problems often can be spotted at an early stage by regular inspection of the equipment.

- Carefully inspect all resistors for signs of overheating, check electrolytic or oil-filled capacitors for signs of leakage and

PARAMETER	TYPICAL VALUE	MEASURED VALUE
RF power output	18.3kW	
Plate current	2.8A	
Plate voltage	7.55kV	
Screen current	380mA	
Screen voltage	650V	
PA grid current	110mA	
PA bias voltage	490V	
PA filament voltage	6V	
Left driver cathode current	142mA	
Right driver cathode current	142mA	
Driver screen voltage	275V	
Driver screen current	35mA	
Driver grid current	1mA	
Driver plate voltage	1.85kV	
28V power supply	27V	
Reflected power	15W	
Transmission line pressure	3.9psi	
Tank pressure	1500psi	
Transmitter hours	5412	
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Figure 1. *Complete and accurate logging of important transmitter parameters is essential to preventive maintenance and troubleshooting. A complete history of the transmitter allows the engineer to spot trends in operation of the equipment. Shown is an example of a transmitter parameter form that should be filled out regularly by the station engineer.*

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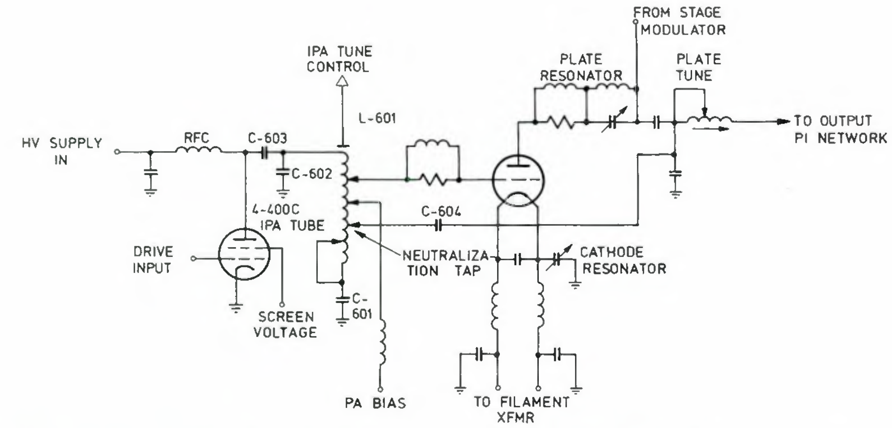

Figure 2. *An example of how detailed logging of transmitter readings and tuning control positions can aid in troubleshooting work. The example shown involves an IPA and PA neutralization problem in an AM transmitter. A history of IPA retuning (through adjustment of L-601) helped determine that loss of neutralization was caused by C-601 changing in value.*

observe feedthrough capacitors and other high-voltage components for signs of arcing. Also check all high-voltage RF capacitors right after sign-off for excessive heating.

Transmitting capacitors—mica, vacuum and *doorknob* types—should never run hot. They may run warm, but generally only because of thermal radiation from other components (such as power tubes) in the circuit. An overheated transmitting capacitor is often a sign of incorrect tuning, and should be investigated right away.

Vacuum capacitors present special requirements for the maintenance technician. Care in handling is a prime requisite for maximum service life. Because the vacuum capacitor is evacuated to a higher degree than most vacuum tubes, it is particularly susceptible to shock and rough handling. Provide adequate protection to vacuum capacitors whenever you are performing maintenance procedures. The weakest parts of the capacitor are the glass-to-metal seals on each end of the unit. Exercise particular care during removal or installation.

The current ratings of vacuum capacitors are limited by the glass-to-metal seal temperature and the temperature of the solder used to secure the capacitor plates. Seal temperature is increased by poor connecting clip pressure, excessive ambient temperatures, corrosion of the end caps and/or connecting clip, excessive dust and dirt accumulation or excessive currents.

Dust accumulation or sharp points in high-voltage circuitry near the vacuum capacitor can cause arcs or corona that may actually burn a hole through the glass envelope.

- Check all power-supply components—transformers, reactors, high-voltage rectifiers and transient suppression devices—for overheating and mechanical problems. Remember to discharge all capacitors in the circuit with a grounding stick before touching any component in the high-voltage sections of the transmitter. Confirm that all primary power has been removed from the transmitter before any maintenance work begins.

Special precautions must be taken with transmitters that receive ac power from two independent feeds. Typically, one ac line provides 208V 3-phase service for the high-voltage section of the system and a separate ac line provides 120Vac power for low-voltage circuits. Older transmitters or high-power transmitters often have this arrangement. Check to see that all ac is removed before you begin maintenance work.

Power transformers and reactors normally run hot to the touch. Check both the transformer frame and the individual windings. On a 3-phase transformer, each winding should produce about the same amount of heat. If one winding is found to run hotter than the other two, further investigation is warranted. Be careful when checking for transformer heating. Some units can run quite hot.

Check modulation transformers and reactors, if used, for excessive heating, and inspect oil-filled transformers for signs of leakage. Check transformers for dirt build-up, loose mounting brackets and rivets and loose terminal connections. Dust, dirt or moisture between terminals of a high-voltage transformer may cause flashover failures. Insulating compound or oil around the base of a transformer indicates overheating or leakage.

- Examine coils and RF transformers for indications of overheating. Such components operating in a well-tuned transmitter will rarely heat appreciably. If you notice discoloration on several loops of a coil, consult the factory service department to see if this condition is normal. Pay particular attention to variable tap inductors, often found in AM transmitters and phasers. Closely inspect the roller element and coil loops of such inductors for overheating or arcing.
- Thoroughly clean the transmitter. Cleaning is a large part of a proper maintenance routine. A shop vacuum and clean brush are generally all you need. Use isopropyl alcohol and a soft, clean cloth for maintaining high-voltage insulators. Cleaning serves a greater purpose than just keeping the transmitter looking nice. Inspect each component as you clean and observe any changes.

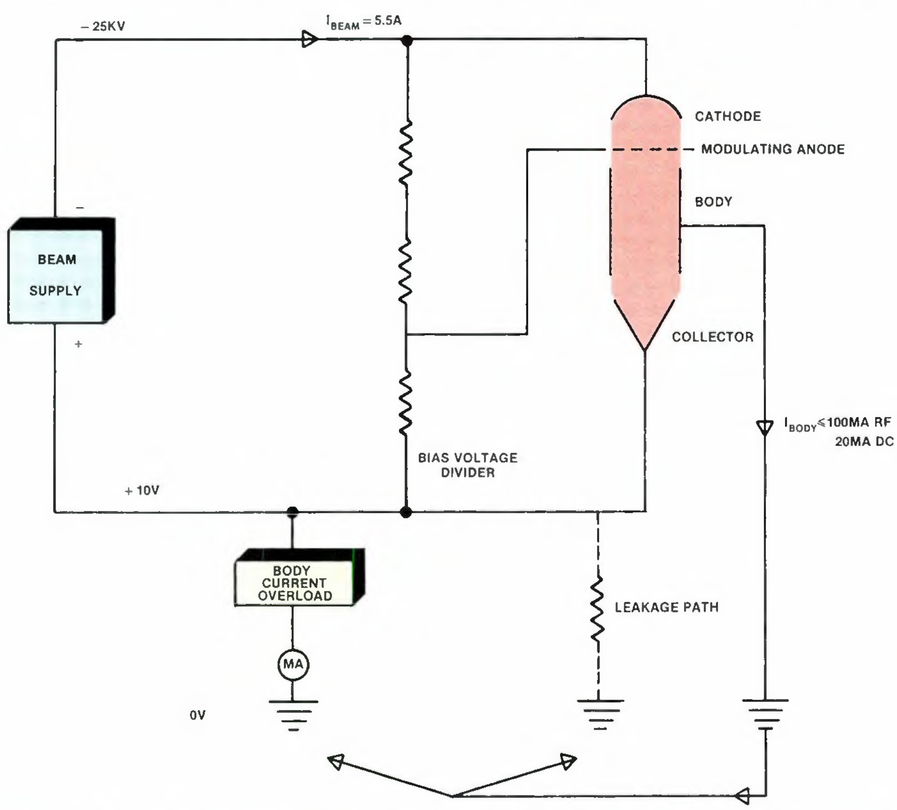

Figure 3. *Simplified HV schematic of a klystron amplifier showing the parallel leakage path that can cause a reduction in protection sensitivity of the body-current circuit. This problem may result from high coolant conductivity or coolant leakage onto the collector insulation or RF radiation shielding.*

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The front panel of the transmitter can tell a great deal about what is going on inside. Make a complete check of all operating parameters on a regular basis.

Regular maintenance of insulators is important to the proper operation of the final amplifier stage because of the high voltages present. Pay particular attention to the insulators used in the PA tube socket. Because the supply of cooling air is passed through the socket, airborne contaminants can be deposited on various sections of the assembly. These can create a high-voltage arc path across the socket insulators.

Perform any cleaning work around the PA socket with extreme care. Do not use compressed air to clean out a power-tube socket. Blowing compressed air into the PA or IPA stage of a transmitter will merely move the dirt from places where you *can* see it to places where you *can't* see it. Use a vacuum instead. When you are cleaning the socket assembly, be careful not to disturb any components in the circuit. Visually check the tube anode to see if dirt is clogging any of the heat-radiating fins.

In your effort to keep the power tube and its socket clean, don't go overboard. If the system is working well and the compartment is clean, leave it alone.

Cleaning is also important to proper

Check resistors, particularly high-power units, regularly for signs of premature wear caused by excessive heating.

Continued on page 36

EIMAC Tubes Provide Superior Reliability at radio station KWAV — over 112,000 hours of service!

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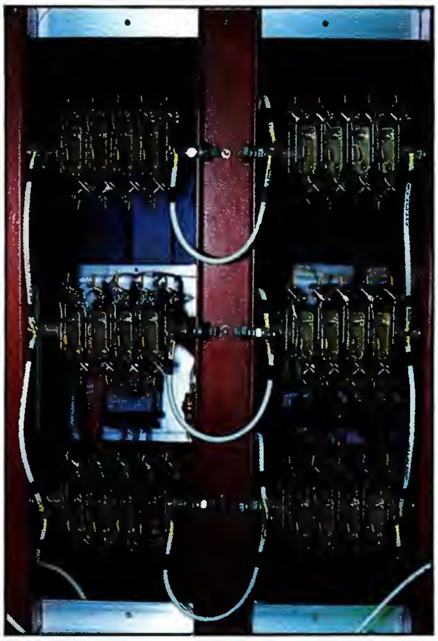
Continued from page 32

cooling of solid-state components in the transmitter. A layer of dust and dirt can become thick enough to create a thermal insulator effect that prevents proper heat exchange from a device into the cabinet.

- Clean relay contacts, including high-voltage or high-power RF relays, as often as needed to keep the current-carrying points free of pitting or discoloration.

Inspecting certain relays will also show if operators are using the proper procedures to change transmitter power or antenna patterns. For example, a high-voltage relay that should never be changed in the *hot* condition should not show signs of arcing between contact points. Evidence of such arcing would indicate that operators were violating established procedures by making *hot changes* from one mode to another.

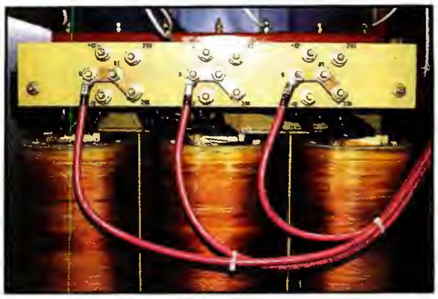


Keep all high-voltage components, such as this rectifier bank, free of dust and contamination that might cause short-circuit paths to ground.

Unless problems are experienced with an enclosed relay, do not attempt to clean it. More harm than good can be done by disassembling properly working components for detailed inspection.

- Inspect all power contactors for signs of wear. Check the mechanical linkage to confirm proper operations. The contactor arm should move freely, without undue mechanical resistance.
- Inspect vacuum contactors for free operation of the mechanical linkage and for indication of excessive dissipation at the contact points and metal-to-glass (or metal-to-ceramic) seals. Contactors, vacuum or conventional, should never run hot.
- Check the mechanical operation of circuit breakers. Confirm that they provide a definite *snap* to the off position (remove all ac power for this test) and that they firmly reseat when reset. Replace any circuit breaker that is difficult to reset.
- Check the tightness of wires and connections from time to time, particularly those that may be subjected to vibration. Tightness of connections is critical to the proper operation of high-voltage and RF circuits. Also inspect barrier strip and printed circuit board contacts for proper termination. Although it is important that all connections are tight, be careful not to overtighten. The connection points on some components, such as doorknob capacitors, can be damaged by excessive force.

There is no section of the transmitter where it is more important to keep connections tight than in the PA stage. Loose connections can result in arcing between components and conductors that will not only put you off the air, but also will destroy an expensive component. It might appear to the casual observer that the PA cavity is mechanically "overbuilt," that individual sections or components are secured with an unusually large number of screws and nuts. However, the manufacturer included each component—even down to the smallest screw—for a reason. It is not enough for *most* of the hardware to be tight. *Everything* must be tight.



Inspect power transformers just after sign-off for indications of overheating or leakage (in the case of oil-filled transformers).

Check the heating of individual rectifiers in a stack assembly. All devices should generate approximately the same amount of heat.

The cavity access door is a part of the outer conductor of the coaxial transmission line circuit in FM and TV transmitters. High-RF circulating currents flow along the inner surface of the door, and it must be fastened securely to prevent arcing.

A word of caution is in order. Although it is important to keep all components in the PA circuit tight, do not overdo it. An engineer who goes overboard on

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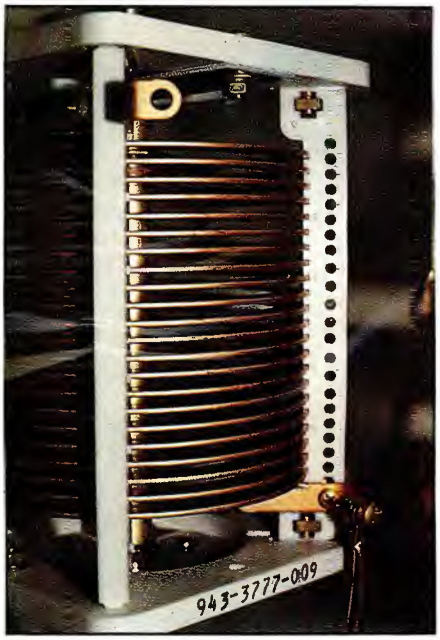
Inspect high-voltage capacitors for signs of leakage around the case feedthrough terminals.

During each maintenance session, check transient suppression devices (shown mounted on the green glass-epoxy cards) for indications of overheating or package rupture. Be sure to discharge the circuit, using the grounding stick provided by the transmitter manufacturer, before checking the components.



Clean RF coils and inductors as often as needed to keep contaminants from building up on the device loops.

preventive maintenance can wind up causing problems.

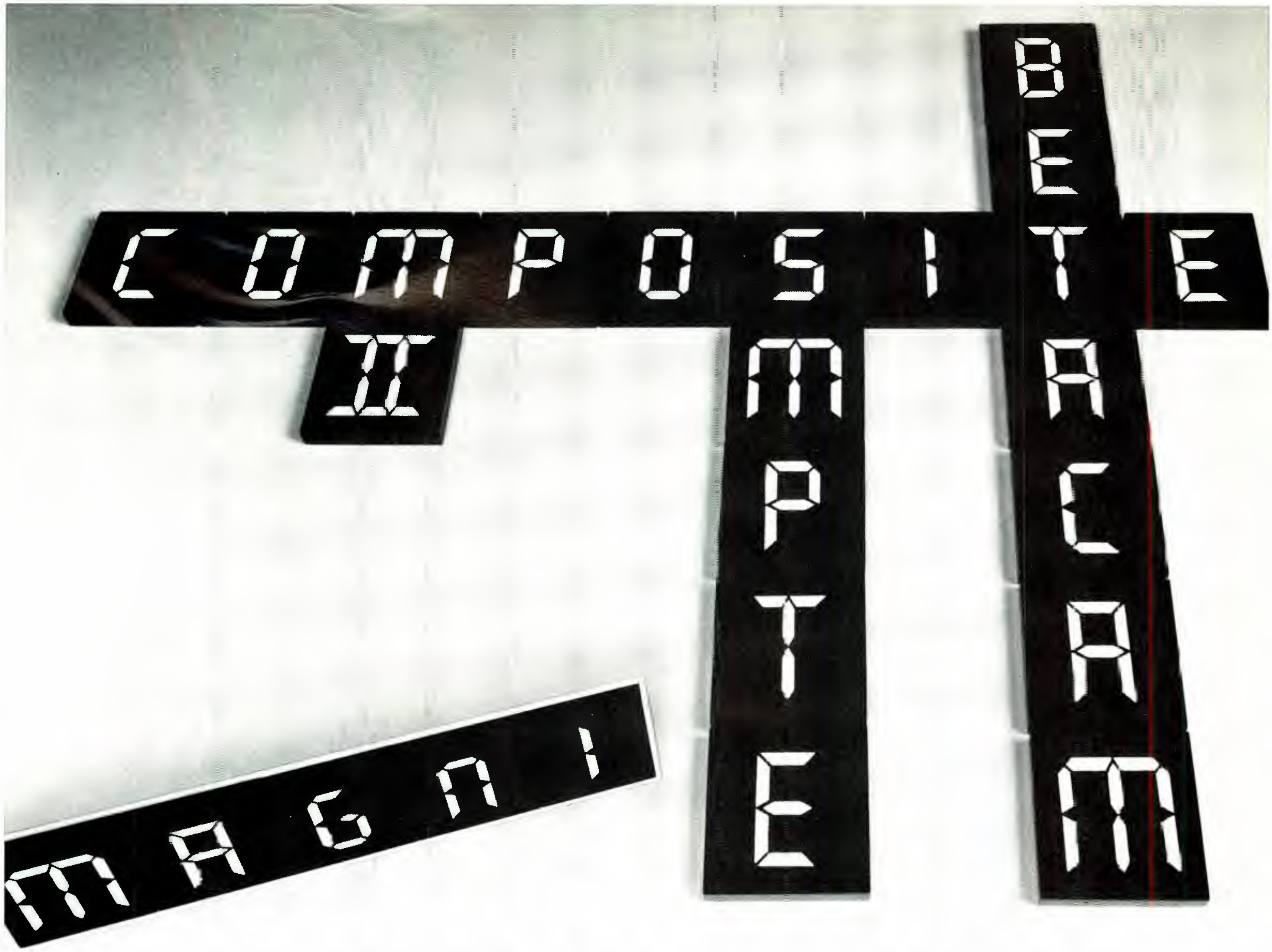
- Paint transmitter surfaces with the original type of paint when inspection shows rust or worn paint. Use a primer coat if necessary.

Klystrons

Klystrons are expensive to buy and to operate. Compared to tetrodes, they require larger auxiliary components (such as power supplies and heat exchangers), and are physically larger. Yet, they are quite stable with high gain and may be easily driven by solid-state circuitry. They are simple to cool and are capable of long life with a minimum of maintenance.

Two different types of klystrons are in use today: the *integral cavity* klystron, in which the resonant cavities are built into the body; and the *external cavity*

Continued on page 42



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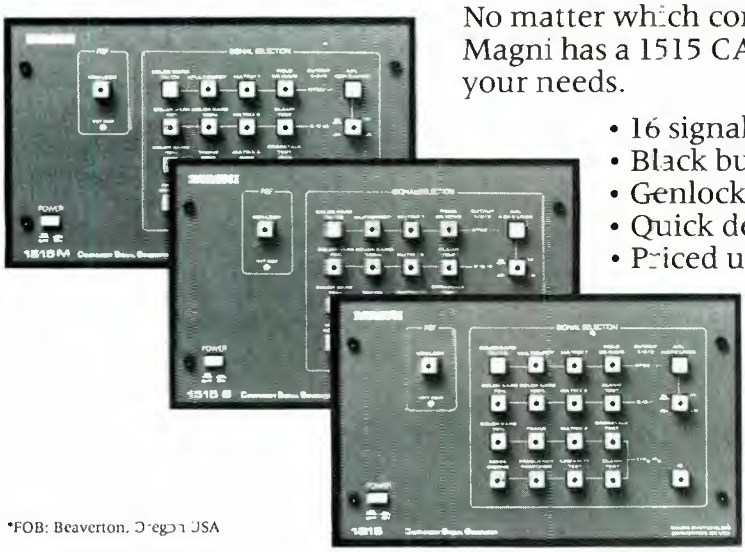

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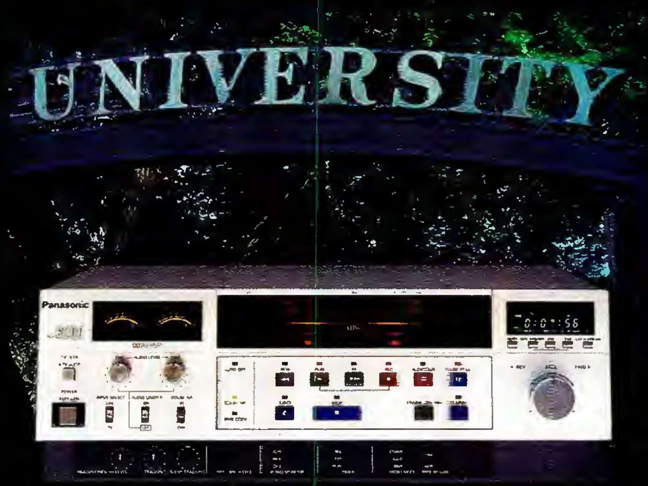
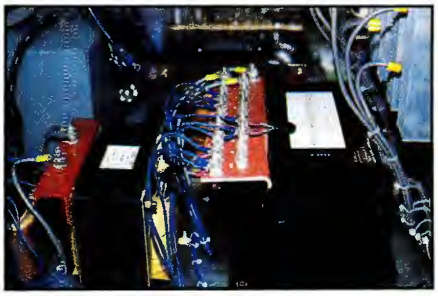


AG-6200 High performance, general purpose VHS recorder. 34-pin parallel remote interface.

AG-6200E Multi-format VHS recorder for worldwide use: PAL, CCIR and 4.43 MHz, NTSC. 14-step dial search.

AG-6100 VHS playback deck. 14-step dial search. Frame advance. Auto-repeat.

Carefully inspect the PA tube socket assembly. Do not remove the PA tube unless necessary.



Check the tightness of connectors on an occasional basis, but do not stress the connection points.

Continued from page 38

klystron, in which the cavities are mechanically clamped onto the body and are outside the vacuum envelope of the device. This difference in construction requires different maintenance procedures.

The klystron body, or the RF *interaction region* of the integral cavity klystron, is cooled by the same liquid that is fed to the collector. The required maintenance involves checking for leaks and adequate coolant flow.

Although the cavities of the external cavity unit are air-cooled, the body may

Clean the PA cavity assembly to prevent an accumulation of dust and dirt. Check hardware for tightness.

be water- or air-cooled. Uncorrected leaks in a water-cooled body can lead to cavity and tuning-mechanism damage. Look inside the magnet frame with a flashlight once a week. Correct leaks immediately and clean away coolant residues.

The air-cooled body requires only sufficient airflow. The proper supply of air can be monitored with one or two adhesive temperature labels and close visual inspection. Look for discoloration of metallic surfaces.

The external cavities also need a clean supply of cooling air. Dust accumulation inside the cavities will cause RF arcing. Therefore, air inlet filters are used in the cooling system design. Check the filters regularly. Some cavities have a mesh filter at the inlet flange. Inspect this point as required.

It is possible to take a look inside the cavities by removing the loading loops and/or air loops. This procedure is recommended only when unusual behavior is experienced, and not as part of routine maintenance. Generally there will be no need to remove a klystron from its magnet frame and cavities during routine maintenance.

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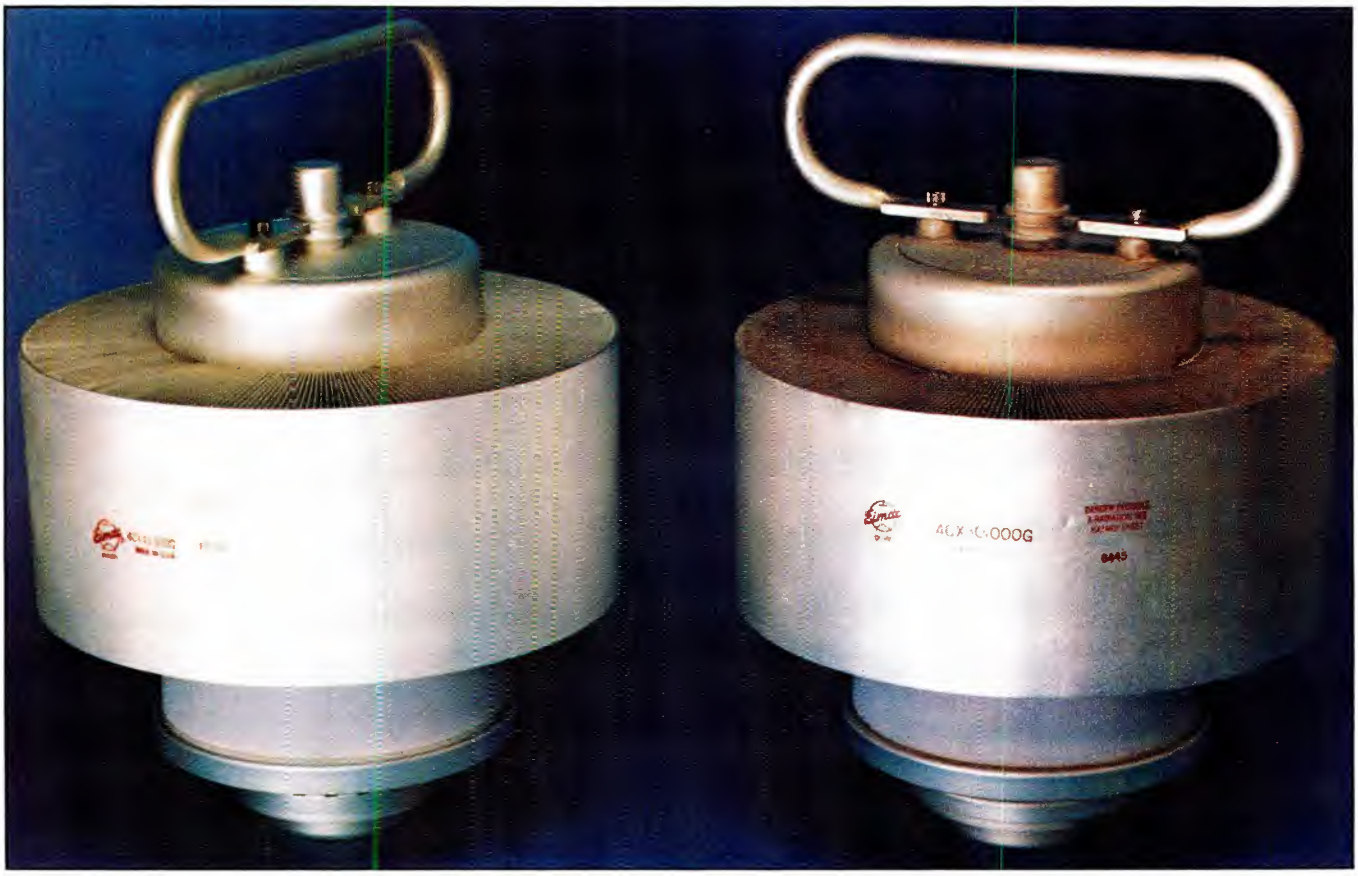
Power tubes

The heart of a transmitter is its power tube.



Two high-power tetrodes used for FM and VHF TV applications. On the left side is a 4CX40,000G and on the right, a 4CX30,000G. These tubes use pyrolytic graphite grid structures.

The power tubes used in a broadcast transmitter are perhaps the most important, and least understood, components in the system. The best way to gain an understanding of the capabilities of the PA tubes used in your transmitter is to secure copies of the tube manufacturer's data sheet for each type of device. These are available either from the tube or transmitter manufacturer. The primary value of the data sheets to the end-user is the listing of maximum permissible values. These give the transmitter engineer a clear rundown of the maximum voltages and currents that the tube can withstand under normal operation. Note these values and avoid them.

An examination of the data sheet will show that a number of operating conditions are possible, depending upon the class of service required by the applica-

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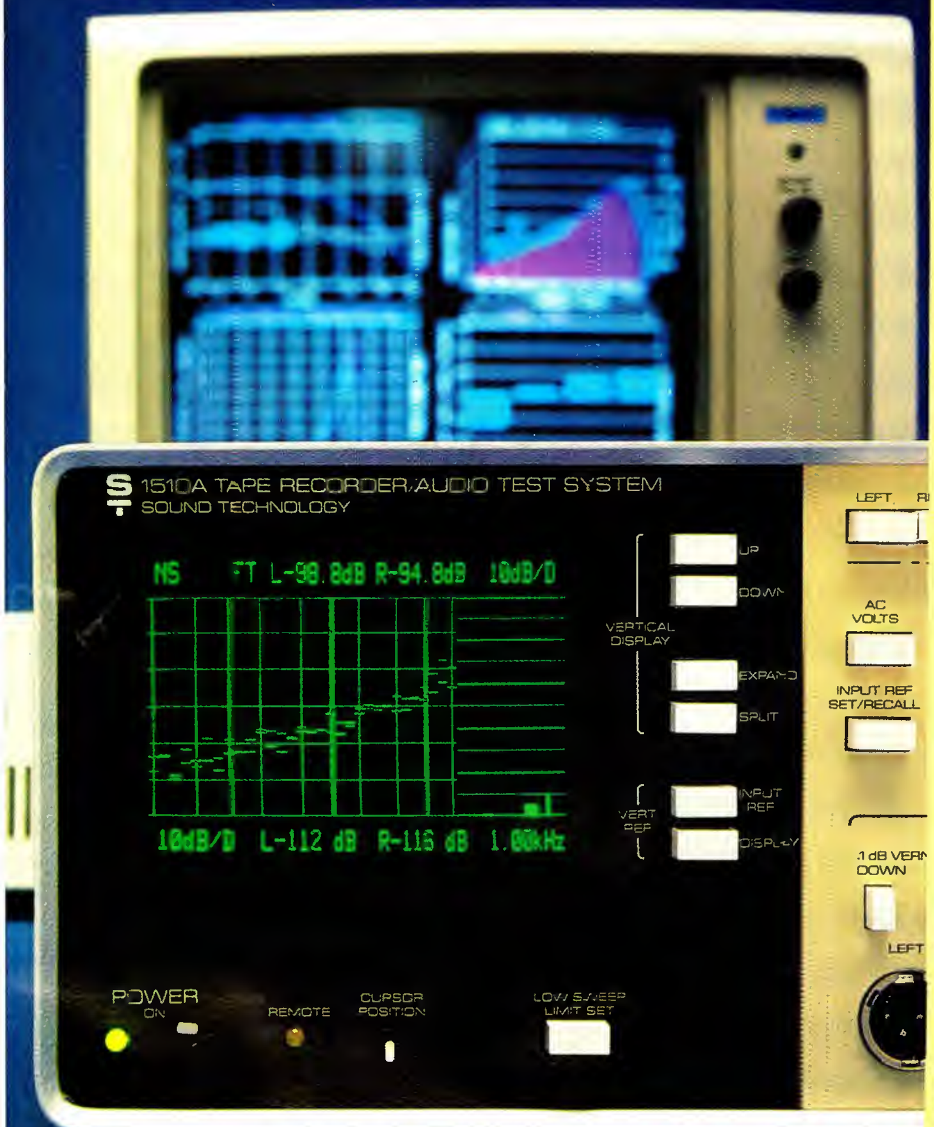

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tion. As long as the maximum ratings of the tube are not exceeded, a wide choice of operating parameters, including plate voltage and current, screen voltage and RF grid drive, are possible.

When studying the characteristic curves of each tube, remember that they represent the performance of a *typical* device. All electronic products have some tolerance among devices of a single type. Operation in your particular transmitter may be different than that specified on the data sheet or in the transmitter instruction manual. This effect is particularly notable at FM and TV frequencies.

Tube dissipation

Proper cooling of the tube envelope and seals is a critical parameter for long tube life. Deteriorating effects that result in shortened tube life and reduced performance increase as the temperature increases. Excessive dissipation is perhaps the single greatest cause of catastrophic failure in a power tube.

PA tubes used in radio and TV applications can be cooled using one of three methods: forced-air cooling, liquid cooling and vapor-phase cooling. In radio and VHF TV transmitters, forced-air cooling is by far the most common method used. Forced-air systems are simple to construct and easy to maintain.

The critical points of almost every PA tube type are the metal-to-ceramic junctions or seals. At temperatures below 250°C these seals remain secure, but above that temperature, the bonding in the seal may begin to disintegrate. Warping of grid structures also may occur at temperatures above the maximum operating level of the tube. The result of prolonged overheating is shortened tube life or catastrophic failure.

Several precautions are usually taken to prevent damage to tube seals under normal operating conditions. A look through your transmitter may reveal air directors or sections of tubing that provide spot-cooling to critical surface areas of the PA tube. Close observation may also show airflow sensors, specially designed actuators for microswitches, associated with the directors.

Tubes that operate in the VHF and UHF bands are inherently subject to greater heating action than devices operated at lower frequencies (such as AM service). This situation is caused by larger RF charging currents into the tube capacitances, dielectric losses and the tendency of electrons to bombard parts of the tube structure other than the grid and plate in high-frequency applications. Greater cooling is required at higher frequencies.

The technical data sheet for the tube will specify cooling data. The end-user is not normally concerned with this information. It is the domain of the transmitter manufacturer. The end-user, however, is responsible for proper maintenance of the cooling system.

The air-handling system

All modern PA tubes use an air-system socket and matching chimney for cooling. Never operate a PA stage unless the air-handling system provided by the transmitter manufacturer is complete and in place. For example, the chimney for a PA tube in AM applications often can be removed for inspection of other components in the circuit. Operation without the chimney, however, may significantly reduce airflow through the tube and result in overdissipation of the device. It also is possible that operation without the proper chimney could damage other components in the circuit because of excessive radiated heat.

Normally the tube socket is mounted in a pressurized compartment so that cooling air passes through the socket and then is guided to the anode cooling fins. (See Figure 4.) Do not defeat any portion of the air-handling system provided by the transmitter manufacturer.

Cooling of the socket assembly is important for proper cooling of the tube base and for cooling of the contact rings of the tube itself. The contact fingers used in the collect assembly of a socket typically are made of beryllium copper. If subjected to temperatures above 150°C for an extended length of time, the beryllium copper will lose its temper (or springy characteristic) and will no longer make good contact with the base rings of the tube. In extreme cases, this socket problem can lead to arcing, which can burn through the metal portion of the tube base ring. Such an occurrence can ultimately lead to catastrophic failure of the device because of a loss of the vacuum envelope.

Other failure modes for tube sockets include arcing between the collect and tube ring that can actually weld a part of the socket and tube together. The end result is failure of both the tube and the socket.

A wide variety of power tubes are used in broadcast transmitters. Shown here are some common triodes ranging from 400W to 15,000W dissipation.

Ambient temperature

A parameter that is directly under the control of the broadcast engineer is the supply air temperature. The preferred cooling air temperature is no higher than 75°F and no lower than the room dew point. The air temperature should not be modulated by oversized air-conditioning systems or by the operation of other pieces of equipment at the transmission facility.

Monitoring the PA exhaust stack

Continued on page 57

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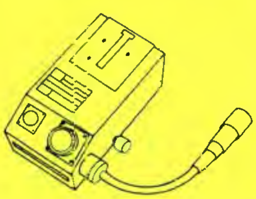

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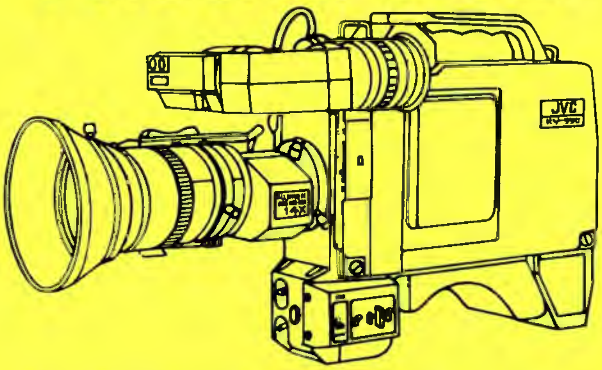

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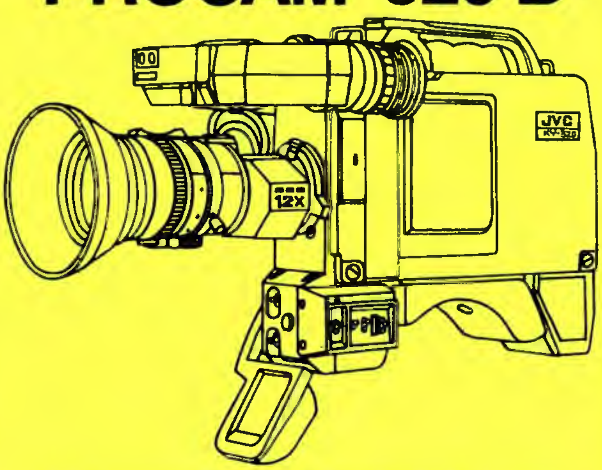

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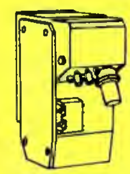

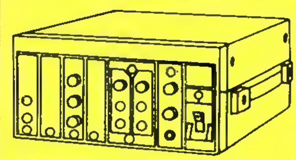

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Continued from page 48

temperature is an effective method of evaluating transmitter performance as a system. This can be easily accomplished and provides valuable data on the cooling system and stage tuning.

Purchase an accurately calibrated thermometer that will measure up to 100°C and locate it directly above the PA stack exhaust within the airflow from the tube. This is a simple procedure, but it must be done with great care.

The thermometer can be a standard laboratory unit or it can be a solid-state temperature-sensing module. A temperature-sensing device offers the capability of tying into your remote-control system and providing feedback on the PA stack temperature from the studio control point. Be careful when selecting a solid-state device for such applications, however, because of the effects that high levels of RF energy may have on the accuracy of the unit.

Another convenient method for checking the efficiency of a transmitter cooling system over a period of time involves documenting the back pressure that exists within the PA cavity. This measurement is made with a *manometer*, a simple device that is available from most heating, ventilation and air-conditioning (HVAC) suppliers. The connection of a simplified manometer to a transmitter PA input compartment is illustrated in Figure 5.

When using the manometer, be extremely careful that the water in the device is not allowed to backflow into the PA compartment. Do not leave the manometer connected to the PA compartment when the transmitter is on the air. Make the necessary measurement of PA compartment back pressure and disconnect the device. Seal the connection point with a subminiature plumbing cap or other appropriate hardware.

By charting the manometer readings, it is possible to accurately measure the

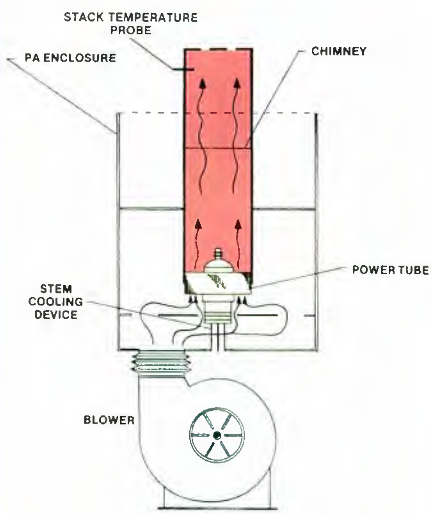


Figure 4. *Typical transmitter PA stage cooling system.*

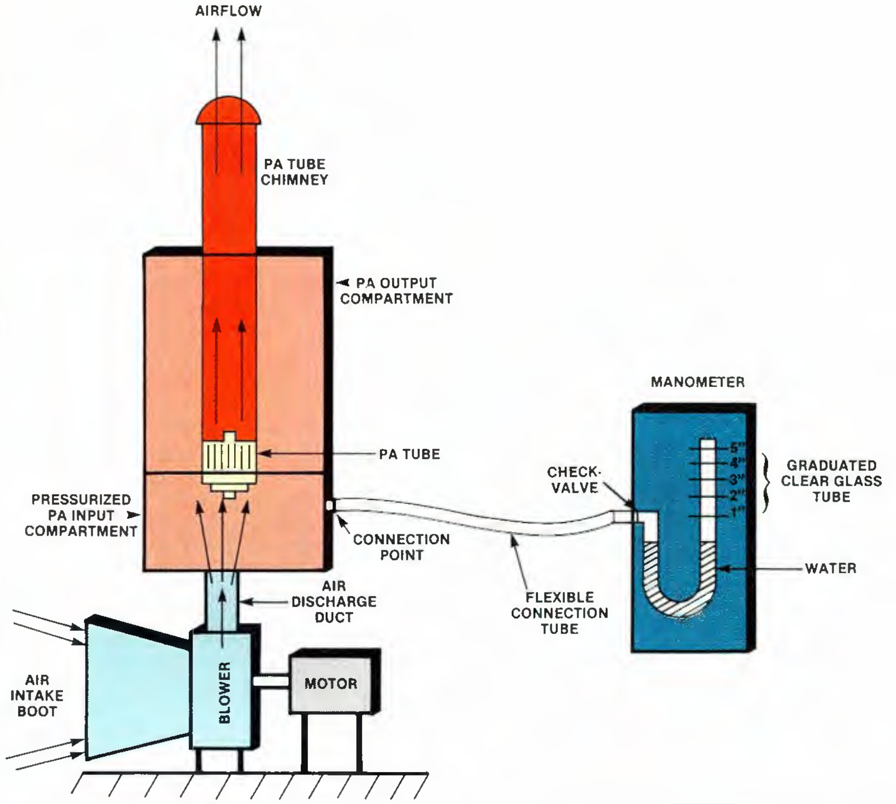


Figure 5. *A manometer device used for measuring back pressure in the PA compartment of a transmitter.*

performance of the transmitter cooling system over time. Changes resulting from the build-up of small dust particles (*microdust*) may be too gradual to be detected except through back-pressure charting. Be certain to take the manometer readings during periods of calm weather. Strong winds can result in erroneous readings because of pressure or vacuum conditions at the transmitter air intake or exhaust ports.

Deviations from the typical back-pressure value, either higher or lower, could signal a problem with the air-handling system. Decreased PA input compartment back pressure could indicate a problem with the blower motor or a build-up of dust and dirt on the blades of the blower assembly. Increased back pressure, on the other hand, could indicate dirty PA tube anode cooling fins or a build-up of dirt on the PA exhaust ducting to the outside. Either condition is cause for concern.

A transmitter suffering from reduced air pressure into the PA compartment must be serviced as soon as possible. Not restoring the cooling system to proper operation may lead to premature failure of the PA tube or other components in the input or output compartments. Blower problems in a transmitter do not improve. They always get worse.

Failure of the PA compartment air-interlock switch to close reliably may be an early indication of impending cooling-system trouble. This could be caused by normal mechanical wear or vibration on the switch assembly, or it may signal that the PA compartment air pressure is dropping. In such instances, documentation of manometer readings will show whether the trouble is caused by a failure of the air-pressure switch or a decrease in the output of the air-handling system.

Warm-up/cool-down

Always follow closely the factory-recommended warm-up period between application of *filament-on* and *plate-on* commands. Most transmitter manufacturers specify a warm-up period of about five minutes. The minimum warm-up time is two minutes. Some units include a time-delay relay to prevent the application of a plate-on command until a predetermined warm-up cycle is completed. Do not defeat these protective circuits. They are designed to extend PA tube life.

Most transmitter manufacturers also specify a recommended cool-down period between the application of *plate-off* and *filament-off* commands. This cool-down, generally about 10 minutes, is designed to prevent excessive temperatures on the PA tube surfaces when the cooling air is shut off. Large vacuum tubes contain a significant mass of metal, which stores heat quite effectively. Unless cooling air is maintained at the base of the tube and through the anode cooling fins, excessive temperature rise can occur. Again, the result can be shorter tube life, or even catastrophic failure, because of seal cracks caused by thermal stress.

Most tube manufacturers suggest that cooling air continue to be directed toward the tube base and anode cooling fins after filament voltage has been removed to further cool the device. Un-

An internal cavity klystron mounted in its magnet frame.

fortunately, however, not all transmitter control circuits are configured to allow this mode of operation.

Changing tubes

Plug-in power tubes must be seated firmly in their sockets and the connections to the anodes of the tubes must be tight. Once it is in place, do not remove a tube assembly for routine inspection unless it is malfunctioning.

Whenever a tube is removed from its socket, carefully inspect the fingerstock for signs of overheating or arcing. Keep the socket assembly clean and all connections tight. If any part of a PA tube socket is found to be damaged, replace the defective portion immediately.

In many cases, the specific fingerstock ring can be ordered and replaced. In other cases, however, the entire socket must be replaced. This type of work is a major undertaking, and an inexperienced engineer should consider calling in a consultant to help on the project.

Extending tube life

Power-transmitting tubes are probably the most expensive replacement part that a system needs on a regular basis. With the cost of new and rebuilt tubes continually rising, engineers should do everything possible to extend tube life.

Inspect each new tube, as soon as you receive it, for cracks or loose connections (in the case of devices that do not socket-mount). Also check for interelectrode short circuits with an ohmmeter. Once these preliminary tests have been completed, store the tube in a safe place.

Tubes must be seated firmly in their sockets to allow a good, low-resistance contact between the fingerstock and contact rings. After a new tube—or one that has been on the shelf for some time—is

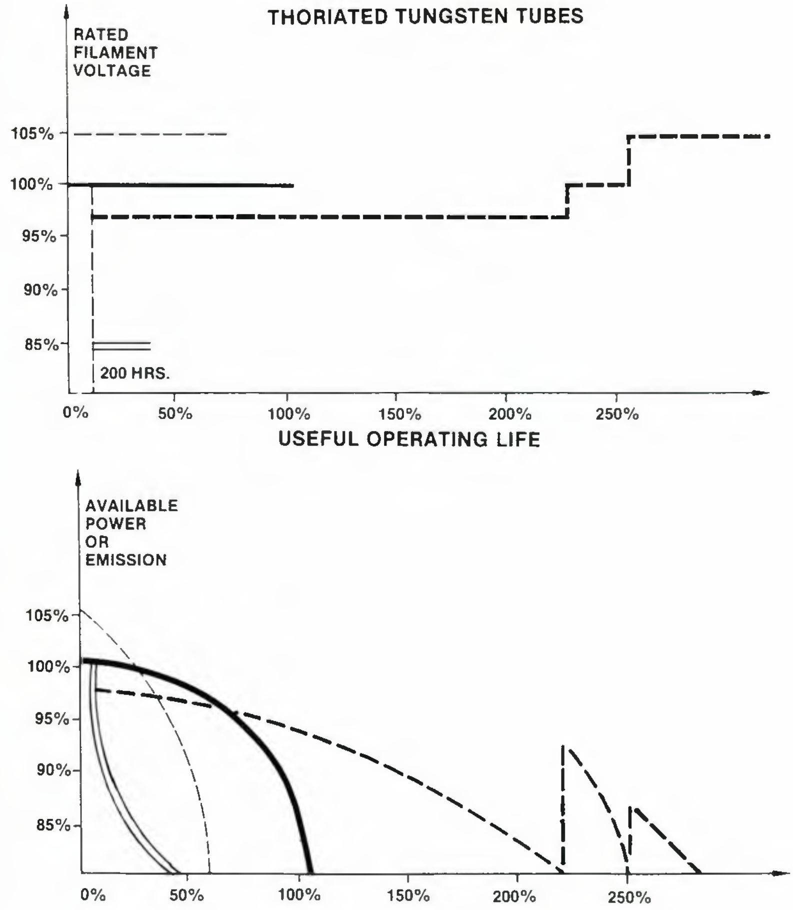


Figure 6. *The effects of filament voltage management on the useful life of a thoriated tungsten filament power tube. Note the dramatic increase in emission hours when filament voltage management is practiced.*

installed in the transmitter, run it with *filaments only* for at least 30 minutes, after which plate voltage may be applied. Next, slowly bring up the drive (modulation), in the case of an AM or TV visual transmitter. Residual gas inside the tube may cause an interelectrode arc (usually indicated by the transmitter as a plate overload) unless it is burned off in such a warm-up procedure.

Keep an accurate record of performance for each tube. Shorter-than-normal tube life could point to a problem in the transmitter itself. Many engineers wonder what type of *average* tube life can be expected in a particular transmitter. However, with the many possible variables in operation (including filament voltage, ambient temperature, RF-power output and frequency of operation), it is difficult to say with any amount of accuracy what you can expect. The best estimate of life expectancy in a particular transmitter at a particular location comes from on-site experience. As a general rule of thumb, however, if a station is not getting at least 12 months of service out of a power tube, something is wrong.

Possible causes of short tube life include improper transmitter tuning; inaccurate panel meters or external wattmeter, resulting in more demand from the tube than is required by the station license; poor filament voltage regulation; insufficient cooling system airflow; or improper stage neutralization.

Once the transmitter is operating properly, the major determining factors of tube life are cooling system performance and filament voltage management.

To accurately adjust the filament voltage, a *true-reading* rms voltmeter is required. Make the measurement directly from the tube socket connections. Secure the voltmeter test leads to the socket connections and carefully route the cables outside the transmitter cabinet. Switch off the plate power supply circuit breaker. Close all interlocks and apply a *filament on* command. Do not apply the high voltage during filament voltage tests. Serious equipment damage and/or injury to the engineer may result.

Use a true-reading rms meter instead of the more common *average responding* rms meter because the true-reading meter can accurately measure a voltage despite an input waveform that is not a pure sine wave (as would be the case in an SCR-regulated filament supply). The front-panel filament voltage meter is seldom a true-reading rms device. (Most are average-responding meters.)

Long tube life requires filament voltage regulation. Many transmitters have regulators built into the filament supply. Older units without such circuits often can be modified to provide a well-regulated supply by adding a ferroresonant transformer or motor-driven autotransformer. A tube whose filament volt-

age is allowed to vary along with the primary line voltage will not achieve the life expectancy possible with a tightly regulated supply. This problem is particularly acute at mountain-top installations, where utility regulation is generally poor.

To extend tube life, some engineers leave the filaments on at all times, not shutting down at sign-off. If the sign-off period is three hours or less, this practice can be beneficial. Filament voltage regulation is a must in such situations because the primary line voltages may vary substantially from the carrier-on to carrier-off value.

Do not leave voltage on the filaments of a klystron for periods of more than two hours if no beam voltage is applied. The net rate of evaporation of emissive material from the cathode surface of a klystron is greater without beam voltage. Subsequent condensation of the material on gun components may lead to voltage holdoff problems and an increased body current.

Filament voltage management

By accurately managing the filament voltage of a thoriated tungsten power tube, you can considerably extend its useful life, sometimes to twice the normal life expectancy. For maximum tube life, operate the filament at its full-rated voltage for the first 200 hours following installation. After this burn-in period, reduce the filament voltage by about one-tenth of a volt per step until power output begins to fall (for FM and TV transmitters) or until distortion begins to increase (for AM transmitters).

When the emissions floor has been reached, raise the filament voltage about two-tenths of a volt. Long-term operation at this voltage can result in a substantial extension in the usable life of the tube. (See Figure 6.) In any event, do not operate the tube with a filament voltage that is at or below 90% of normal. Some tube manufacturers put the minimum level at 95%. At regular intervals, about every three months, check the filament voltage and increase it if power output begins to fall or distortion begins to rise. The filament voltage should never be increased to more than 105% of normal.

When it becomes necessary to boost filament voltage to more than 103%, it's time to order another tube. If you replace the tube while it still has some life remaining, the station will have a standby device that will perform well as a spare.

Check the filament current when the tube is first installed, and at annual intervals thereafter, to assure that the filament draws the desired current. Tubes have failed early because of an open filament bar that would have been discovered in warranty if a current check had been made on installation.

For one week of each year of tube operation, run the filament at full-rated

PA TUNING ADJUSTMENT

- **Unload the transmitter (switch the loading control to *lower*) to produce a PA screen current of 400mA to 600mA.**
- **Peak the PA screen current with the plate-tuning control.**
- **Maintain screen current at or below 600mA by adjusting the loading control (switch it to *raise*).**
- **Position the plate-tuning control in the center of travel by moving the coarse-tune shorting plane up or down as needed. If the screen current peak is reached near the *raise end* of plate tune travel, raise the shorting plane slightly. If the peak is reached near the *lower end* of travel, lower the plane slightly.**
- **After the screen current has peaked, adjust the loading control for maximum power output and minimum synchronous AM.**
- **Peak the driver screen current with C37.**
- **The driver screen peak should coincide with PA screen peak and PA grid peak. Driver screen peak should also coincide with a dip in the left and right driver cathode currents.**

Table 1. *A sample documented transmitter tuning procedure. Note in your listing of tuning steps the side effects of various actions.*

voltage. This will operate the *getter* and clean the tube of gas.

Filament voltage supplies should be *soft*. Make sure that inrush current to the filament is limited by some means.

Filament voltage is an equally important factor in achieving long life in a klystron. The recommended voltages must be followed and checked on a regular basis. Measure the voltage at the filament terminals and calibrate the front-panel meter as needed.

Unless specifically recommended in the klystron data sheet, do not reduce filament voltage below the knee of the emission curve. Such a setting may cause uneven emission from the surface of the cathode with little or no improvement in cathode life.

Why tubes wear out

A tube wears out when the filament emission is inadequate for full power output or acceptable distortion levels. Three primary factors determine the number of hours a tube will operate before reaching this condition: the amount of carbon originally processed into the filament, the quality of the tube vacuum and the filament temperature.

The maximum amount of carbon that can be burned into the filament assembly is limited by the increased fragility that results from high carbon-processing levels. The carbon concentration is also limited by the reduction in filament temperature (below the level required for adequate emission at the rated filament voltage) that occurs with high carbon percentages.

The residual vacuum level affects tube life because the *decarburization rate* (the rate at which carbon is burned out of the filament assembly) is a function of the partial pressures of the active gases inside the envelope, primarily oxygen compounds, reacting with the carbon. Good vacuum processing and proper gettering in the tube results in the lowest residual gas levels.

The decarburization rate is closely related to the filament operating temperature. This temperature is determined by the power to the filament and, therefore, is controllable by proper filament voltage management.

These factors taken together determine the wear-out rate of a tube. Catastrophic failures because of interelectrode shorts or failure of the vacuum envelope are considered abnormal and are usually the result of some external influence.

Tuning up for efficiency

There are probably as many ways to tune the PA stage of a transmitter as there are types of transmitters. Experience is the best teacher when it comes to adjusting a transmitter for peak efficiency and performance. Compromises often must be made among various operating parameters. Some engineers follow the tuning procedures contained in the transmitter instruction manual to the letter. Others never open the manual, preferring to tune according to their own methods.

Whatever procedure you use, document the operating parameters and steps for future reference—yours and your successor's. Do not rely on memory for a listing of the typical operating limits and tuning procedures for the system. Write down the information and post it at the transmitter building. If you are out of town one day and someone else has to service the transmitter, the list will be invaluable.

The factory service department can be an excellent source for information about tuning your particular transmitter. Many times the factory can give you pointers on how to simplify the tuning process, or what interaction of adjustments may be expected. Whatever you learn from conversations with the factory, write it down. Again, a written record will help you and your successor.

Table 1 shows a typical tuning procedure for an FM transmitter. The actual procedures vary, of course, from transmitter to transmitter. However, if the particular tuning characteristics of the unit are documented in a detailed manner, future repair work can be simplified. This record can be of great value to an engineer who is fortunate enough to have a reliable transmitter that does not require regular service. Many of the tuning tips learned during the last service session may be forgotten by the time transmitter work must be performed again.

When to tune

Tuning can be affected by any number of changes in the PA stage. Replacing the final tube in an AM transmitter usually does not significantly change the stage tuning, but run through a touch-up tuning procedure just to be sure. Replacing a tube in an FM or TV transmitter, on the other hand, can significantly alter stage tuning. At higher frequencies, normal tolerances and variations in tube construction result in changes in element capacitance and inductance. Likewise, replacing a component in the PA stage may cause tuning changes because of normal device tolerances. Whenever you replace a component in a transmitter RF stage, run through the complete tuning procedure.

One of the primary objectives of transmitter tuning is stability. Avoid tuning positions that do not provide stable operation. Adjust for broad peaks or dips, as required. Tune so that the transmitter is stable from a cold startup to normal operating temperature. Readings should not vary measurably after the first minute of operation.

Adjust tuning not only for peak efficiency, but also for peak performance. These two elements of transmitter operation, unfortunately, do not always coincide. Trade-offs must sometimes be made in order to ensure proper operation of the system. For example, FM or TV aural transmitter loading can be critical to wide system bandwidth and low synchronous AM. Loading beyond the point required for peak efficiency must often be used to broaden cavity bandwidth. Heavy loading lowers the PA plate impedance and cavity Q. A low Q also reduces RF circulating currents in the cavity.

Because of the interdependence of transmitter tuning and system performance, carefully consider the tuning procedures outlined in the instruction manual. There's nothing wrong with improving on the factory's recommended procedures, just as long as you don't create any new problems in the process.

Preventing failures

Don't wait for a failure. Prevent one from occurring.

The sections of a transmitter most vulnerable to failure are those exposed to the outside world: the ac-to-dc power supplies and RF output stage. These circuits are subject to high-energy surges from lightning and other sources. For this reason, particular attention must be given to the dc power supplies—especially the high-voltage plate supply—and the PA output stage.

Check transmission line hardware for overheating and mechanical tightness.

VSWR

The voltage standing wave ratio (VSWR) of an antenna and its transmission line is a vital parameter that has a considerable effect on the performance and reliability of a transmission system. VSWR is a measure of the amount of power reflected back to the transmitter because of an antenna and/or transmission line mismatch. (See Figure 7 for calculation data.) A mismatched or defective transmission system will result in a high degree of reflected power, or a higher VSWR.

Common practice in FM applications calls for a VSWR of 1.1:1 as the maximum level within the transmission channel that can be tolerated without degrading the quality of the on-air signal. For TV systems, a VSWR into the antenna feeder of more than 1.04:1 will start to degrade picture quality, particularly with a long line. The reflection down the line from a mismatch at the antenna, in addition to disrupting the performance of the transmitter output stage, causes multipath distortion *within* the transmission line itself. When power is reflected back to the transmitter, it causes the RF output stage to look into a mismatched load with unpredictable phase and impedance characteristics.

Because of the reflective nature of VSWR on a transmission system, the longer the transmission line (assuming the reflection is originating at the antenna), the more severe the problem may be for a given VSWR. A longer line means that reflected power seen at the RF output stage has greater time (phase) delays, increasing the load's reactive nature.

The effects of transmission line length vary depending on the service. For example, the crosstalk performance of an FM transmission system can be degraded because of a long line. It has been suggested that the maximum VSWR for a system with up to 100 meters (328 feet) of transmission line must be below 1.1:1 for top performance. Systems with lines from 100 to 200 meters must have a VSWR of at least 1.08:1 for equally good performance in FM broadcasting.

Always maintain positive pressure on the transmission line and antenna (if pressurized). Feedline pressurization keeps moisture out of the system and subsequently prevents oxidation. Disastrous burnups may occur when water collects on an insulator, causing oxidation and resulting increased attenuation.

VSWR is affected not only by the rating of the antenna and transmission line as individual units, but also by the combination of the two as a system. The worst-case system VSWR equals the antenna VSWR multiplied by the transmission line VSWR. For example, if an antenna with a VSWR of 1.05:1 is connected to a line with a VSWR of 1.05:1, the resultant worst-case system VSWR would be 1.1025:1.

Given the right set of conditions, an interesting phenomenon can occur in which the VSWR of the antenna cancels the transmission line VSWR, resulting in a perfect 1:1 match. The determining factors for this condition are the point of origin of the antenna VSWR, the length of transmission line and the observation point.

The effects of modulation

The VSWR of a transmission system is a function of frequency and changes with carrier modulation. This change may be large or small, but it will occur to some extent. The cause can be traced to the frequency dependence of the VSWR of the antenna (and to a much lesser extent, the transmission line). See Figure 8.

Although this plot, showing VSWR vs. frequency for a common FM antenna, is good, notice that with no modulation the system VSWR is one figure. VSWR measurements are different with *positive modulation* (carrier plus modulation) and *negative modulation* (carrier minus modulation).

VSWR is further complicated because power reflected back to the transmitter from the antenna may not come from a single point, but instead, from a number of different points. One reflection might be caused by the antenna-matching unit, another by various flanges in the line and a third by a damaged part of the antenna system. Because these reflection points are different lengths from the transmitter PA plate, a variety of standing waves can be generated along the line, varying with the modulating frequency.

Energy reflected back to the transmitter from the antenna is not all lost. A small percentage of the energy is turned into heat, but the majority of it is radiated by the antenna, delayed in time by the length of the transmission line.

Maintenance

In order to maintain low VSWR, service the transmission line and antenna system regularly.

- Inspect the antenna elements, interconnecting cables, impedance transformers and support braces at least once

$$\text{VSWR} = \frac{1 + \sqrt{\dfrac{\text{Reflected power}}{\text{Forward power}}}}{1 - \sqrt{\dfrac{\text{Reflected power}}{\text{Forward power}}}}$$

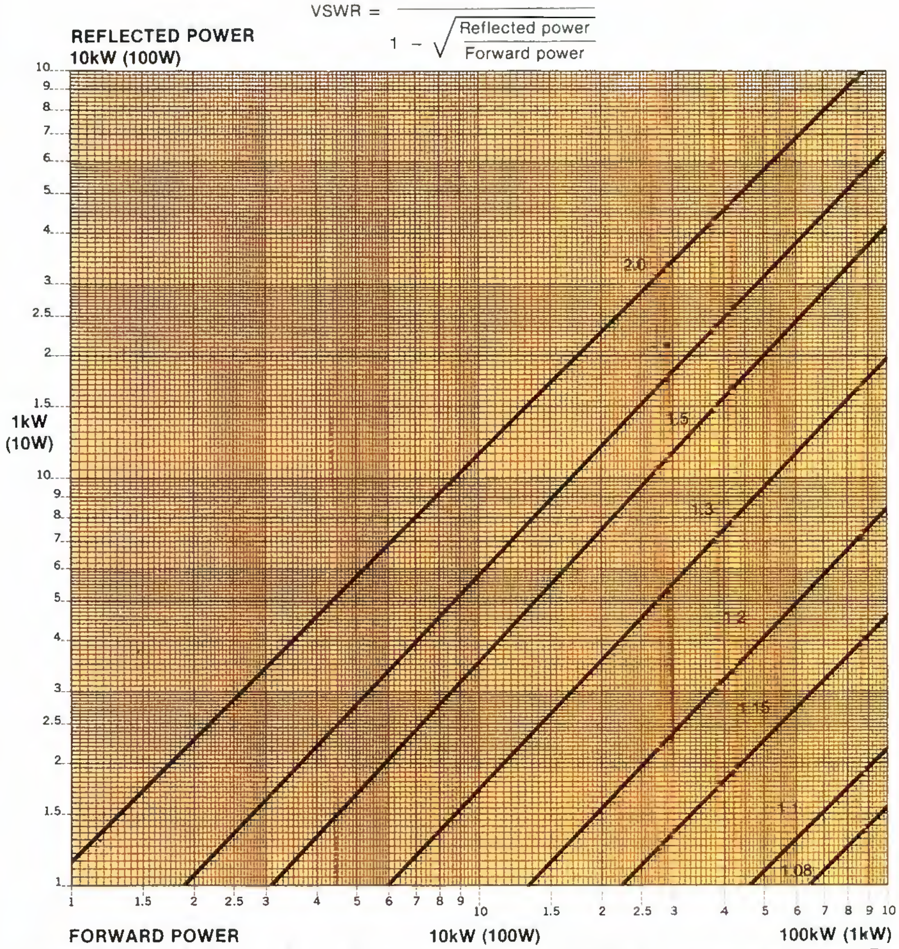


Figure 7. *A graph that can be used for determining the VSWR of a transmission system. For low-power operation, use the values shown in parentheses.*

each year. Falling ice can damage FM and TV antenna elements if proper precautions are not taken.

Icing on the elements of an FM or TV antenna will degrade the antenna VSWR because the ice lowers the frequency of the electrical resonance of the antenna. Two methods are commonly used to prevent a build-up of ice on an antenna: electrical de-icers and radomes.

- Check AM antennas regularly for structural integrity. Because the tower itself is the radiator, bond together each section of the structure for good electrical contact.
- Clean base insulators and guy insulators (if used) as often as required. Obviously, it is only practical to clean the guy insulators near the tower and near the ground.
- Keep lightning ball gaps or other protective devices clean and properly adjusted.
- Inspect the transmission line for signs of damage. Check supporting hardware and investigate any indication of abnormal heating of the line immediately.
- Keep a detailed record of VSWR in the station's maintenance log and investigate any increase above the norm.
- Regularly check the RF system test load. Although it probably isn't used often, be sure you can use it when it's needed. Inspect the coolant filters and flow rate, as well as the resistance of the load element. It might have been damaged the last time you used it.

UHF systems

The RF transmission system of virtually any high-power UHF station is externally diplexed after the final RF amplifiers with either coaxial or waveguide-type diplexers. Maintenance of combining sections is largely a matter of observation and record keeping.

- Monitor the reject loads on diplexers and power combiners regularly to ensure adequate cooling.
- Check the temperature of the transmission line and components, particularly coaxial elements. Don't be surprised to find that coax of the same size, carrying the same RF power, runs warmer in UHF than in VHF systems. This phenomenon is caused by the reduced *skin effect* (or penetration depth) of UHF signal currents.

Hot spots in the transmission line can be caused by poor contact areas or by high VSWR. If they are the result of a VSWR condition, the hot spots will be repeated every ½-wavelength toward the transmitter.

• Monitor the reverse power/VSWR meters closely. Some daily variation is not unusual, in small amounts. Greater variations that are cyclical in nature are an indication of a long-line problem, most likely at the antenna. Transmission lines are usually long at UHF (a taller tower allows greater coverage) and the wavelength is small, which leads to large phase changes of a mismatch at the antenna.

Mismatches inside the building do not cause the same cyclical variation. If the reverse power begins varying significantly, immediately arrange for an RF sweep of the line. You may be able to avoid major failure. Before you consider a sweep procedure, however, run the system with the test load to see whether the problem disappears.

Another effect of VSWR variation on a UHF transmitter is change in klystron output power. The output coupler transforms the line characteristic impedance upward to approximately match the beam impedance, for a maximum power transfer from the cavity. Large VSWR phase variations associated with long lines change the impedance that the output coupler sees. This causes the output power to vary, sometimes more significantly than the reverse power metering indicates.

A common indication of antenna VSWR problems in long-line TV systems is ghosting on the output waveform. If the input signal is clean and the output has a ghost, call for an RF sweep.

High-voltage power supply

The second section of a transmitter most vulnerable to damage because of outside influences is the high-voltage plate power supply.

Figure 9 shows a high-reliability power supply of the type common in broadcast transmission equipment. Many transmitters use simpler designs, without some of the protection devices shown, but the principles of preventive maintenance are the same.

• Thoroughly examine every component in the high-voltage power supply. Look for signs of leakage on the main filter capacitors (C1 and C2).
• Check all current-carrying meter/overload shunt resistors (R1 to R3) for signs of overheating.
• Carefully examine the wiring throughout the power supply for loose connections.
• Examine the condition of the filter capacitor series resistors (R4 and R5), if used, for indications of overheating. Excessive current through these resistors could spell a pending failure in the associated filter capacitor.
• Examine the condition of the bleeder resistors (R6 to R8). A failure in one of the bleeder resistors could result in a potentially dangerous situation for maintenance personnel by leaving the main power-supply capacitor (C2) charged

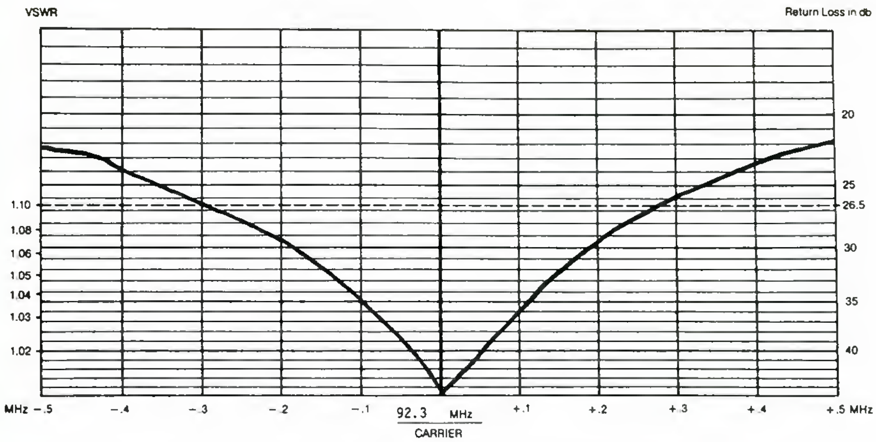


Figure 8. *The measured performance of a single-channel FM antenna (tuned to 92.3MHz). This antenna—a 10-bay circularly polarized unit—provides a VSWR of below 1.1:1 over a frequency range of nearly ± 300kHz.*

after the removal of ac input power.

• Examine the plate voltage meter multiplier assembly (A1) for signs of resistor overheating. Replace any resistors that are discolored.

When changing components in the transmitter high-voltage power supply, be certain to use parts that meet with the approval of the manufacturer. Do not settle for a close match of a replacement part. Use the *exact* replacement part. This ensures that the component will work as intended and will fit in the space provided.

Metering

Proper metering is one of the best ways to prevent failures in broadcast transmission equipment. Accurate readings of plate voltage and current are fundamental to transmitter maintenance. Check each meter for proper mechanical and electrical operation. Replace any meter that sticks or will not *zero.*

With most transmitter plate current meters, accuracy of the reading can be verified by measuring the voltage drop across the shunt element (R2 of Figure 9) and using Ohm's law to determine the actual current in the circuit. Be certain to take into consideration the effects of the meter coil itself. Contact the transmitter manufacturer for suggestions on how best to confirm the accuracy of the plate current meter.

The plate voltage meter can be checked for accuracy by using a high-voltage probe and a high-accuracy external voltmeter. Be extremely careful when making such a measurement. Follow to the letter instructions for use of the high-voltage probe. Do not defeat transmitter interlocks to make this measurement. Instead, fashion a secure connection to the point of measurement and route the meter cables carefully out of the transmitter. Never use common test leads to measure a voltage of more than 600V. Standard test lead insulation for most meters is not rated for use above 600V.

Overload sensor

The plate supply overload sensor in most transmitters is arranged as shown in Figure 9. An adjustable resistor—either a fixed resistor with a movable tap or a potentiometer—is used to set the sensitivity of the plate overload relay. Check potentiometer-type adjustments periodically. Fixed-resistor-type adjustments rarely require additional attention. Most manufacturers have a chart or mathematical formula that may be used to determine the proper setting of the adjustment resistor (R9) by measuring the voltage across the overload relay coil (K1) and observing the operating plate current value.

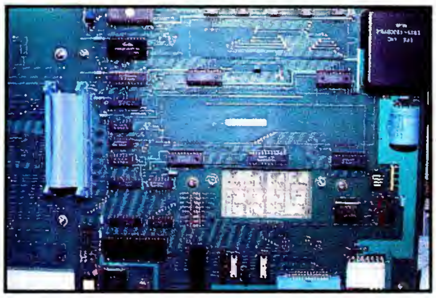
Clean the overload relay contacts periodically to ensure proper operation. If you encounter mechanical problems with a relay, replace it.

Transmitter control logic for UHF systems will almost certainly be configured for two states. An *operational level* requires all the *life-support* systems to be present before the HV command is enabled. An *overload level* removes HV when one or more fault conditions occur. Inspect the logic ladder for correct operation at least once a month.

At longer intervals, perhaps annually, check the speed of the trip circuits. (A storage oscilloscope is useful for this measurement.) Most klystrons require an HV removal time of less than 100ms from the occurrence of an overload. If the trip time is longer, you may be ordering another klystron sooner than you expected.

Pay particular attention to the body-current overload circuits. Occasionally check the body current without applied drive to ensure that the dc value is stable. Relatively small increases in dc body current can lead to overheating problems.

Other UHF transmitter overload circuits requiring periodic monitoring include the RF arc detectors. External cavity klystrons generally have one detector in each of the third and fourth cavities.



Power semiconductors are being used increasingly in transmission equipment today. For this reason, closer attention must be given to incoming ac line voltage transients, grounding and air filtration at the transmitting site.

Integral devices use one detector at the output window.

A number of factors cause RF arcing: overdrive, mistuning, poor cavity fit (external type only), undercoupling of the output and high VSWR. Regardless of the cause, arcing can destroy the vacuum seal, if drive and/or HV are not removed quickly.

A lamp is included with each arc detector photocell for test purposes. If the lamp fails, a flashlight can provide sufficient light to trigger the cell until a replacement can be obtained.

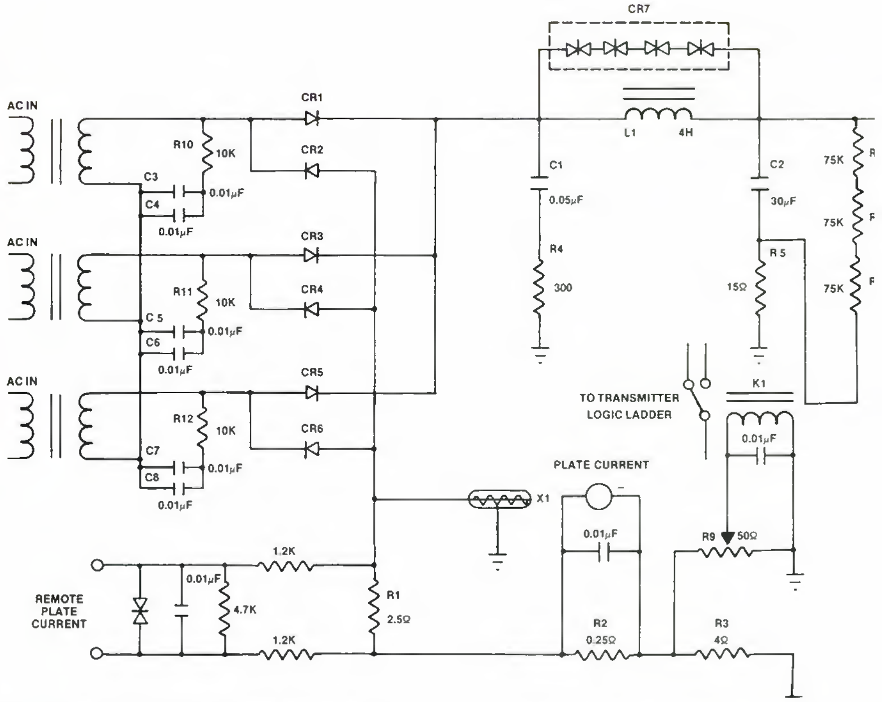
Transient disturbances

Every electronic installation requires a steady supply of clean power in order to function properly. Recent advances in technology have made the question of ac-power quality even more important, as microcomputers are integrated into radio and TV transmitters.

The threat of damaging transient overvoltages from the utility company power system is a very real problem for broadcasters. Transients have been recorded on typical primary power drops ranging from harmless values just above normal, to dangerous spikes measuring several kilovolts. Experience in the computer industry has shown that equipment not protected against the possibility of power-supply disturbances will have a poor mean-time-between-failures record. The degree of protection needed at a facility depends on the type of service used, the utility company system layout and the frequency of lightning and other natural occurrences in the area.

Different types and makes of transmitters have varying degrees of transient overvoltage protection. Given the experience of the computer industry, it is hard to overprotect electronic equipment from ac line disturbances.

Figure 9 (page 70) shows surge suppression at two points in the power supply circuit. C1 and R4 make up an R/C snubber network that is effective in shunting high-energy, fast-rise time spikes that may appear at the output of the rectifier assembly (CR1 to CR6). Similar R/C snubber networks (R10 to



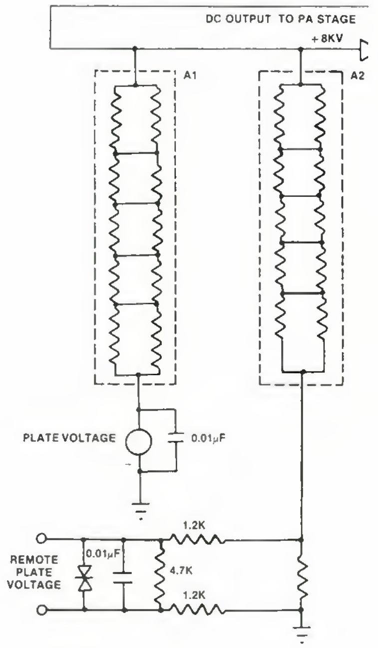


Figure 9. *A common high-voltage transmitter power-supply circuit design.*

R12 and C3 to C8) are placed across the secondary windings of each section of the 3-phase power transformer. Any signs of resistor overheating or capacitor failure are an indication of excessive transient activity on the ac power line. Transient disturbances should be suppressed before the ac input point of the transmitter.

Assembly CR7 is a surge-suppression device that should be given careful attention during each maintenance session. CR7 is typically a selenium thyrector assembly that is essentially inactive until the voltage across the device exceeds a predetermined level. At the trip point, the device will break over into a conducting state, shunting the transient overvoltage.

CR7 is placed in parallel with L1 to prevent damage to other components in the transmitter in the event of a loss of RF excitation to the final stage. A sudden drop in excitation will cause the stored energy of L1 to be discharged into the power supply and PA circuits in the form of a high-potential pulse. The results of this transient can be damaged or destroyed filter, feedthrough or bypass capacitors, damaged wiring or PA tube arcing. CR7 prevents this problem by dissipating the stored energy in L1 as heat.

Investigate discoloration or other outward signs of damage to CR7. Such an occurrence could indicate a problem in the exciter or IPA stage of the transmitter. Immediately replace CR7 if it appears to have been stressed.

Check spark-gap surge-suppressor X1 periodically for signs of overheating. X1 is designed to prevent damage to circuit wiring in the event that one of the meter/overload shunt resistors (R1 to R3) opens. Because the spark-gap device is nearly impossible to accurately test in the field and is relatively inexpensive, it is an advisable precautionary measure to replace the component every few years.

Single phasing

Any transmitter using a 3-phase ac power supply is subject to the problem of *single-phasing*, the loss of one of the three legs from the primary ac power distribution source. Single phasing is usually a utility company problem, caused by a downed line or a blown polemounted fuse.

The loss of one leg of a 3-phase line results in a particularly dangerous situation for 3-phase motors, which will overheat and sometimes fail. AM transmitters using *pulse width modulation* (PWM) systems also are vulnerable to single-phasing faults. AM transmitters using PWM schemes can suffer catastrophic failure of the plate power-supply transformer as a result of the voltage regulation characteristics of the modulation system. The PWM circuit will attempt to maintain carrier and sideband power through the remaining leg of the 3-phase supply. This forces the active transformer section and its associated rectifier stack to carry as much as three times the normal load.

Figure 10 shows a simple protection scheme that has been used to protect transmission equipment from damage caused by single phasing. Although at first glance the system looks as if it would easily handle the job, operational problems can result.

The loss of one leg of a 3-phase line rarely results in zero (or near-zero) voltages in the legs associated with the problem line. Instead, a combination of leakage currents caused by regeneration of the missing legs in inductive loads and the system load distribution usually results in voltages of some sort on the fault legs of the 3-phase line.

It is possible, for example, to have phase-to-phase voltages of 220V, 185V and 95V on the legs of a 3-phase, 208Vac line experiencing a single-phasing problem. These voltages often change, depending upon the equipment turned on at the transmitter site.

Integrated circuit technology has provided a cost-effective solution to this common design problem in medium- and high-power transmitting equipment. Phase-loss protection modules are available from several manufacturers that provide a contact closure when voltages of proper magnitude and phase are present on the monitored line. The relay contacts can be wired into the logic control ladder of the transmitter to prevent the application of primary ac power during a single-phasing condition.

Figure 11 shows the recommended connection method. Note that the input to the phase monitor module is taken from the final set of 3-phase blower motor fuses. In this way, any failure inside the transmitter that might result in a single-phasing condition is taken into account. Because 3-phase motors are particularly sensitive to single-phasing faults, the relay interlock is tied into the filament circuit logic ladder. For AM transmitters using PWM schemes, connect the input of the phase loss protector to the load side of the plate circuit breaker.

The phase-loss protector shown in Figure 11 includes a sensitivity adjustment for various nominal line voltages.

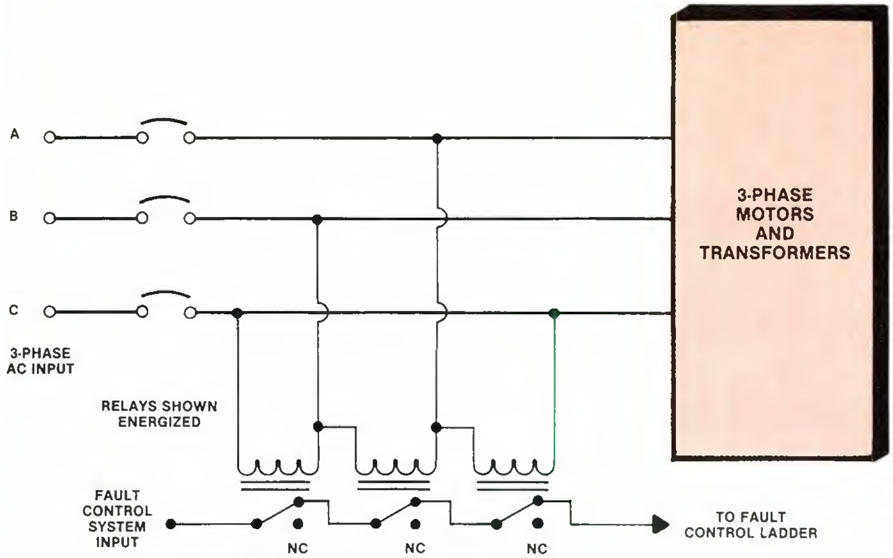


Figure 10. *Using relays for utility company ac phase-loss protection.*

The unit is small and relatively inexpensive (about $55). If your transmitter does not have such a protection device, consider installing one. Contact the factory service department for recommendations on the connection methods that should be used.

Modifications and updates

If you experience a problem, examine what can be done to prevent the failure from recurring. You might avoid a repeat by installing various protection devices or consulting the factory for updates to your equipment. If the transmitter is several years old, the factory service department can detail any changes that may have been made in the unit to provide more reliable operation. Many of these modifications are minor and can be incorporated into older models with little cost or effort.

Modifications could include changing a variable capacitor in a critical tuning stage to a vacuum variable for more stability; installing additional filtering in the high-voltage power supply; replacing older technology transistorized circuit boards with newer IC and power semiconductor PCBs; improving the overload protection circuitry; or adding protection against transient overvoltages in various stages of the transmitter.

Spare parts

A key aspect of any successful broadcast equipment maintenance program is the spare parts inventory. Having adequate replacement components on hand for the transmitter is important not only for the repair of equipment failures, but for identifying those failures as well. Many parts, particularly in the high-voltage power supply and RF chain, are difficult to test under static conditions. The only reliable way to check the component may be to substitute one of known quality. If the system returns to normal operation, then the substituted component is defective. Substitution is also a valuable tool in troubleshooting intermittent failures caused by component breakdown under peak power (or modulation) conditions.

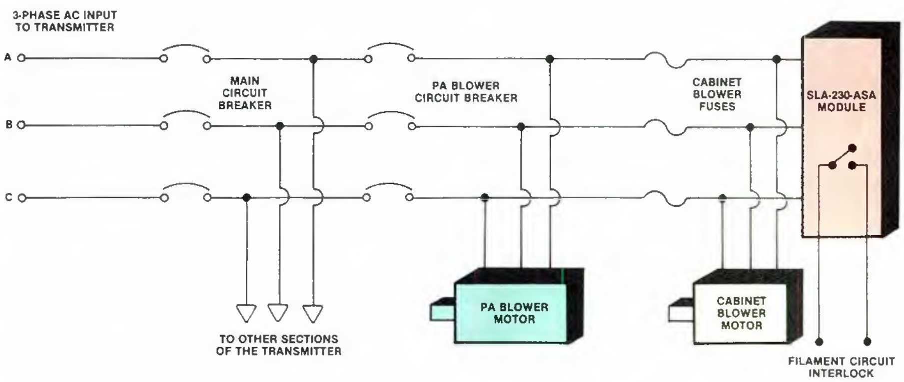


Figure 11. *A high-performance single-phasing protection circuit using a phase-loss module as the sensor. (Note: The device shown in this diagram is a model SLA-230-ASA phase-loss protector module manufactured by Diversified Electronics of Evansville, IN. Units performing comparable functions are also available from other manufacturers.)*

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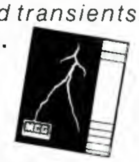

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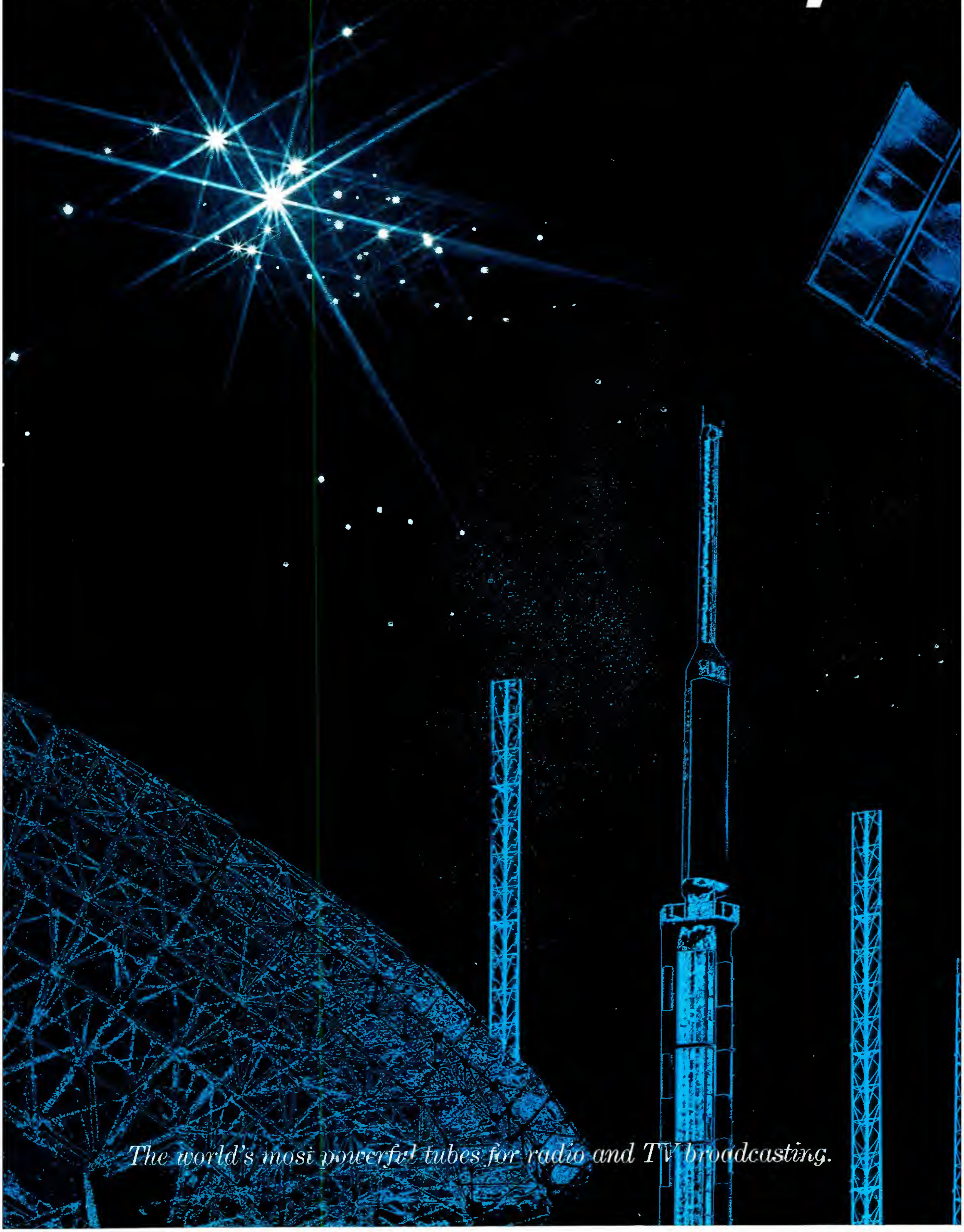

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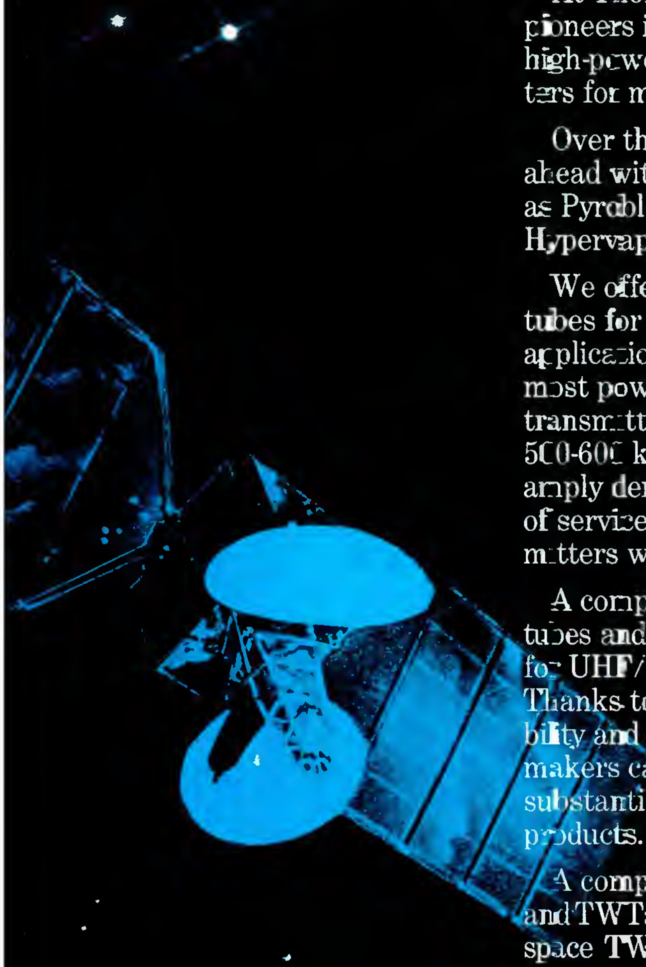

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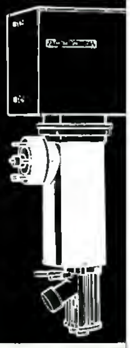

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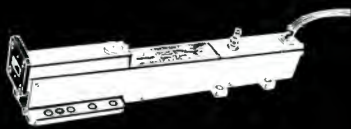

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Temperature control

A controlled environment is critical to reliability.

The environment in which the transmitter is operated is a key factor in determining system reliability. Proper temperature control must be provided for the transmitter to prevent thermal fatigue in semiconductor components and shortened life in vacuum tubes. Thermal fatigue occurs in semiconductor power devices because of differential expansion and contraction of the individual parts of the device itself (the silicon pellet, solder and case). Some semiconductor manufacturers have been able to predict the approximate number of thermal cycles that their devices are capable of withstanding without failure.

For example, RCA's RC-5258 NPN power transistor has a life expectancy of nearly two million thermal cycles from ambient temperature to 50°C above ambient. At 100°C above ambient, however, the number of thermal cycles possible before device failure drops to about 40,000. At 150°C above ambient, the number of thermal cycles is only 800. Removing heat is vital to the long-term survival of semiconductors and vacuum tubes.

Keeping cool

Airflow system problems can be avoided if preventive maintenance work is performed on a regular basis.

- Keep all fans and blowers clear of dirt, dust and other foreign material that might restrict airflow. Check the fan blades and blower impellers for any imbalance conditions that could result in undue bearing wear or damage. Inspect belts for proper tension and alignment.

An example of how additional filtering can be added to the air-intake port of a transmitter. Standard furnace filter panels can be used and held in position by adhesive tape squares. Alternatively, special computer room filtering material can be cut to size and placed over air-intake ports. Confirm that no loss of air pressure inside the equipment results from the additional filters.

Regular cleaning of a blower motor is important because motors are cooled by the passage of air over the component. If the ambient air temperature is excessive or the airflow is restricted, the lubricant gradually will be vaporized from the motor bearings and bearing failure will occur. If dirty air passes over the motor, the accumulation of dust and dirt must be blown out of the device before the debris impairs cooling.

- Follow the manufacturer's specifications for suggested frequency and type of lubrication. Bearings and other moving parts normally require some lubrication. Carefully follow any special instructions on operation or maintenance of the cooling equipment.
- Inspect motor-mounting bolts periodically. Even well-balanced equipment experiences some vibration, which can cause bolts to loosen over time.
- Inspect air filters weekly and replace or clean them as necessary. Replacement filters should meet original specs.
- Clean dampers and all ducting to avoid airflow restrictions. Lubricate movable and mechanical linkages in dampers and other devices as recommended. Check actuating solenoids and electromechanical components for proper operation.

Movement of air throughout the transmitter causes static electrical charges to develop. Static charges can result in a build-up of dust and dirt in ductwork, dampers and other components of the system. Filters should remove the dust before it gets into the system, but no filter traps every particle.

- Check thermal sensors and temperature system-control devices for proper operation.

Words on water

The cooling system is vital to any transmitter. In a UHF unit, the cooling system must dissipate an average of 70%

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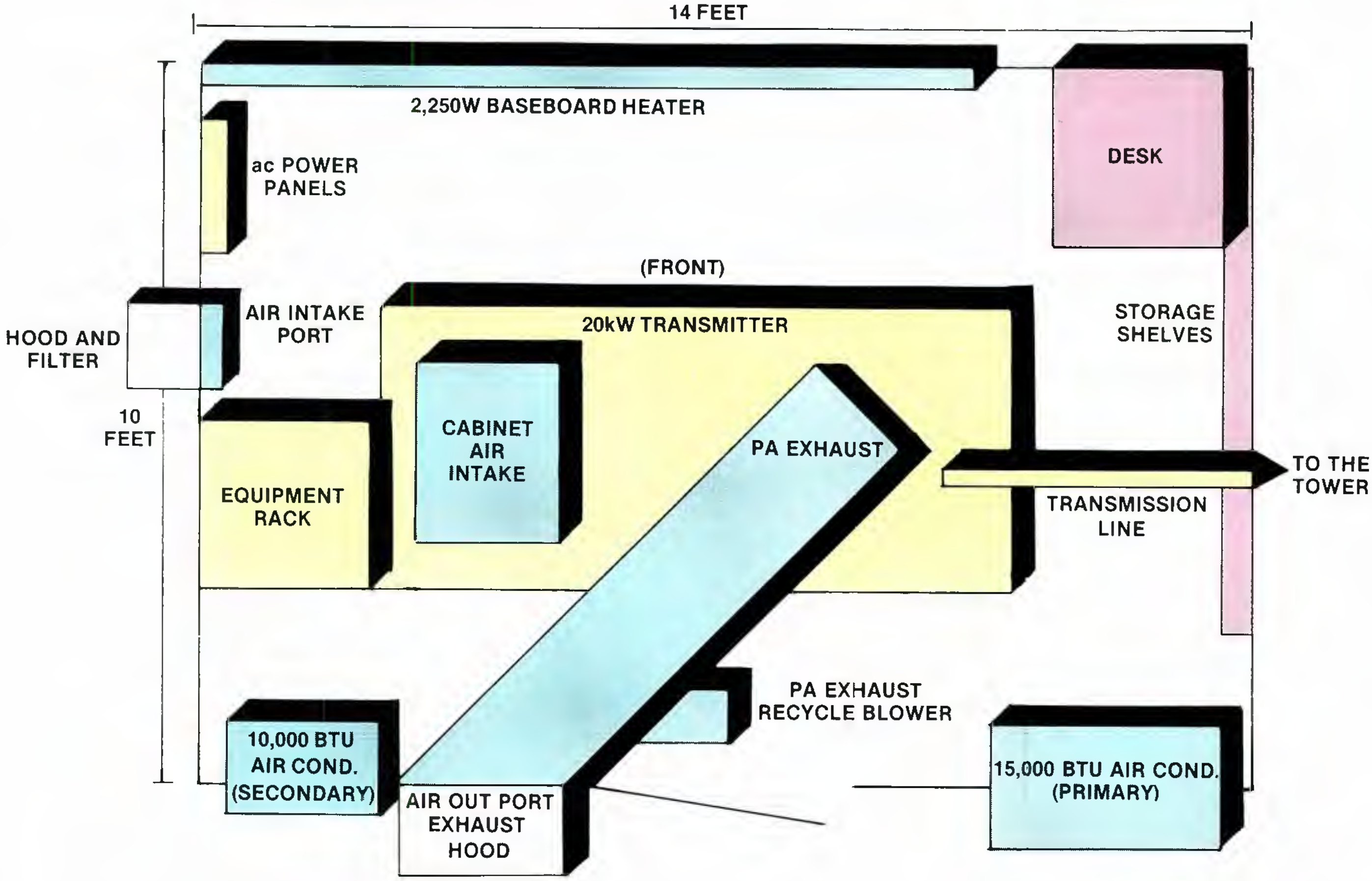

Figure 12. *A typical heating and cooling arrangement for a 20kW FM transmitter installation. Ducting of PA exhaust air should be arranged so that it offers minimum resistance to airflow. Ideally, the transmitter PA exhaust would go straight up through the roof of the building.*

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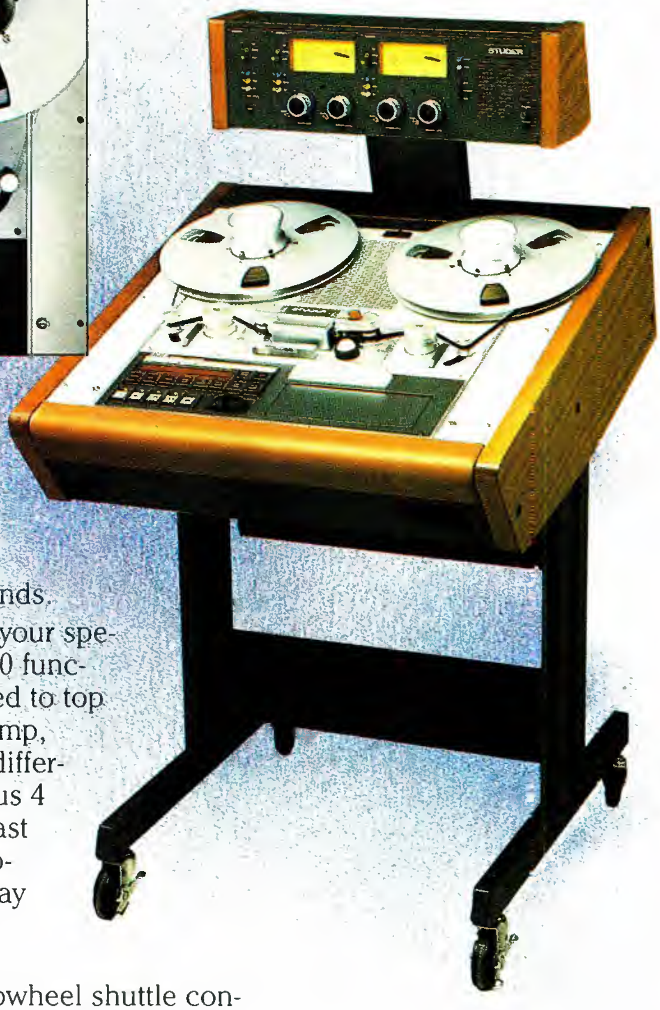

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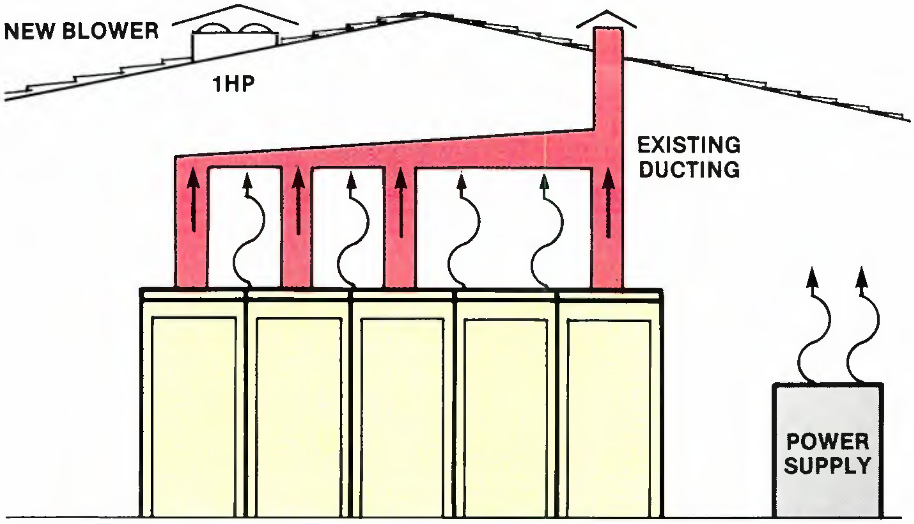

Figure 13. *A case study in which excessive summertime heating was eliminated through the addition of a 1hp exhaust blower to the building.*

of the input ac power in the form of waste heat in the klystron collector. For vapor phase-cooled klystrons, pure (distilled or demineralized) water must be used. Because the collector is only several volts above ground potential, it is not necessary to use de-ionized water.

The collector and its water jacket act like a distillery. Any impurities in the water will eventually find their way into the water jacket and cause corrosion of the collector. It is essential to use high-purity water with low conductivity, less than 10mS/cm (millisiemens per centimeter), and to replace the water in the cooling jacket as needed.

Efficient heat transfer from the collector surface into the water is essential for long klystron life. Oil, grease, soldering flux residue and pipe sealant containing silicone compounds must be excluded from the cooling system. This applies to both vapor- and liquid-conduction cooling systems, although it is usually more critical in the vapor-phase type.

The sight glass in a vapor-phase water jacket provides a convenient checkpoint for coolant condition. Look for unusual residues, oil on the surface, foaming and discoloration. If any of these appear, contact the manufacturer for advice on how to flush the system.

Water quality is important to proper operation of a liquid-cooled klystron. In general, greater flows and greater pressures are inherent in liquid-cooled-vs.-vapor-phase systems, and when a leak occurs, large quantities of coolant can be lost before the problem is discovered. Inspect the condition of gaskets, seals and fittings regularly.

Most liquid-cooled klystrons use a distilled water and ethylene glycol mixture. Do not exceed a 50:50 mix by volume. The heat transfer of the mixture is lower than that of pure water, requiring the flow to be increased, typically by 20% to 25%. Greater coolant flow means higher pressure and warrants close observation of the cooling system after adding the glycol. Allow the system to heat and cool several times. Then check all plumbing fittings for tightness.

The action of heat and air on ethylene glycol causes the formation of acidic products. The acidity of the coolant can be checked with litmus paper. Buffers

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can and should be added with the glycol mixture. Buffers are alkaline salts that neutralize acid forms and prevent corrosion. Because they are ionizable chemical salts, the buffers cause conductivity of the coolant to increase. Measure the collector-to-ground resistance periodically. Coolant conductivity is acceptable if the resistance caused by the coolant is greater than 20 times the resistance of the body-metering circuitry.

Experience has shown that the only practical way to ensure good coolant condition is to drain, flush and recharge the system every spring. The equipment manufacturer can provide advice on how this procedure should be carried out and can recommend types of glycol to use.

Maintain unrestricted airflow over the heat exchanger coils and follow the manufacturer's instructions on pump and motor maintenance.

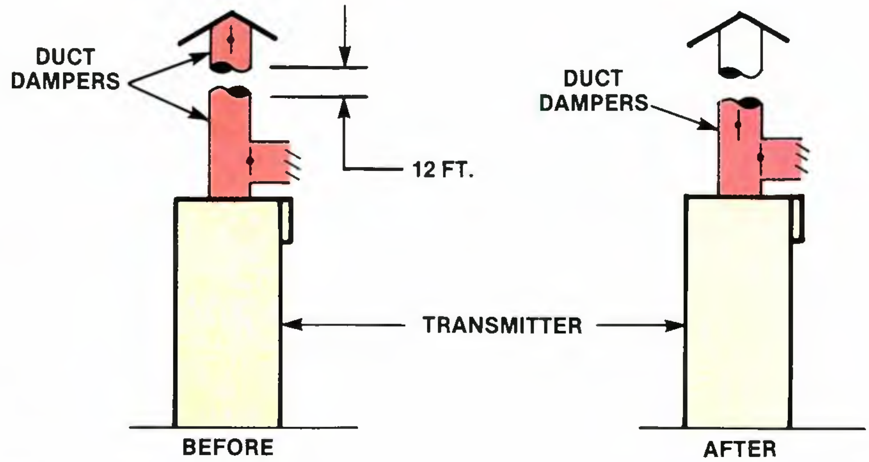


Figure 14. *A case study in which excessive back pressure to the PA cavity during winter periods (when the rooftop damper was closed) was eliminated by repositioning the damper as shown.*

Cooling system design

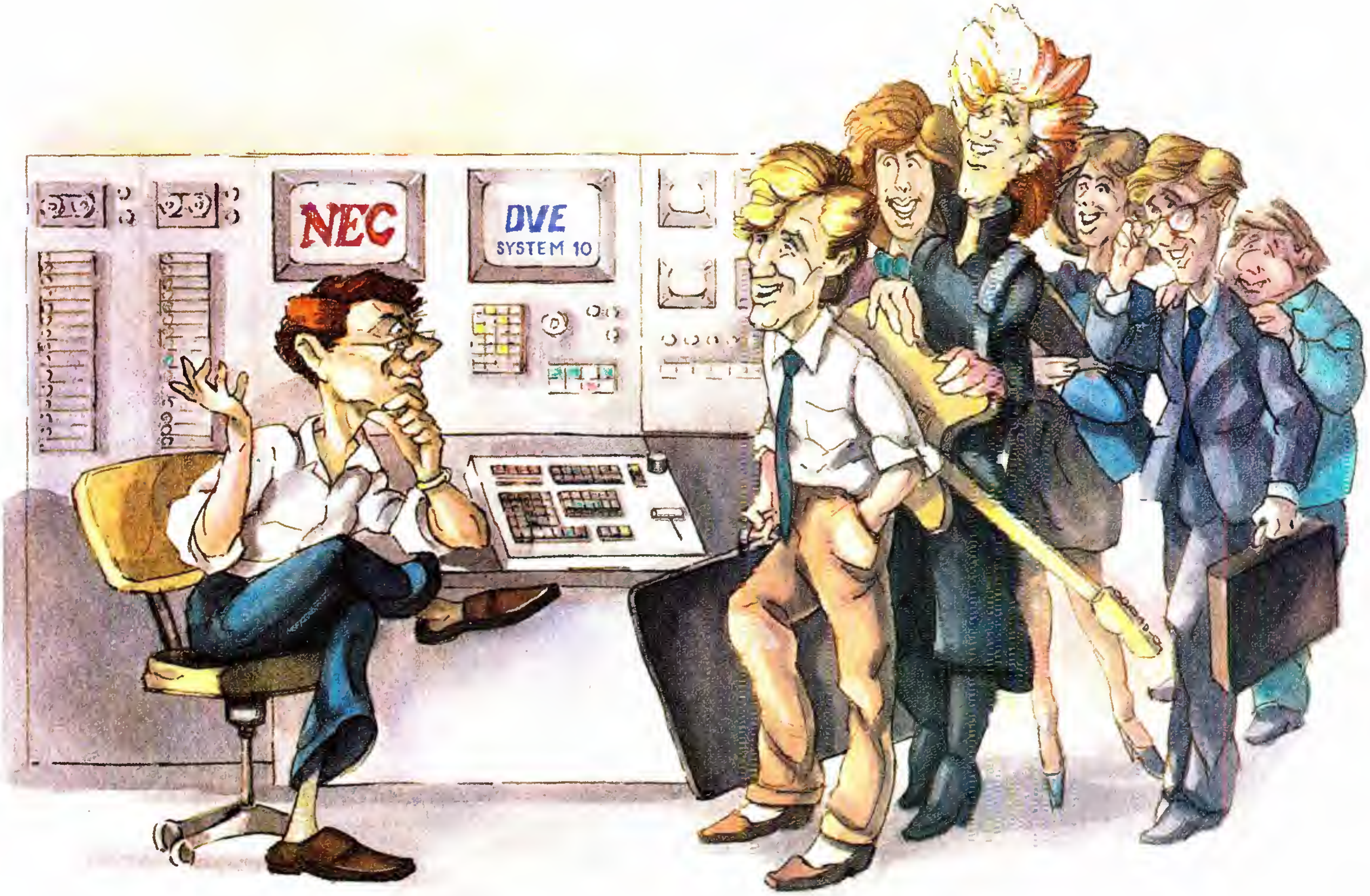
Transmitter room cooling requirements vary considerably from one location to another, but some general statements on cooling apply to all installations.

A transmitter greater than 1kW must have its exhaust ducted to the outside whenever the outside temperature is greater than 50°F. Transmitter buildings must be equipped with refrigerated air-conditioning units when the outside temperature is greater than 80°F. The exact amount of cooling capacity needed is subject to a variety of factors, such as actual transmitter efficiency, thermal insulation of the building itself and size of the transmitter room.

Here again, though, some generalizations can be made. Radio transmitters up to and including 5kW usually can be cooled (if the exhaust is efficiently ducted outside) by a 10,000BTU air conditioner. Installations of 10kW will require a minimum of 17,500BTU of air conditioning and 20kW plants need at least 25,000BTU of air conditioning. For larger radio installations or TV systems, consult an air-conditioning expert.

Figure 12 shows a typical 20kW FM transmitter plant installation. The building is oriented so that the cooling activity of the blowers is aided by normal wind currents during the summer months. Air brought in from the outside for cooling is well filtered in a hooded air-intake assembly that holds several filter panels.

This layout includes two air conditioners, one 15,000BTU and the other 10,000BTU. The thermostat for the smaller unit is set for slightly greater sensitivity than the larger air conditioner,



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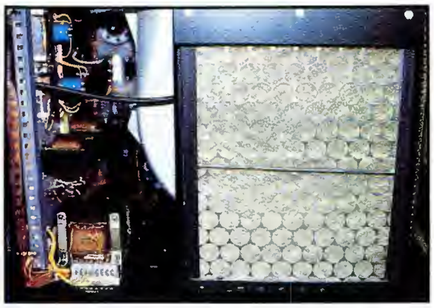
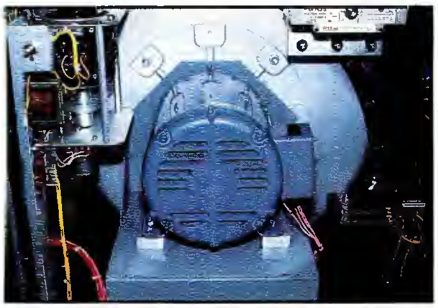


Replace transmitter filters as often as necessary. Use only the type of filter recommended by the manufacturer.



Consult the transmitter instruction manual for the recommended blower motor maintenance schedule.

allowing small temperature increases to be handled more economically.

It is important to keep the transmitter room warm during the winter, as well as cool during the summer. Install heaters and PA exhaust recycling blowers as needed. A transmitter that runs 24 hours a day normally will not need additional heating equipment, but stations that sign off for several hours during the night should be equipped with electric room heaters (baseboard types, for example) to keep the room temperature above 50°.

PA exhaust recycling can be accomplished by using a thermostat, relay logic circuit and solenoid-operated register or electric blower. By controlling the room temperature to between 60°F and 70°F, tube and component life will be extended substantially.

Layout considerations

The layout of a transmitter room HVAC (heating, ventilation and air conditioning) system can have a significant impact on the life of the PA tube(s) and the ultimate reliability of the transmitter.

Air intake and output ports must be designed with care to avoid airflow restrictions and back-pressure problems. This process, however, is not as easy as it may seem. The science of airflow is complex and generally requires the advice of a qualified HVAC consultant.

To help illustrate the importance of proper cooling system design and the real-world problems that some stations have experienced, consider the following examples taken from actual case histories:

Case 1:

A fully automatic building ventilation system (Figure 13) was installed to maintain room temperature at 20°C during the fall, winter and spring. During the summer, however, ambient room temperature would increase to as much as 60°C.

A field survey showed that the only room exhaust for the system was through the transmitter. Therefore, air entering the room was heated by test equipment, people, solar radiation on the building and radiation from the transmitter itself before entering the transmitter.

The problem was resolved through the addition of an exhaust fan (3,000cfm). The 1hp fan lowered room temperature by 20°C.

Case 2:

A simple remote installation was constructed with a heat-recirculating feature for the winter (see Figure 14). Outside supply air was drawn by the transmitter cooling system blowers through a bank of air filters and hot air was exhausted through the roof. A small blower and a damper were installed near the roof exit point. The damper allowed hot exhaust air to blow back into the room through a tee duct during winter months.

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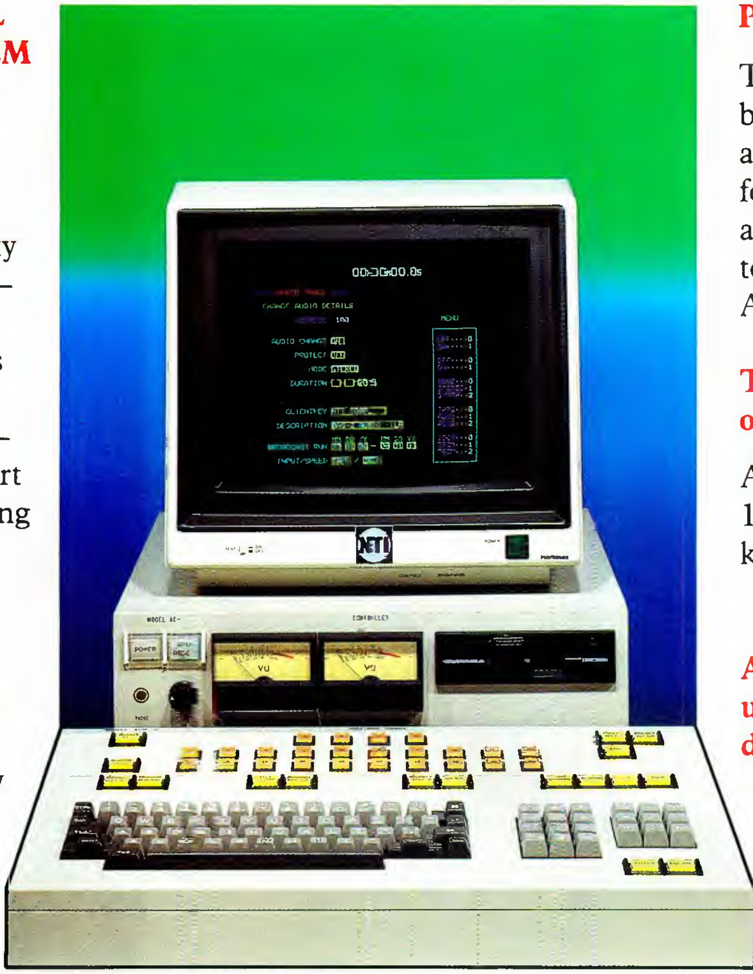

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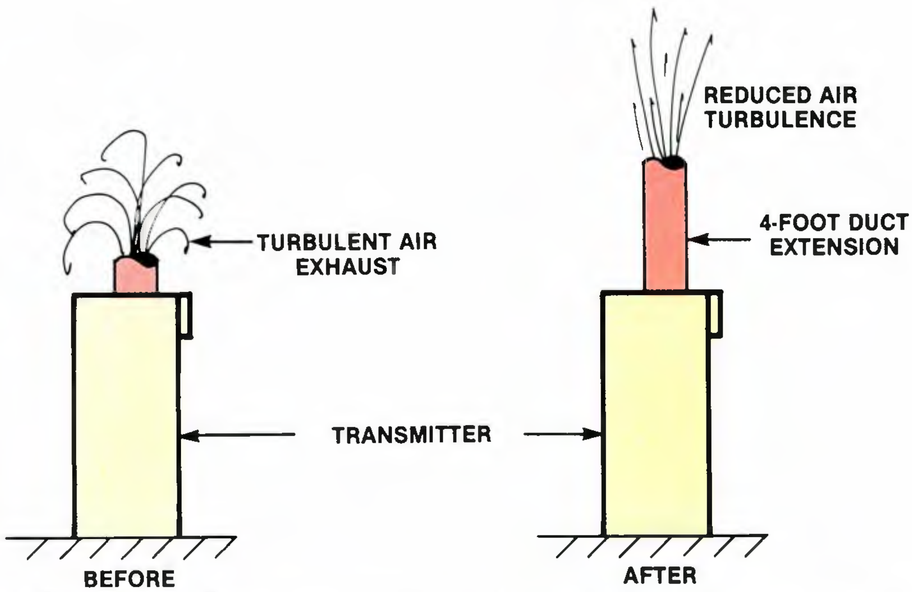

***Figure 15.** A case study in which air turbulence at the exhaust duct resulted in reduced airflow through the PA compartment. The problem was eliminated by adding a 4-foot extension to the output duct.*

damper was switched open and the damper closed. For winter operation, the arrangement was reversed. The station, however, experienced short tube life during winter operation, even though the ambient room temperature during the winter was not excessive.

The solution involved moving the roof damper 12 feet down to just above the tee. This eliminated the stagnant *air cushion* above the bottom heating duct damper and significantly improved airflow in the region. Cavity back pressure was, therefore, reduced. With this relatively simple modification, the problem of short tube life disappeared.

Case 3:

An inconsistency regarding test data was discovered within a transmitter manufacturer's plant. Units tested in the engineering lab typically ran cooler than those at the manufacturing test facility. Figure 15 shows the test station difference, a 4-foot exhaust stack that was used in the engineering lab. The addition of the stack increased airflow by up to 20% because of reduced air turbulence at the output port, resulting in a 20°C decrease in tube temperature.

These examples point out how easily a cooling problem can be caused during HVAC system design. All power delivered to the transmitter is either converted to RF energy and sent to the antenna or becomes heated air. Proper design of a cooling system, therefore, is a part of transmitter installation that should not be taken lightly.

Transmitter cooling system performance is not necessarily related to airflow volume. The cooling capability of air is a function of its mass, not its volume. The designer must determine an appropriate airflow rate within the equipment and establish the resulting resistance to air movement. A specified static pressure that should be present within the ducting of the transmitter can be a measure of airflow.

For any given combination of ducting, filters, heat sinks, RFI honeycomb shielding, tubes, tube sockets and other elements in the transmitter, a specified system resistance to airflow can be determined. It is important to realize that any changes in the position or number of restricting elements within the system will change the resistance and, therefore, the effectiveness of the cooling.

The altitude of operation is also a consideration in cooling system design. As altitude increases, the density (and cooling capability) of the air decreases. A calculated increase in airflow can maintain the cooling effectiveness the system was designed to achieve.

Air filters

Once the transmitter is clean, keeping it that way for long periods of time may require improving the air-filtering system. Most filters are inadequate to keep out small dirt particles (microdust), which can become a serious problem in an unusually dirty environment. Microdust also can become a problem in a relatively clean environment after a number of years of operation.

In addition to providing a well-filtered air-intake port for the transmitter building, an additional air filter can be placed in front of the normal transmitter filter assembly. A computer system filter panel can be secured to the air-intake port to provide additional protection. With the extra filter in place, it generally is necessary only to replace or clean the outer filter panel. The transmitter's integral filter assembly will stay clean, eliminating the work and problems associated with pulling out the filter assembly while the transmitter is operating. Be certain that the addition of supplemental filtering does not restrict airflow into the transmitter.

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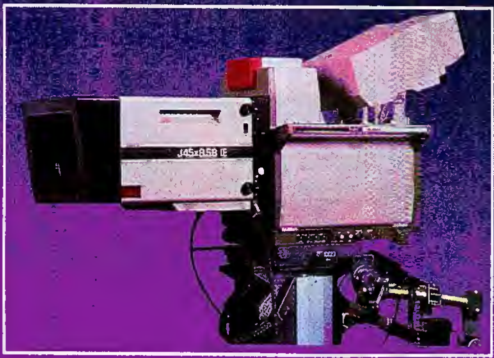

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Safety first

Don't take chances with high voltages. They can kill.

Approach any work on a transmitter with extreme caution. The high voltages that exist in a transmitter can be lethal. Perform such work only when a second engineer is in the room.

Work inside the transmitter only after all ac power has been removed and after all capacitors have been discharged using the grounding stick provided with the transmitter. Remove primary power from the unit by tripping the appropriate power-distribution circuit breakers at the transmitter building. Do not rely on internal contactors or SCRs to remove all dangerous ac.

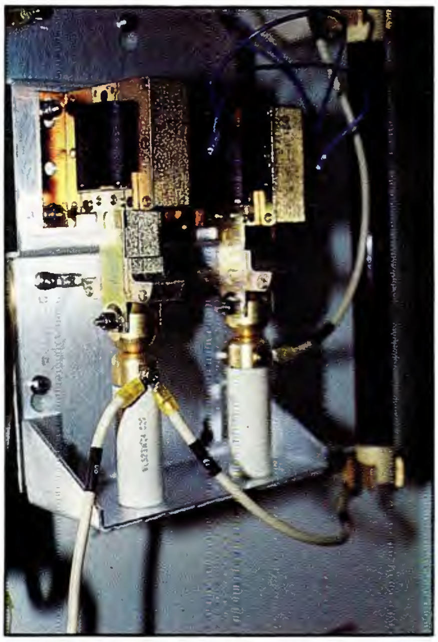
Do not remove, short-circuit or tamper with interlock switches on access covers, doors, enclosures, gates, panels or shields. Keep away from live circuits. Know your equipment and don't take chances. Although defeating an access panel or interlock switch may save work time, the consequences can be tragic.

Allow any apparently defective component to completely cool down before attempting to replace it. If a leak or bulge is found on the case of an oil-filled or electrolytic capacitor, do not attempt to service the part until it has completely cooled. Servicing the component while it is hot can cause case rupture and subsequent injury.

Operating hazards

Hazards exist in the operation of radio and TV transmitters. Maintenance personnel must exercise extreme care near such equipment.

• Use caution around the high-voltage stages of the transmitter. Many power tubes operate at voltages high enough to kill by electrocution. Always break the primary ac circuit of the power supply and discharge all high-voltage capacitors.



Verify that the high-voltage protection circuits included with the transmitter operate properly and short any residual dc to ground when the interlocks are open.

• Minimize exposure to RF radiation. Do not permit personnel to be in the vicinity of open energized RF-generating circuits, RF transmission systems (waveguides, cables or connectors) or energized antennas. High levels of radiation can result in severe bodily injury, including blindness. Cardiac pacemakers may also be affected by radiation.

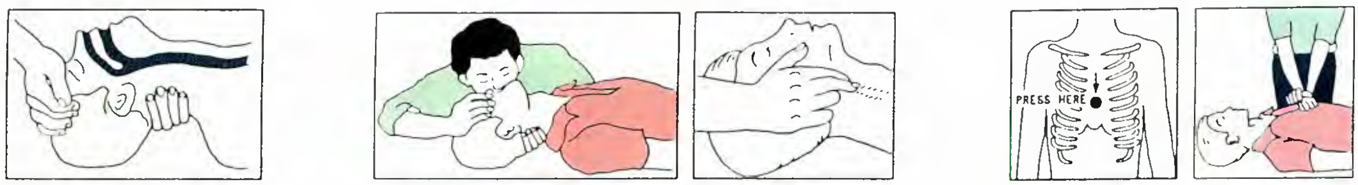
The effects of prolonged exposure to *low level* RF radiation continues to be a subject of investigation and controversy. It is generally agreed that exposure of personnel to radiation should be limited to an absolute minimum. It is also generally agreed that exposure should be reduced in working areas where the personnel *heat load* is above normal. A 10mW/cm² per one-tenth-hour average level has been adopted by several U.S. government agencies, including the Occupational Safety and Health Administration (OSHA), as the standard protection guide for employee work environments. An even stricter standard is recommended by the American National Standards Institute (ANSI), which advises a 1.0mW/cm² per one-tenth-hour average level exposure between 30Hz and 300MHz as the standard employee protection guide (ANSI C95.1-1982).

RF energy must be contained properly by shielding and transmission lines. All input and output RF connections, cables, flanges and gaskets must be RF-leakproof. Never operate a power tube without a properly matched RF energy absorbing load attached. Never look into or expose any part of the body to an antenna or open RF-generating tube, circuit or RF transmission system while it is energized. At regular intervals and after servicing, monitor the RF system for radiation leakage.

• Avoid contact with beryllium oxide (BeO) ceramic dust or fumes. BeO ceramic material is often used as a thermal link to carry heat from a tube or transistor to the heat sink. Do not perform any operation on any BeO ceramic that might produce dust or fumes, such as grinding, grit blasting or acid cleaning. Beryllium oxide dust and fumes are highly toxic, and breathing them can result in serious injury or death. BeO

TREATMENT OF ELECTRICAL SHOCK

1. IF VICTIM IS NOT RESPONSIVE, FOLLOW THE A-B-Cs OF BASIC LIFE SUPPORT.



2. IF VICTIM IS RESPONSIVE, KEEP HIM WARM AND QUIET, LOOSEN CLOTHING AND PLACE IN RECLINING POSITION.
PLACE VICTIM FLAT ON HIS BACK ON A HARD SURFACE
CALL FOR MEDICAL ASSISTANCE AS SOON AS POSSIBLE

Figure 16. *Basic first aid treatment for electrical shock.*

ceramics must be disposed of only in a manner prescribed by the device manufacturer.

• Avoid contact with hot surfaces within the transmitter. The anode portion of most power tubes is air-cooled. The external surface normally operates at a high temperature (up to 250°C). Other portions of the tube, especially the cathode insulator and the cathode/heater surfaces, also may reach high temperatures. All hot surfaces may remain hot for an extended time after the tube is shut off. To prevent serious burns, avoid bodily contact with these surfaces both during tube operation and for a reasonable cool-down period afterward.

First aid

Be familiar with first-aid treatment for electrical shock and burns. Always keep a first-aid kit on hand at the transmitter site. Figure 16 illustrates the basic treatment for electrical shock victims. Copy the information and post it at the transmitter site. Or, better yet, obtain more detailed information from your local American Heart Association or Red Cross chapter. Personalized instruction on first aid is usually available locally.

Treatment of burns

Extensively burned and broken skin:

• Cover affected area with a clean sheet or cloth.

• Do not break blisters, remove tissue, remove adhered particles of clothing, or apply salve or ointment.

• Treat victim for shock as required.

• Arrange for transportation to a hospital as quickly as possible.

• If arms or legs are affected, keep them elevated.

If medical help will not be available within an hour and the victim is conscious and not vomiting, make a weak

Apirolio	Dykanol	Non-Flammable Liquid
Abestol	EEC-18	Phenoclor
Askarel	Elemex	Pydraul
Aroclor B	Eucarel	Pyralene
Chlorextol	Fenclor	Pyranol
Chlophen	Hyvol	Pyroclor
Chlorinol	Inclor	Sal-T-Kuhl
Clorphon	Inerteen	Santothern FR
Diaclor	Kanechlor	Santovac 1 & 2
DK	No-Flamol	Solvol
		Therminal

Table 2. *Some of the trade names under which PCBs were marketed.*

solution of salt and soda. Use one level teaspoon of salt and one-half level teaspoon of baking soda to each quart of water (neither hot or cold). Allow the victim to sip about four ounces (one-half glass) over a period of 15 minutes. Discontinue intake of fluid if vomiting occurs. Do not allow alcohol consumption.

Less severe burns (first- and second-degree):

- Apply cool (not ice-cold) compress, using the cleanest available cloth article.
- Do not break blisters, remove tissue, remove adhered particles of clothing, or apply salve or ointment.
- Apply clean dry dressing if necessary.
- Treat victim for shock as required.
- Arrange for transportation to a hospital as quickly as possible.
- If arms or legs are affected, keep them elevated.

PCB dangers

Polychlorinated biphenyls (PCBs) were used as a dielectric fluid in most pre-1980 radio and TV transmitter oil-filled power transformers and high-voltage capacitors. The health dangers associated with PCBs led to a ban on the production and use of the chemical. The Environmental Protection Agency (EPA) has established strict regulations regarding the use and disposal (if necessary) of electrical components containing PCBs.

Many products containing PCBs were marketed under various trade names, as detailed in Table 2. A large number of PCB power transformers and capacitors are still in use, and the safe operation and disposal of such components is the sole responsibility of the owner. Failure to follow applicable rules is unlawful and leaves the owner subject to criminal prosecution. The owner of equipment containing PCBs is responsible for adherence to the EPA rules regardless of whether the owner is familiar with the regulations. A PCB cleanup could cost hundreds of thousands of dollars.

The EPA regulations are outlined in a government publication titled *40 CFR Part 761.* If your transmitter contains components that use PCBs, contact the government printing office and order a copy of the rules. The regulations cover four major areas of concern:

- *Marking of PCB components:* Each PCB transformer and capacitor must be labeled with a warning sticker that complies with EPA rules.
- *Inspection and documentation:* Logs must be kept to identify all devices that contain PCBs (including spare parts) and the condition of those parts.
- *Disposal of PCB components:* Disposal must be done only through a disposal company that is licensed to handle PCBs. A transmitter cannot be disposed of with its associated PCB capacitors and transformers still inside. They must be removed and disposed of by an authorized agent. General Electric Company is licensed in many cities to take title and remove PCBs, as well as to clean up spills.
- *Reporting requirements:* The owners of PCB transformers are required to register the components with their local fire departments.

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Comprehensive preventive maintenance

Don't just react to problems. Anticipate them.

The operating costs over the lifetime of a transmission installation can be significantly impacted by the effectiveness of the preventive maintenance program designed and implemented by the engineering staff. When dealing with a *critical-system unit* such as a broadcast transmitter, maintenance can have a major impact—either positive or negative—on downtime and bottom-line profitability of the facility.

Because of the requirement for maximum uptime and top performance, establish a *comprehensive preventive maintenance* (CPM) program that includes a systematic consideration of transmission system functions and the failure modes possible for each piece of equipment in the RF chain. Apply priority-based consideration of reliability and economics to identify the applicable and appropriate preventive maintenance tasks to be performed.

Put simply and into everyday language, CPM involves a realistic assessment of the vulnerable sections or components within the system, and a cause-and-effect analysis of the consequences of component failure. Basic to this analysis is the importance of keeping the system up and running at all times. In the most critical application of CPM—a station with no standby transmitter—anticipation of future problems and the establishment of contingency plans to deal with them is a necessity.

Obvious applications of CPM analysis include the stocking of critical spare parts used in stages of the transmitter exposed to high temperatures and/or voltages, or the installation of transient protection equipment at the ac input point of the transmitter. Remember, as identified previously, the sections of a transmitter most vulnerable to failure are those exposed to the outside world.

The primary goals of any CPM program are to prevent equipment deterioration and/or failure and to detect impending failures. There are, logically, three broad categories into which preventive maintenance work can be classified:

- *Time-directed,* in which tasks are performed based upon a timetable established by the system manufacturer or user.
- *Condition-directed,* in which a maintenance function is undertaken because of feedback from the equipment itself (such as declining power output from a PA tube).
- *Failure-directed,* in which maintenance is performed first, to return the system to operation and second, to prevent future failures through the addition of protection devices or component upgrades recommended by the maker.

Regardless of whether you describe such work as CPM or just plain common sense, the result is the same. Preventive maintenance is a requirement for reliability. In broadcasting, you have nothing else to sell but your air signal. And when you're off the air, you're dead in the water.

Training for personnel

Major broadcast equipment manufacturers this author has talked with over the years have expressed concern at the lack of technical expertise (or even good common sense) of an alarming number of engineers in the field. Too many radio and TV station managers—in an effort to protect their bottom-line incomes—have skimped on equipment maintenance salaries, supplies and test equipment. The laws of physics eventually catch up with everyone, however, and stations that have not paid their maintenance dues will reap an expensive harvest.

The complexity of the equipment in the industry is continually increasing, and this hardware requires competent technical personnel to keep it running. The need for well-trained engineers has never been greater.

Proper maintenance procedures are vital to the top performance required of broadcast stations in today's marketplace. A comprehensive maintenance program can prevent transmission equipment failures that impact productivity, station image and advertising revenue. In broadcasting, good maintenance is good business.

Acknowledgments: The author wishes to thank the following individuals who helped in the preparation of this report:

- Gil Housewright, Mark Fryer and Jeffrey Steinkamp of Broadcast Electronics, Quincy, IL.
- Dave May, Terry Bonkowski and Joe DeAngelo of Harris Broadcast, Quincy, IL.
- Dave Chenoweth, Ken Branton and Steve Claterbaugh of Continental Electronics, Dallas.
- Andrew Whiteside of Comark Communications, Southwick, MA.
- William Orr, Eimac/Varian, San Carlos, CA.
- Information on the dangers of PCBs courtesy of the NAB, Washington, DC.

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Video monitor setup

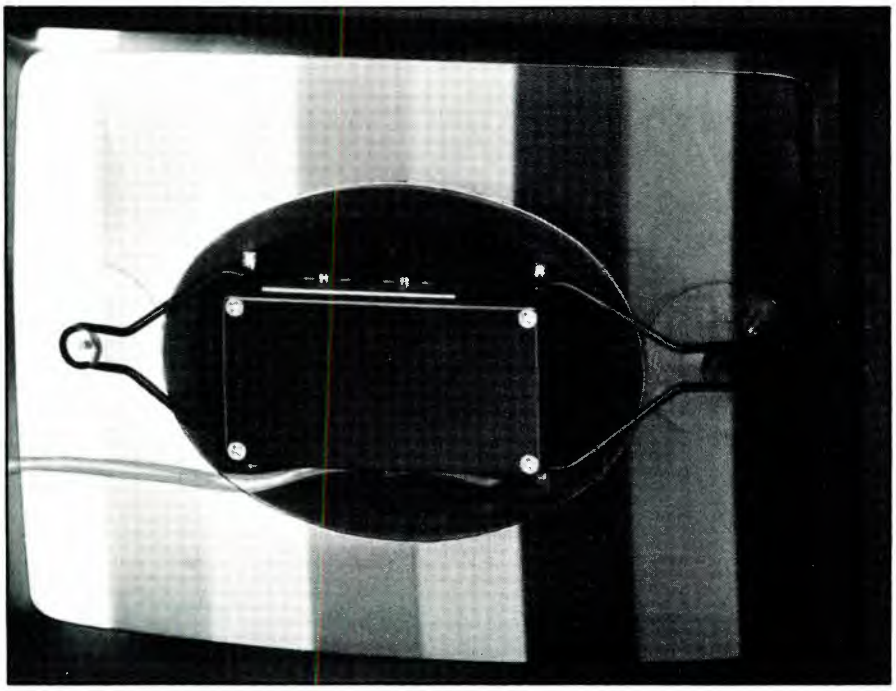
By Joseph J. Kane Jr.

If the monitor settings and levels aren't quite right, the perfect color picture will probably elude you. Capture it through analysis.

The NTSC TV system moniker of *never twice the same color* can be traced, to a great extent, to the lack of properly calibrated color picture monitors. It is impossible to have good color without first being able to display a good black-and-white picture on a color monitor. The difficulty of setting gray scale and proper levels for black and white has caused many inconsistencies in video displays. Still, for many years, picture quality judgments have been made by people who are looking at improperly calibrated monitors.

The first major solution to this problem was an optical comparator, used in conjunction with a light meter. Color temperature was set by matching the white to the reference in the optical comparator, then using the light meter to set the final white or contrast level. Such a time-consuming operation was rarely used for daily monitor calibration.

Professional, broadcast-quality monitors are not perfect devices. Minor variations exist in electronics driving the picture tube and in the picture tube (CRT) itself, variations that won't be corrected in the near future. In the electronics, for example, the composite signal decoders do not always produce the same red, green and blue signals from a given input signal. In the CRT, the light output is not always consistent in color or intensity over the entire tube display surface. These differences make absolute matching of monitors difficult.



The sensor head attaches to the CRT faceplate with suction cups.

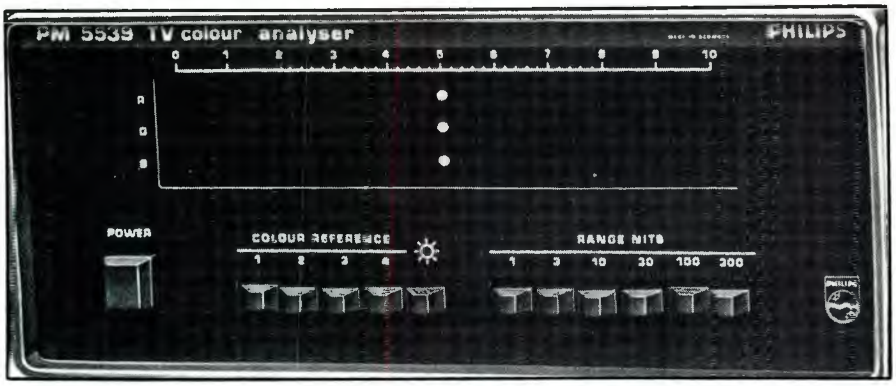
Although the perfect broadcast monitor is a long way off, manufacturers have been successful in reducing the variations, and are standardizing some of the specifications. In addition, test instruments are now available to make monitor setup easier. One such device is the color analyzer.

The color analyzer is used to measure light—red, green and blue—in units of NITs (candela/m²). (The NIT is the metric equivalent of the English footlambert, where 1fL = 3.42NIT and is the luminance in terms of $1/\pi$ candelas per square foot.) The instrument provides a means for the operator to know precisely how much red, green and blue light is emitted from the CRT for a given input signal. The part that an analyzer can play in monitor calibration prompts this discussion.

Preconditions

The monitor must be operating for at least half an hour before any calibration adjustments are made. A test pattern of color black or another low-luminance level video signal should be applied to the video input. Video information that is constantly changing, such as typical program material, is the best source. (It is unwise to leave a high-intensity video signal, such as color bars, on a monitor for a prolonged period of time. The image may eventually burn the phosphor.)

Kane is Western region sales manager for Philips Test and Measuring Instruments.



An LED display indicates RGB illumination levels detected by the sensor.

A number of initial conditions must be met before routine monitor calibration can be started. These include checking and adjusting purity, initial setup of the screen controls for CRT cutoff, convergence, vertical and horizontal linearity, picture size and centering. With those adjustments set, the monitor should be ready for an initial or periodic setup.

The first parameter to be set on a regular basis is the gray scale, a consistent color temperature from black to white. Most TV systems throughout the world have now standardized 6,500° Kelvin as the color temperature. After a 6,500° gray scale is established, other parameters that must be set are black level, white level, color and phase. A color analyzer can assist in black level and white level adjustments, but not necessarily with color or phase.

The color analyzer is a standards-transfer device. Different design concepts have resulted in one type with factory-preset values for one or more selectable color temperatures. The second type can learn what standard is displayed by a given CRT or set of similar CRTs. The units typically have working ranges from less than 3,000°K to more than 9,000°K to accommodate most CRTs and different setup requirements. Consider a monitor for a critical viewing room environment. The analyzer will need to be taught where 6,500°K is on the CRT.

Establishing white D

Apply a 70IRE to 100IRE window test pattern to the monitor video input and bring a reference white D comparator to the center of the window pattern. The aim is to get a single point in the brightness scale of the CRT at white D (6,500°K). From this, the analyzer will know how much red, green and blue is needed for the CRT to produce the proper color temperature.

Using the monitor contrast control, match the intensity of the window pattern to the brightness level of the reference source. Change the CRT gain controls (also called white or drive level) and the contrast to match both the intensity and color of the CRT white to the white D reference. Your monitor may have only two of the three color controls available.

When the two match, white D has been established for a single point in the gray scale. This information can teach the color analyzer how much red, green and blue are necessary to repeat a particular color temperature setting. Do not make any additional changes to the monitor controls until the analyzer has been calibrated for the current monitor setting.

Teaching the analyzer

With a point on the gray scale established, place the sensor head of the color analyzer on the CRT. Adjust the

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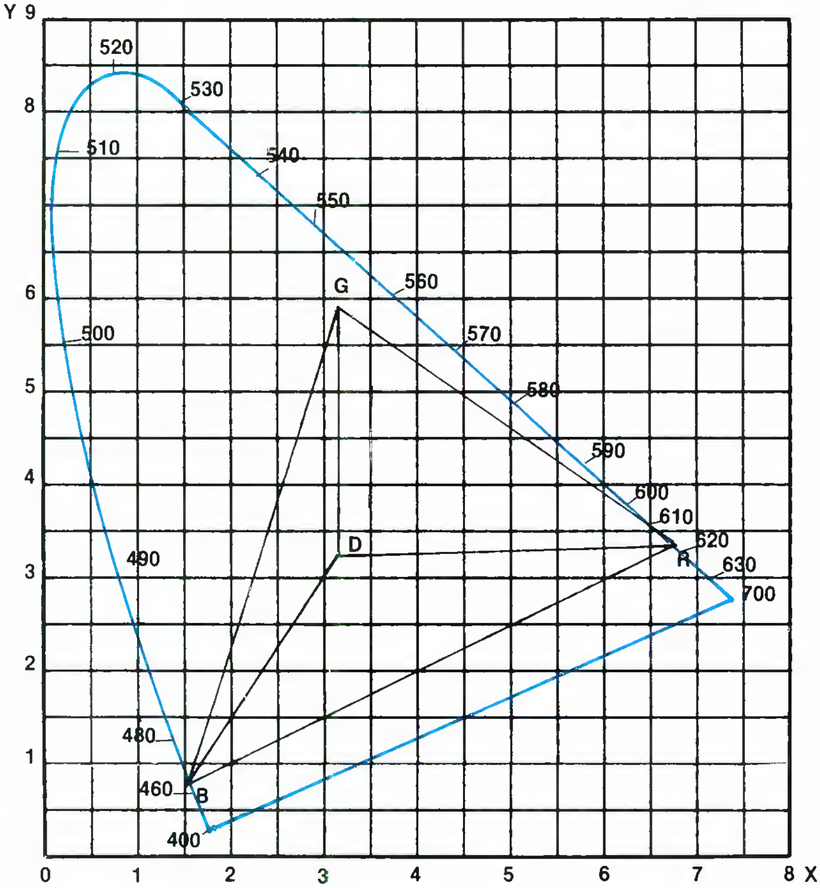


Figure 1. *On a CIE X–Y color diagram, points R, G and B represent the saturation and wavelength of the three primary colors. D is the standard illuminant reference white 6,500 K.*

analyzer range or sensitivity controls—first the green channel, then red and blue—to bring the LED front-panel meters on scale. For analyzers with a memory capability, select one of the reference memories for this and other monitors with the same phosphor to be set to the same color temperature.

Adjust the analyzer red and blue gain for the selected reference memory until the LEDs for red and blue on the front panel match the green LED position. The dots should line up vertically.

If you vary the contrast control on the monitor, the dots should move. You may need to readjust the red and blue gain controls slightly to make the dots exactly track the green for a jump in one LED space. When tracking is established, you know proper color temperature for the specific phosphor has been achieved whenever the three LED dots line up.

Setting gray scale

The dark end of the gray scale is set with the red, green and blue screen (bias) monitor controls. For the brighter high end, the gain or drive controls are used. Ideally, the high end of the scale will be set at a light intensity of about 30fL or 100NIT (a reading of 0.32 on the 300NIT scale).

A video signal level just above black is needed to set the low end. You can use a 10IRE or 20IRE window or color black

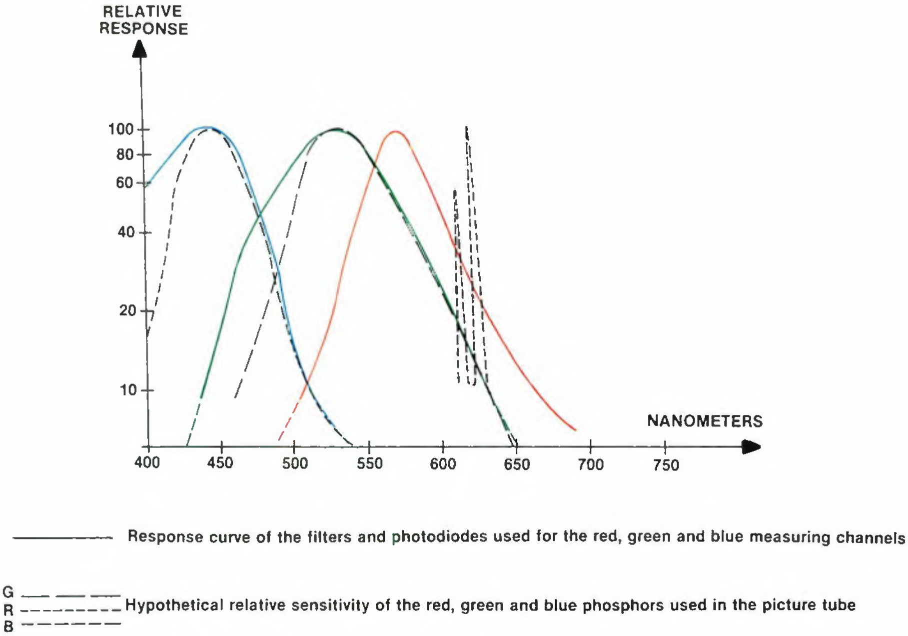


Figure 2. *Emission spectra of the three primary CRT phosphors are compared with corresponding filter characteristics.*

input signal with the brightness control (black level) advanced slightly. The brightness control will affect the white level as well as the black. Both levels are properly set once a satisfactory gray scale is established.

It is necessary to use a 100IRE window pattern at the high end (not a 100IRE flat field) to be sure the high-voltage power supply is operating in a linear area of its power output capability. A 100IRE flat field may cause the picture to bloom (non-linear operation of high voltage) or clip (protective clamping mode). Even when using a window pattern, it is wise to keep peak white-intensity levels at 100NIT or just slightly above. Remaining within that range will ensure that the gray scale is set within the linear operating characteristics of most monitors.

Attach the color analyzer sensor head to the center of the monitor screen with the suction cups provided. (If the suction cups fail to adhere, it is time to clean both the CRT faceplate and the cups.)

Set the analyzer to a 1NIT sensitivity level and connect a 10IRE window or color black signal. Advance the brightness slightly to bring the analyzer meter dots on scale. Now adjust the red, blue and green screens (for low lights) to make the dots line up vertically. If the dots are initially far apart, try to average the distance as you line them up.

With a 100IRE window pattern applied to the monitor, change the intensity of the CRT to about 100NIT with the contrast control. Then use the CRT gain controls to bring the dots into alignment around the 0.32 position of the 300NIT scale.

It may be necessary to alternate between the 10IRE and 100IRE signals several times to arrive at an acceptable gray scale because of the interaction between screen and gain controls. For those monitors that have only the blue and green gain controls, the indicating positions of the three colors can be shifted on the instrument intensity scale by adjusting the monitor contrast.

Establishing levels

Set the black level with the brightness control, using a full-field PLUGE (picture line-up generating equipment) pattern or the PLUGE in the lower right-hand portion of SMPTE color bars. The PLUGE is a video pattern containing an area just slightly blacker than black by 4%, or 7.5IRE units; and just slightly above black by 4%.

Adjust the brightness until the blacker-than-black and standard black areas appear at the same level. The 4% higher area will still appear lighter than black.

Set the peak white level with the monitor contrast control to 100NIT (0.32 on the 300NIT scale) while displaying a 100IRE window pattern. This establishes peak white at about 30fL.

If you want to take the subjectivity out of adjusting black once it is established, measure and record the value of a 10IRE to 20IRE window or flat field pattern with the color analyzer after the initial setting of the brightness and contrast controls. The light level measured is where the brightness control should be set when the same 10IRE to 20IRE pattern is applied.

Accurate repeatability of the test patterns is critical to monitor setup. This modification to positioning of the black level gives you metered settings for both black and white levels. Accurate measurement of the incoming video signal levels can be made with a video-level meter.

Set the chroma gain (color) and phase (hue) monitor controls with the SMPTE color-bar pattern and the monitor's blue-only feature. When the two controls are properly adjusted, the four blue bars display equal intensity. The two outside bars are most affected by the chroma gain, while the two inside bars are most affected by the phase control. There is interaction between the two controls, so it will probably be necessary to adjust each more than once.

Check the results of these adjustments by using a 5- or 10-step gray-scale pattern for color temperature tracking. Connect a good video source for luminance level and color adjustments.

Potential problem areas

Monitors should always be adjusted for the display mode in which they are most often used. In other words, adjust the black-to-white gray scale with the monitor in the color mode. The monochrome mode may give a slightly different color temperature, because the decoder used in the color mode has been bypassed. Test patterns should have burst on them to make sure the color decoder is not being bypassed. If the monitor is a combination composite and component monitor, set the gray scale in the mode most often used.

The 100NIT peak white setting used in this procedure is for a low ambient light environment. If room lighting around the monitor is bright, higher black and white levels will be necessary.

If the purity of the monitor is less than perfect, the gray scale will appear to be inconsistent over the screen. Gray-scale tracking, in absolute terms, should be measured at one point in the screen, preferably at the center. It is measured by changing the intensity of the window pattern and watching the levels of the R, G and B channels of the color analyzer. The three channels should always equal one another with the dots lined up vertically for each level of the window pattern.

Additional equipment

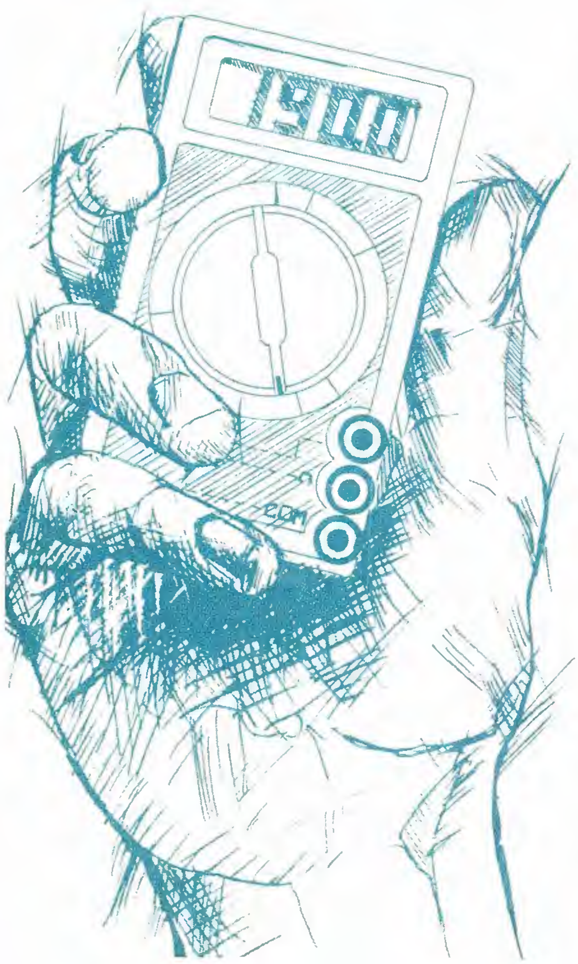
Proper monitor setup requires a source of accurate test patterns. The video input facilities of the monitors to be tested must determine whether composite or component pattern-generator equipment is required. A video-level meter is desirable as well, to achieve accuracy when a variable uncalibrated signal source, such as the output of a video production switcher, is used.

Although the procedure that has been outlined may seem a bit complicated at first, it becomes easy with practice. After the analyzer has been taught the gray scale for each type of CRT in use, the adjustment time is greatly reduced. It will be time well spent, however, because the resulting improvement in the color pictures displayed in the studio (and at home) will be noticed by your directors and your commercial clients.

Choosing a digital multimeter

By Patrick Chu

If you're buying a DMM—or any other general-purpose test equipment—approach it by applying a tried-and-true decision-making method.



Specifying and buying diagnostic tools such as digital multimeters (DMMs) are major concerns for the broadcast engineer. You need to know that you've picked the right tool for the job—at a cost that is justified by your station's specific service needs.

When you make these buying decisions, apply a formal decision process to develop buying strategies for DMMs and other general-purpose measuring instruments.

Decision strategy

Among the various DMMs, broad categories include: low-cost (mostly imports, $40 to $100); professional ($100 to $300); and heavy-duty or *ruggedized* ($150 to $300). Within these categories, and even among a single manufacturer's offerings, there can be a wide variety of features and performance specifications.

A main goal, of course, is to find the product that does the job at the lowest cost. If you consider price alone, you might end up with a DMM that's low cost, but it might be useless in some applications. Avoid the pitfall of considering this essential service tool only in terms of purchase price. If you don't match your choice carefully to your requirements, the meter might not perform needed functions, might not give accurate readings, might not operate under conditions that you consider normal and could even be a safety hazard in some uses.

In such situations, the unexpected costs could far outweigh the initial higher cost of a better product. If a DMM doesn't do the job or fails in the field, you could waste time and then have to repair or replace the meter.

On the other hand, however, there's no point in spending extra money for features that are not essential for your specific applications.

You can minimize these risks by analyzing your needs and making a thorough evaluation of the alternatives. The following decision model will help you look at the situation objectively.

Decision model

The process or model for decision-making is shown in Figure 1. The core of the model is a sequence of seven steps:

1. State your need as a desired outcome.
2. Define the application and scope.
3. Identify requirements and write specifications.

Chu is product manager for Beckman Industrial Corporation, Brea, CA.

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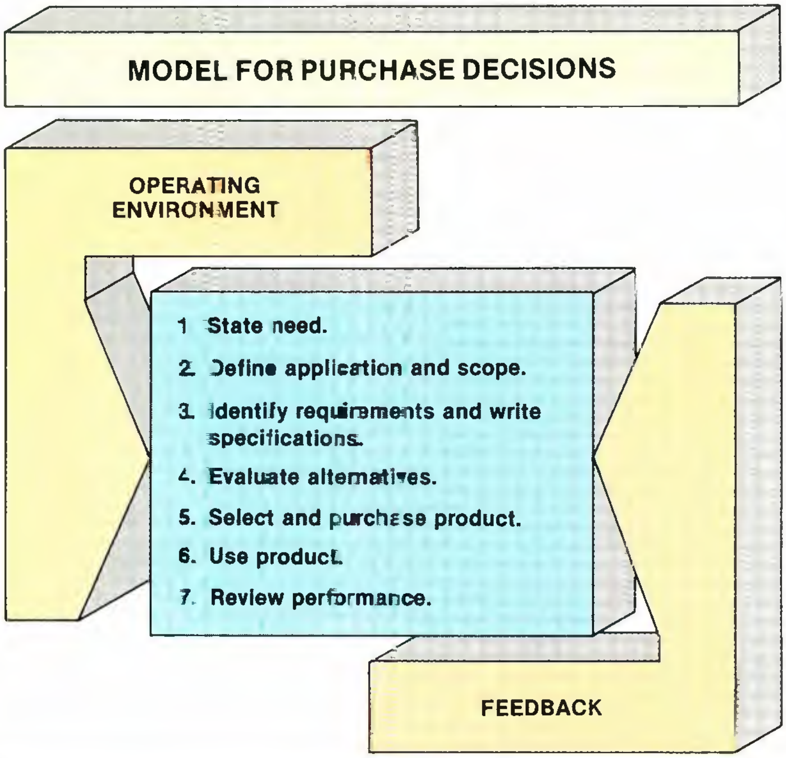


Figure 1. *The basic model for purchase decisions can be used for almost any general-purpose test equipment. The iterative process permits an effective selection of the appropriate test instrument for a particular task.*

4. Identify and evaluate alternatives.
5. Make a purchase decision and procure the product.
6. Put it to use.
7. Review the results.

Note that two arrows feed into the set of steps in the decision process. These arrows represent factors that can influence your decision:

- feedback and
- operating environment.

Feedback loops are caused by intermediate results that trigger re-evaluation of a prior step and another cycle of the decision process. Also, your own situation will affect the process at each step. Examples of how these factors might affect your decision are included in the following description.

Need statement

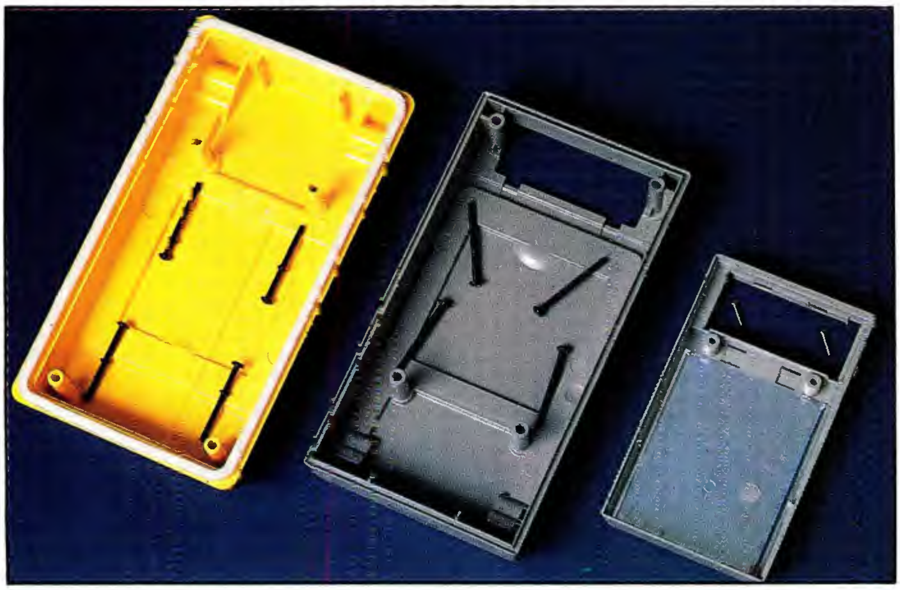
In the first step, you state your needs in terms of a desired outcome, or intended result, such as:

The station will be equipped for preliminary troubleshooting of electrical and electronic component failures in microcomputers, video monitors, VTRs, VCRs, printers, modems and transmitters.

This concise statement will shape your thinking from the outset. Your evaluation decision might be completely different if you state your needs some other way, emphasizing another aspect.

Even though you want to be as precise as possible, being able to state your needs doesn't mean that you must have all the answers before you start. The process model helps you derive the answers because it is iterative, or can be performed repeatedly until satisfactory results are achieved. That's the function of the feedback arrow on the right of the model diagram. At any point, if you reach a conclusion that doesn't fit your

(Photo above, left) Note the difference in size and mechanical ruggedness of the heavy-duty DMM (left), the professional DMM (center) and the low-cost DMM at the right.



(Photo at left) The major factor in mechanical protection is case design, including the number of internal ribs, the thickness of the material and the number of screws holding the case together. For protection from contaminants such as water, a gasket is needed, as shown in white on the yellow heavy-duty meter.

requirements, you can back up, change your assumptions and repeat the process.

The first time through, for example, you can identify your *ideal* requirements and extend them to actual costs. If the results exceed your budget, you can make a second pass, focusing on requirements that are essential, such as safety in measuring high-voltage power circuits or exceptional accuracy.

The arrow on the left side of the diagram shows that conclusions at each step will be affected by the way your station does business. If you don't take this into consideration, your decision might be fine—for someone else.

Application and scope

Based on your need statement, this step involves identifying the service procedures in the application. You also will want to think about the scope of your decision, including short- or long-term goals and purchase quantities.

Let's continue with the example of needing to troubleshoot microcomputer-based equipment in the field. A review of the troubleshooting procedures might produce the following list:

- test power supply for function and output;
- measure surface temperature of boards and IC;
- look for shorts and leaks;
- check for presence of digital signals at outputs or on the data bus; and
- test control circuit signals.

For each of these tests, you should be able to identify specific measurements. For each type of measurement, you can determine the range and accuracy required. This information is fed to the next step, in which you develop a set of requirements and specifications for your purchase.

Requirements and specifications

For DMMs, your application requirements can be defined in terms of measurement functions and desired test capabilities. (See Figure 2, page 112.)

In this step, the specific types of tests that you've identified are matched with specific DMM functions. Most DMMs, for example, measure Vac, Vdc, Aac, Adc and ohms. Many of these meters also will perform continuity and diode tests. These basic functions will be found on DMMs in all price ranges, although some models might not include all of them.

Specific functions, which might be found on a few DMM models, include true rms, temperature, frequency, capacitance, conductance, transistor gain (hFE), decibels (dB) and logic.

DMM options and individual cost items correspond to some of these functions. For temperature measurements, special thermocouple test probes must be used. Some high-voltage measurements require special probes. Logic probes are special-purpose devices, and should be considered separately from the DMM. Frequency functions on hand-held DMMs are needed mainly in the field for preliminary requirements, because a bench-located frequency counter is typically used to perform more detailed tests in the shop.

Surveys of DMM users indicate that the following factors are among the most important:

- *Size.* Each engineer has an opinion on DMM size. Some low-cost DMMs are exceptionally compact, about the size of small calculators, and are well suited for shirt pockets or briefcases. Professional and heavy-duty DMMs, on the other hand, tend to be larger because of the thicker plastic materials and case designs needed to protect internal electronics.

Some of the larger units have two parts: the meter itself and a protective plastic holder. This holder adds to the physical bulk of the meter. Some of the heavy-duty DMMs, however, are relatively compact.

- *Ease of use.* Both reliability and convenience may be enhanced if the DMM has a single rotary switch for selecting functions and ranges. The rotary switch makes it possible to turn the meter on and to select the desired function and range in a single action. By contrast, DMMs that use push-button selectors

may require three steps: Turn the meter on, select ac or dc measurement and select function and range.

Another consideration is the readability of the meter's display. Two important factors are the size of the digits and how well they contrast with the background of the LCD. Large digits against a contrasted background make it possible to read the display from different angles. This is especially important when you're working in cramped spaces or under adverse lighting conditions.

You should determine whether the meter comes with convenience features such as tilt bail, anti-skid pads on the back of the case, or a spare fuse inside.

• *Protection.* Types of protection needed in some DMM applications include mechanical, environmental and electrical.

Mechanical protection. This requirement relates to the meter's impact resistance, or its capability to withstand dropping or vibrating. Some ruggedized DMMs are guaranteed to withstand a 10-foot drop to a concrete surface.

Mechanical protection is largely a matter of case design and the thickness of the plastic housing. The thickness and the degree of protection provided varies even within the offerings of a single manufacturer. Other factors that determine the degree of mechanical protection provided are the number of internal ribs that support the various parts of the case and the number of screws that are used to hold together the case and the internal modules. The greater the number of rib supports and screws, the more durable, or rugged, the meter will be.

A stringent guideline in this area is MIL-T-28800 for Style A, Class 2 instruments. This military specification sets standards for resistance of test instruments to mechanical shock and vibration. Some heavy-duty DMMs meet this specification.

Other mechanical protection features include shock-mounting of the LCD and recessing the glass faceplate of the display below the surface of the meter's face. To prevent damage, the rotary function switch also should be recessed.

Environmental protection. Meters that must hold up under routine field use should be sealed against external contaminants such as dirt and dust and also should resist penetration by moisture, flammable gases and liquids. This protection can be provided by using gaskets at case seals and O-rings at case openings, such as input jacks. Also, fewer case openings minimize the number of places where contaminants might get inside.

Another environmental hazard that can affect a DMM's accuracy is radio frequency interference (RFI). Any engineer who has tried to use an inexpensive DMM at a transmitter site knows how serious this problem can be. Inside the case, RFI shielding for meter electronics may be necessary, both to shield the DMM from interference from high-RF levels and to prevent RFI generated by the DMM from causing disturbances in external circuits.

If you plan on using the DMM at your transmitter site, try to obtain a demo unit and see if it works in high-RF fields. This test might save you a lot of grief later when you discover that your new meter is producing inaccurate results because of RFI. In general, demanding requirements for environmental protection point to the need for a heavy-duty DMM.

Electrical protection. Protection against electrical overload is important for the safety of the operator, as well as to prevent damage to the DMM itself. This is a point for careful consideration, because such protection often is sacrificed in low-cost models.

Professional and heavy-duty DMMs often use metal oxide varistors (MOVs) as protection devices against static discharge. An MOV goes into low-impedance conducting state if the voltage exceeds a certain value. In a DMM, the MOV is put directly across the input leads, usually in a series with a resistor. The MOV typically conducts at about 1,700V, clamping the voltage transient and protecting the meter, as well as the user.

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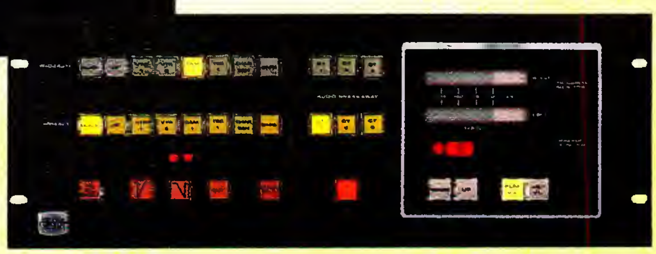

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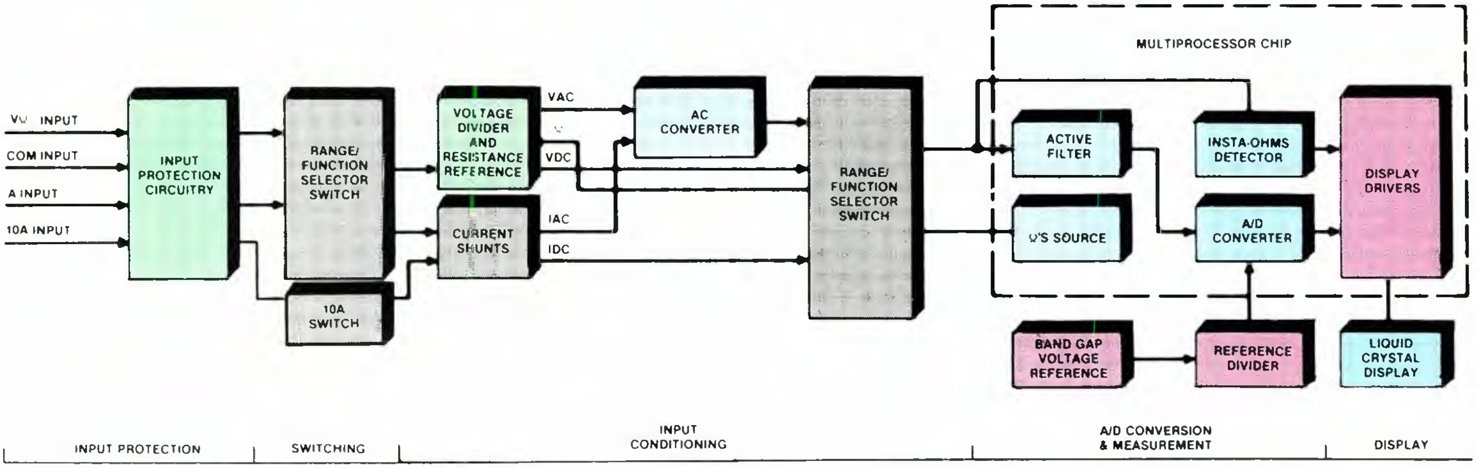
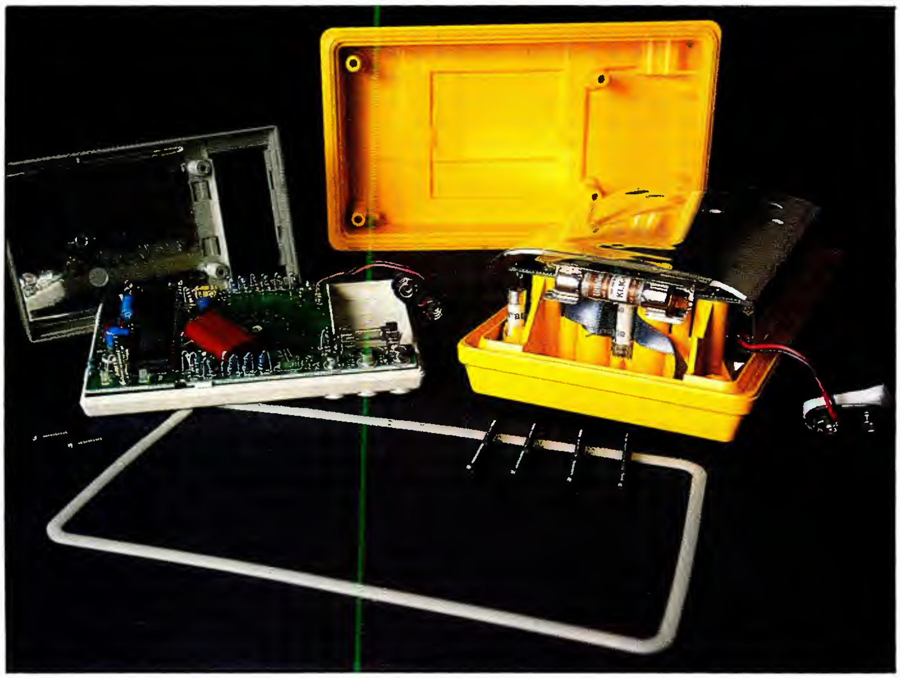


Figure 2. *A simplified block diagram of a typical DMM.*



The heavy-duty meter, shown on the right, provides both RFI shielding and padding for the meter's circuit board.

Most DMMs have a fuse to protect the meter's current ranges. The fuse is placed in series with the probes. The higher its current rating, the higher the fused rating of the meter. Fuses should also be capable of withstanding high voltages when blown, so the protection is provided throughout any overload.

Most DMMs have fused 2A ranges. Some heavy-duty DMMs are fused even in the 10A range. Meters without a fused 10A range rely on the current ratings of their electronic components, which might help to protect the operator but won't prevent damage to the meter itself. A stringent specification for a ruggedized DMM would be a fused rating of 15A/600V in the 10A range.

Higher-quality DMMs have cases that are made of self-extinguishing plastic. A relevant spec for fire-retardant plastic is UL 94V.

Other electrical protection considerations include the maximum allowable voltage in resistance mode and maximum overvoltage protection. Probes should have recesses and sleeves to prevent fingers from slipping and accidentally touching any conductors. For the same reason, input jacks should be recessed into the case.

- *Performance.* Factors that affect DMM performance in specific applications include resolution, accuracy and bandwidth.

Resolution. The resolution of the DMM is determined by the number of digits in the display and the number of ranges available within each function. DMMs that display four digits are said to have *3½-digit displays*, because the first (leftmost) digit is either 0 or 1. Similarly, higher-priced DMMs that show five digits have *4½-digit displays.*

DMM measurement functions are subdivided into ranges. The range selected determines the position of the decimal point in the display and the interpretation of the reading. The more ranges that are provided for each function, the more precise the measurement.

Accuracy. Closely related to resolution is the DMM's overall accuracy. Specifications for accuracy usually are expressed as a percentage of the reading, plus or minus a number of digits.

Another factor that affects the DMM's accuracy is the sampling method used for measuring ac voltage. Low-cost models typically use an averaging method, which is less accurate than a true root-mean-square (rms) formula. True rms measurements are needed when working with switching power supplies, SCR- or TRIAC-controlled power supplies or distorted signals.

Bandwidth. Another DMM performance specification is bandwidth, or the frequency range within which readings can be sensed. Costlier DMMs have bandwidths of 10kHz, perhaps even 40kHz. Low-cost models generally have bandwidths of 500Hz to 1kHz. Responsiveness to high-frequency signals often is needed in microprocessor-based and video applications.

Once you've identified all requirements and specifications, you're ready to look at specific DMM models.

Identify and evaluate alternatives

You are now ready to begin the *shopping* phase of the process. As you gather data on different products, you might compile the specifications in a comparison chart.

You can evaluate the choices by comparing their costs and benefits. Tech-

Note the difference in meter protection. The heavy-duty meter has both a 10A and 2A fuse, while the smaller meter has only a 0.8A fuse.

niques for performing such evaluations include rating each alternative against a checklist of ideal requirements, assigning and tabulating point scores for requirements met by each product, or actually testing product samples in the lab or in the field.

Another advantage of actually obtaining a sample of the product is to get a feel for its quality and reliability. Look closely at the graphics. Are they well protected, or might they be rubbed away or scratched off easily? Open the case. Is the PCB paper-based and/or phenolic or glass-based? Are switch contacts gold? Is the PCB soldering clean?

It is not uncommon to find that no single product meets all your requirements. It's also not unusual to discover that a product that meets all stated requirements will strain your equipment budget. Feedback loops from this evaluation step carry results back to your definition of requirements, causing another cycle of decision steps.

Purchase decision

In making your selection, remember that the alternative with the highest rating or lowest cost isn't necessarily the most favorable. If an alternative has a high overall rating but does not meet a critical requirement, such as overload protection or durability, it's probably a poor choice. That's why it's important to make a distinction between *ideal* and *must-have* requirements. For example, the extra cost of a 4½-digit display might not be justified unless you require up to four decimal places in the reading. (In the 2V range, the least significant digit would represent tenths of a millivolt, or 1/10,000V.)

Use the product

Use the meter on the job to determine whether your selection meets the needs that you outlined in the first step and the requirements that you have identified for the application.

Review the results

Evaluation of results comes after the equipment has been in use for at least one year. Your ideas about basic tradeoffs will be confirmed or disproved in practice. For example, your decision might have been to buy a low-cost DMM on the assumption that it would be less costly over the long term to replace a broken unit than to repair it. In practice, there is a precise breakeven point at which higher-priced, repairable units become more economical.

The DMM is becoming a common instrument both for field and station maintenance. Modern DMMs are capable of many advanced functions including analog-type displays. With the wide range of options available, the DMM can probably handle your most demanding troubleshooting tasks—at a cost that fits into the engineering department budget.

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Future features

In today's test-equipment market, hand-held DMMs have largely replaced conventional volt-ohm meters (VOMs) as general-purpose measurement devices. Reasons include increased performance, convenience and reliability at modest cost, the benefits of all-solid-state microprocessor technology and digital sampling techniques.

Remarkable enhancements may be seen in the following areas:

Input protection

Fuses probably will become physically smaller, with higher voltage ratings, providing increased safety and meter reliability. Fuses will increasingly be incorporated on all current ranges, especially in heavy-duty industrial models.

A valuable feature that is found in some of today's more sophisticated DMMs is the metal oxide varistor (MOV), which protects against high-voltage electrostatic transients, often up to 6,000V. Formerly, this protection was provided by a spark gap, which can be a hazard, especially if the meter contains a low-cost exposed-type spark gap and the meter is used in the presence of explosive gas or dust. The trend in MOVs will be to still-higher voltage protection.

Switching

The trend is likely to be toward electronic switching, thereby reducing mechanical switch movements and the number of contacts. Microprocessor-controlled switching will permit autoranging, in which the user selects a function and the meter selects the appropriate range upon sensing the input. Elimination of mechanical switch contacts also designs out some of the potential sources of DMM failure, such as corrosion, dirt and wear of contacts. Where it is impractical to eliminate mechanical switching, contacts will be gold-plated and will have a wiping action to minimize impurities.

Also, watch for DMM switches to be replaced with a keypad-style switch similar to that used on pocket calculators. Switch types include conductive rubber pads and bubble-type switches sealed in vinyl.

A/D conversion and measurement

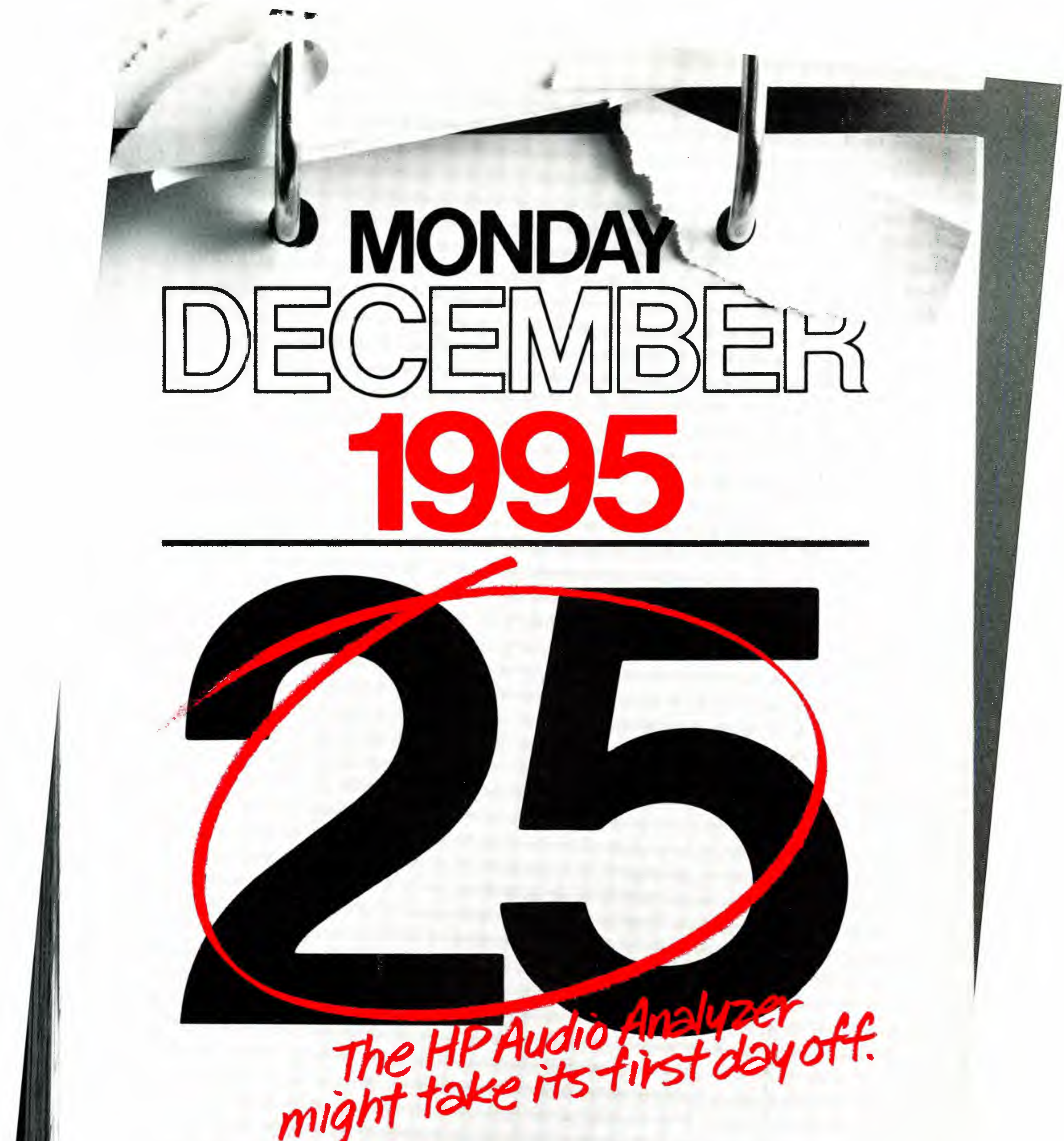
CMOS chip technology has produced microprocessors with low current drain, greatly improving battery life. In 1979, custom LSI microprocessor chips were first introduced into professional and heavy-duty DMMs. This technology extended battery life to 2,000 hours.

DMM designers predict a trend toward more custom chips. Silicon-foundry technology will make relatively low production runs feasible. The result will be more proprietary designs to suit specific needs. Product differentiation is likely to increase, as will the diversity of offerings. In short, users will have more choices.

Display

The changes in chip technology also will increase the flexibility of display formats. Some existing DMM designs handle analog-to-digital (A/D) conversion, measurement and display control all within the same chip. Future DMM designs may separate these functions between at least two chips, one for A/D conversion and one for meter operation and display control. Having a separate chip for display control means that meters can be customized further. The number of available display formats may increase, with features tailored more closely to specific applications. Users may be able to control output formats through soft-touch buttons.

An extra display feature on some DMMs is a bar graph that supplements the numeric reading. This simulates d'Arsonval needle (analog) movement and provides for quick visual checks. With new display-controller chips, bar-graph graduations will become finer, permitting more accurate representation. Other features may include user-selectable temperature readings in degrees Fahrenheit or Celsius; decibel measurement; relative readings and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LCD (liquid-crystal display) technology also is changing. The use of LCD devices in DMM displays was a major advance that replaced light-emitting diodes (LEDs). LCDs using CMOS technology require less current and promote longer battery life, but there is room for improvement. Display formation depends on the liquid-crystal flow, which becomes impaired at temperature extremes. Cold-weather exposure causes extremely slow display performance. At temperatures below freezing, the liquid ceases to flow and produces no reading. Hot environments also must be avoided. Tomorrow's DMMs should be capable of producing readings even after being subjected to freezing weather or to the heat of the sun for extended periods.

Flexible materials may replace the glass that is currently used for the face of the display. These materials have already appeared on some pocket calculators. On a DMM, this will mean enhanced durability, greater safety and reduced size. DMMs also will have luminescent displays. Illuminated displays today depend on lighting or backlighting with conventional bulbs that can rapidly drain the battery. In the future, the displays will glow.

Display readouts today are available in 3½ digits (1 to 1,999 counts) or 4½ digits (1 to 19,999 counts). Providing the extra counts requires more expensive electronics. Low-cost alternatives in the future will increase the range of the first count to 3½-digit displays. Options should include 1 to 2,499, -2,999 or -3,999 counts.

Batteries to casings

New lithium batteries will soon be introduced. The toxicity of lithium has been a barrier to this technology, but recent advances protect the user against exposure to the chemical if the battery becomes damaged. Lithium batteries could power DMMs for more than twice the life of conventional alkaline batteries.

Some DMMs, especially the autorange types, put out 3V to 4V in resistance mode. This voltage is sufficient to switch on diodes in the circuit under test, perhaps causing malfunction or accidental system activation. Future DMM circuits will overcome this problem by incorporating more complex processing logic.

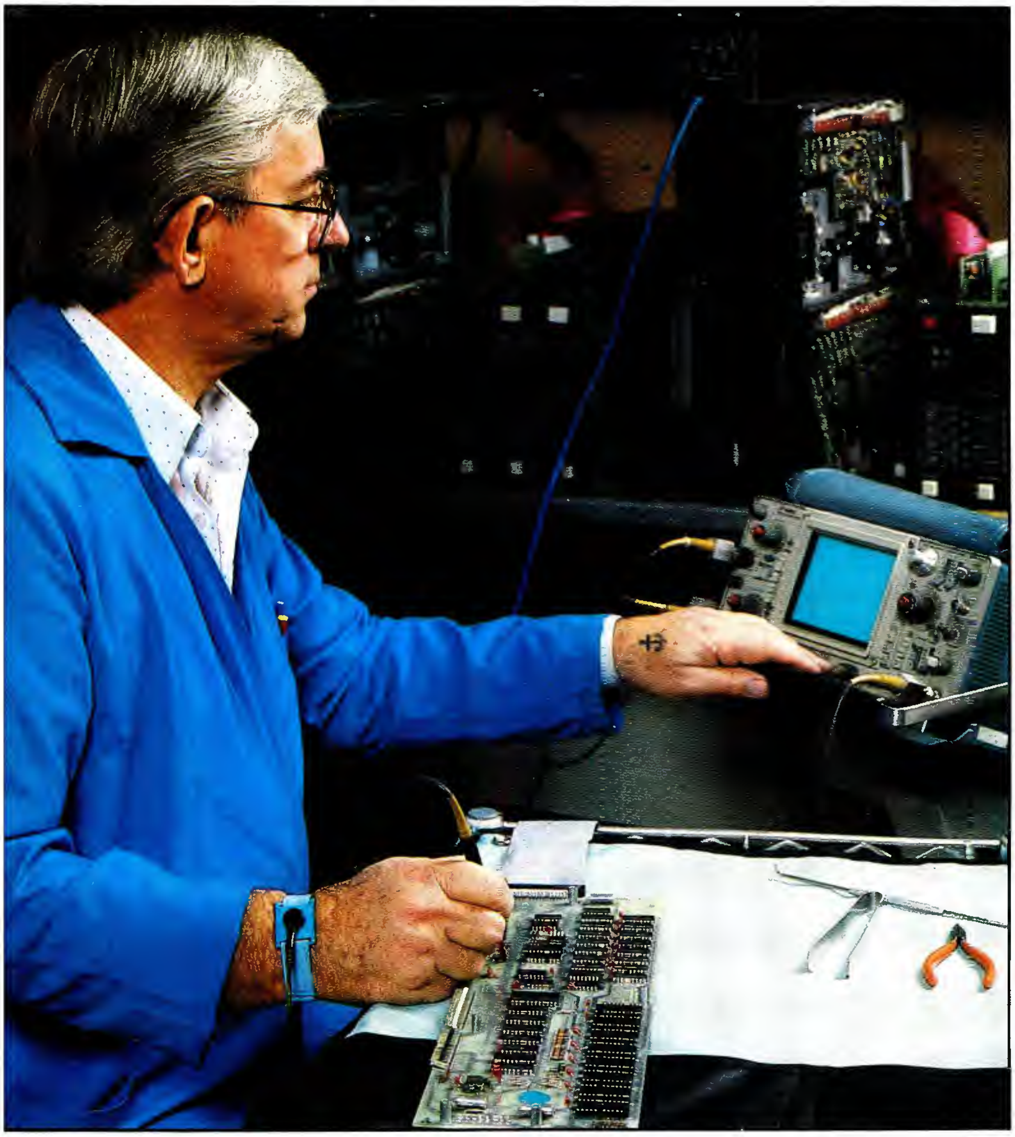
New plastics promise to enhance the durability of DMM casing materials. These plastics offer better resistance to solvents and physical impact. Cases made of these materials should hold their shape even at relatively high temperatures—if a DMM were set on the dashboard of a car on a hot summer day, for example.

The prospects for the future of DMMs include enhanced convenience, durability and reliability. Users will have a greater number of product choices, including many models that are tailored to specific applications.

Getting a handle on ESD

By Jess Kanarek

Electrostatic discharge is a problem technicians face every day.



Repair of the sophisticated microprocessor-based equipment in use at broadcast stations today requires careful control of ESD potentials.

Stop! Don't touch that chip.

Integrated circuits are incredible devices that perform wonders. They are also, however, highly sensitive to damage from electrostatic discharge (ESD) overvoltages. This problem is becoming a serious concern to broadcast engineers as the complexity of the equipment used in radio and TV stations steadily increases. ESD is a problem that will not go away.

Scope of the problem

Engineers have known for a long time that static electricity poses a threat to microprocessors. Those who service products using microprocessors have learned basic procedures for protecting against damage caused by electrostatic discharge (ESD).

However, through the years more functions have been compressed into small microprocessor chips. This increase in efficiency has come at the cost of two trade-offs:

- The built-in switches that equalize static electricity potentials have been reduced in relation to the total size of the circuit, while the speeds of the circuits have increased. As a result, the *protective* switches are no longer able to provide adequate protection.
- In order to access all the added functions, lead diameters and spacing between leads have been reduced. These circuits cannot handle static transients as high as before.

Leads have been reduced from 5μ of a few years ago to today's 1.5μ and less. Spacing between leads has been reduced by a factor of three or four. In the past the ESD peril was to semiconductor

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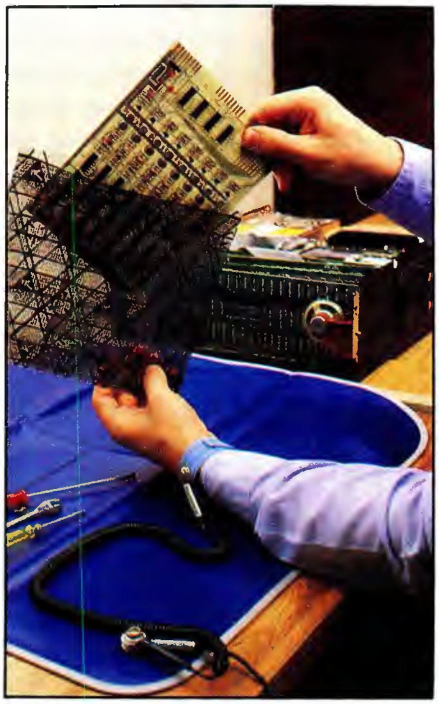

This technician's work station is equipped with a field service kit, grounding mat and grid bag. The technician wears a grounded wrist strap when working with static-sensitive devices.

substrates, but in today's devices the metallization itself is subject to damage.

The coming 1-megabit chips are called *submicron devices* because the conductor widths will be only 0.9μ in diameter, in order to provide access to all functions, with a similar reduction in spacing between leads.

These circuits will be more than five times as sensitive to static-electricity damage as the devices in use today.

Minimizing ESD damage

Easy-to-use, relatively low-cost anti-static materials and products are being developed to meet the needs of this new generation of devices. If ESD damage is to be avoided, however, engineers must upgrade their anti-static procedures. To establish a starting point, refer to the following list of basic anti-static precautions commonly used:

- Don't touch an individual lead, pin or trace while handling a static-sensitive semiconductor device. Hold the chips only by the plastic body.
- Keep static-sensitive parts in their original containers until ready for use. Bags, tubes or boxes provide anti-static protection.
- Drain static electricity from your body by touching a conductive, grounded surface such as a metal rack before handling or working on a chip.
- Do not slide static-sensitive devices over any surface.
- Practice good housekeeping in the work area. Remove all non-conductors such as cardboard boxes, paper work orders, blueprints and cigarette and candy packages.

MEANS OF STATIC GENERATION	ELECTROSTATIC VOLTAGES 10% TO 20% RELATIVE HUMIDITY	65% TO 90% RELATIVE HUMIDITY
WALKING ACROSS CARPET	35,000	1,500
WALKING OVER VINYL FLOOR	12,000	250
WORKER AT BENCH	6,000	100
VINYL ENVELOPES FOR WORK INSTRUCTIONS	7,000	600
COMMON POLY BAG PICKED UP FROM BENCH	20,000	1,200
WORK CHAIR PADDED WITH POLYURETHANE FOAM	18,000	1,500

Table 1. *The magnitude of electrostatic voltages that can be generated by everyday activities. The higher the relative humidity, the lower the voltage generated.*

- Wear a smock made of cotton, which generates considerably less static electricity than manmade fabrics. Gloves, if used, should also be cotton. Anti-static smocks are now available.
- Keep visitors away from static-sensitive devices.
- Have a portable conductive surface on the work area, which is grounded. Never use carpeting.

Basic improvements are necessary on four levels to meet the static-electricity challenges of the *submicron* era.

ESD and the engineer

Normal movements can generate up to 50,000V, and less than 100V can ruin some devices. A conductive wrist strap is a standard anti-static device. It drains electricity from the wrist—the last feasible point between the body and the work where harmful potentials can build up.

One new wrist strap, designed to meet the needs of the submicron era, is made of conductive elastic polyester fabric with an adjustable buckle to assure a snug fit even after extended use. Stainless steel threads woven into the elastic fabric assure positive, low-resistance conductivity, provide resistance to corrosion and foster cleanliness.

A 10-foot conductive cord links the wearer's wrist to a grounded surface. Any static electricity is conducted to ground before it can accumulate to harmful levels.

To meet OSHA and other requirements for safety, the outside of the wrist attachment is insulated and a 1MΩ resistor is molded into the cord at the wrist end (in case the cord crosses an open electrical line).

Other personal items are static-safe

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OBJECT OR PROCESS	MATERIAL OR ACTIVITY	
WORK SURFACES	• WAXED, PAINTED OR VARNISHED SURFACES • COMMON VINYL OR PLASTICS	
FLOORS	• SEALED CONCRETE • WAXED, FINISHED WOOD	• COMMON VINYL TILE OR SHEETING
CLOTHES	• COMMON CLEAN ROOM SMOCKS • COMMON SYNTHETIC PERSONNEL GARMENTS • VIRGIN COTTON[1]	• NON-CONDUCTIVE SHOES
CHAIRS	• FINISHED WOOD • VINYL	• FIBERGLASS
PACKAGING AND HANDLING	• COMMON PLASTIC BAGS, WRAPS, ENVELOPES • COMMON BUBBLE PACK, FOAM	• COMMON PLASTIC TRAYS, PLASTIC TOTE BOXES,VIALS, PARTS BINS
ASSEMBLY, CLEANING, TEST AND REPAIR AREAS	• SPRAY CLEANERS • COMMON PLASTIC SOLDER SUCKERS • SOLDER IRONS WITH UNDERGROUNDED TIPS • SOLVENT BRUSHES (SYNTHETIC BRISTLES) • CLEANING OR DRYING FLUID OR EVAPORATION • CRYOGENIC SPRAYS • HEAT GUNS AND BLOWERS • SAND BLASTING • ELECTROSTATIC COPIERS	• TEMPERATURE CHAMBERS

[1]Virgin cotton can be a static source at low relative humidities such as below 30%.

Table 2. *These materials, commonly found in a maintenance area, are considered to be prime sources of static electricity.*

smocks and conductive shoe grounders to drain static electricity generated from walking on floors.

ESD in the work area

The most common anti-static safeguard in the work area is the covering for the workbench and floor. Other items include non-nuclear ionizing air guns and fans.

Since the 1970s, suppliers have been able to extrude polyethylene compounded with approximately 30% carbon granules to obtain a rigid conductive material that could be used on tables and floors. The material had great strength and abrasion resistance and eliminated the need for conductive surfaces.

Some manufacturers claimed that this conducted too fast, so they introduced *anti-static* materials that were conductive on the surface. They followed by introducing *static-dissipative* materials, which dispersed the same conductive surface throughout, making them faster than anti-static but slower than *conductive* materials.

Subsequently, suppliers introduced rigid anti-static materials that could be permanently laminated onto bench and table tops. They came in decorator colors, which greatly improved the decor compared with the proliferation of black conductive, blue dissipative and pink anti-static materials.

Problems began to arise, however, when faster microcircuits were developed. First, the effectiveness of these bench tops was difficult to confirm. A test probe five pounds in weight and three inches in diameter is used for the standard test of surface conductivity. The devices that actually will come in contact with the surface, however, weigh only a few milligrams. The material could pass the test and might blow out the next microcircuit it contacted.

In addition, faster switching speeds of newer microcircuits left doubt that these materials dissipated ESD fast enough.

Surface covering materials of the future should be:

• Conductive throughout, rather than on the surface. This would eliminate degradation of anti-static performance from abrasions, and shorten the path to the grounded table top for faster EDS decay.
• Non-sloughing, for use in clean rooms.
• Testable with standard ohmmeters.
• Impossible to puncture with hot soldering irons. (This rules out the 3-layer and homogeneous soft mats introduced in the early 1980s.)
• Fireproof.
• Capable of lying flat on the surface without curling.
• Resistant in the range from 500,000Ω to 10MΩ per square, which is the optimum range needed by users.
• Capable of retaining their anti-static qualities for long periods without deteriorating.

Non-nuclear *de-ionizers,* which generate alternate flows of positively and negatively charged ions to keep them in balance, can reduce the static-electricity build-up in all work areas.

Protection during transportation

Clearly, a tote tray sliding across the bed of a pickup truck when it goes around corners will generate enough static electricity to undo careful shop work. In fact, friction of conveyor rollers or dollies in the shop is enough to ruin microprocessors in electronic subassemblies.

Static-safe shipping boxes and trays are now available. Some manufacturers encourage the return of these containers, which cost much more than ordinary corrugated boxes, and others write them off as the cost of assuring that the product is delivered safely without static-electricity damage.

Anti-static cushioning also is available to protect products from shock when they are traveling in static-safe containers, and to protect against static electricity damage when they are not. The most common packaging material is coated polyurethane foam made conductive by formulating carbon granules or other conductive additives to the plastic. The material is soft enough to be cut with scissors.

Board removal procedure

Probably the most commonly encountered type of work at a radio or TV station that poses a significant ESD hazard involves removal of a printed circuit board from a defective system. Precautions must be taken to assure that the area in and on which the service technician works is grounded, so that any static electricity that exists or is generated during board removal is drained away.

Use the following procedures when removing a circuit board:

• Unplug the system to be serviced.
• Place an ESD protective mat near the system and connect it using a ground cord terminated in an alligator clip to the system chassis.
• Wear a wrist strap that is connected to the mat. Placing the mat in series avoids the possibility of a floating ground. (Keep in mind the necessity for retaining an equal potential between the engineer

Handling tips

Years of experience in designing and implementing ESD control programs have resulted in the following list of dos and don'ts for use by any maintenance engineer:

- *Minimize handling.*
- *Keep parts in original containers until ready for use.*
- *Use ESD protective containers to handle and transport small components.*
- *Discharge static electricity before handling devices by touching a grounded metallic surface such as a rack or cabinet.*
- *Handle ICs by the body, not leads.*
- *Do not slide static-sensitive devices over any surface.*
- *Eliminate static generators (plastics, vinyl, styrofoam, etc.) in the area where you are working.*
- *When handling parts in an office, stockroom, training class or repair shop, use a static-free work station.*
- *Always touch the anti-static or ESD protective package before touching the device inside.*

and the system.) Both the mat and the wrist strap should be equipped with 1MΩ resistors to protect the technician.

- Assemble a similar static-free work station (as described previously) for inspecting and testing the circuit boards. Again, it is vitally important that the proper ESD protective packaging materials be used whenever components are in transit, so that the chain of ESD control is never broken.

Static-electric potential

High static-electric voltages can be caused by many common activities, as illustrated in Table 1. Note the effects that relative humidity has on the generation of electrostatic voltages.

The static-electric potential that exists in a shop area or machine room can be determined with a static-electricity meter. Such devices are more economical and easier to use than they were a few years ago. You can quantify the static-electricity potential of every operation and location—work station, storage shelves, service counter and shipping area—by isolating them from ground one at a time. See Table 2.

Balance this information with the static sensitivity of the chips being used. The Department of Defense has classified devices into three ranges of sensitivity and an appropriate grade of conductivity for each class. The most sensitive devices, such as metal oxide silicone (MOS) without protective circuitry, have a sensitivity range of 0V to 1,000V. These require conductive materials.

Class 2 devices have a sensitivity range of 1,000V to 4,000V, such as MOS devices with protective circuitry. Static-dissipative materials can be used for protection.

Class 3 products, such as resistor chips, have a sensitivity of 4,000V to 15,000V. Anti-static products are suitable for these devices.

The sensitivity level of a given device is available from the manufacturer. In addition, the level of conductivity selected by the chip manufacturer for shipping is generally a guide to the sensitivity of the contents: black indicates the addition of carbon, meaning it is most conductive; blue generally indicates it is static-dissipative; and pink, or anti-static, is least protective, because it offers less Faraday shielding.

The key to preventing ESD damage involves protecting sensitive devices at *every step* in the maintenance chain. Failure to adhere to proper rules for device handling will expose you and the station to serious failures that are difficult to troubleshoot, and even more difficult to explain. [BE]

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Omni 4 logic analyzer

By Gerry Kaufhold II

Look inside a typical modern videotape recorder and you'll find five functional circuit groups: power supply, mechanical subassemblies, audio circuits, video circuits and the digital control circuits. Although each section can be repaired with common test equipment, there are occasions when specialized test equipment is required.

Common circuits

The power supply can usually be analyzed adequately with a general-purpose oscilloscope, voltohm-meter and a capacitance checker. The mechanical subassemblies, such as motors, pulleys, gear linkages and rotating heads, can generally be checked for proper operation by visual inspection. The servo motors may require an oscilloscope, a torque meter or a wow-and-flutter meter. Quad tape machines also may require pressure gauges.

The audio circuits can be checked with an oscilloscope. However, there is often the need for more specialized test equipment such as frequency counters, signal generators and distortion meters.

Although a technician may be able to repair video circuits using a general-purpose scope, four pieces of specialized video test gear usually come into play: a color monitor, color-bar test pattern generator, vectorscope and a waveform monitor. Sometimes a sync generator or proc-amp also may be necessary.

Although most of the circuits mentioned can be repaired with the listed equipment, there is one class of circuits that may require specialized test equipment—digital circuits. Unlike audio and video signals, digital signals are both fast and slow. It's also necessary to view more than one signal at a time, and this

Performance at a glance

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- *Stores 1,024 bus cycles, 16 bits per cycle, per test*
- *Upgradable to monitor 36 simultaneous signals*
- *Signature analysis and instruction disassembly*
- *Disk storage of setups and test data*
- *Optional pattern generator and EPROM programmer*

Kaufhold is an engineer at KAET-TV, Tempe, AZ.

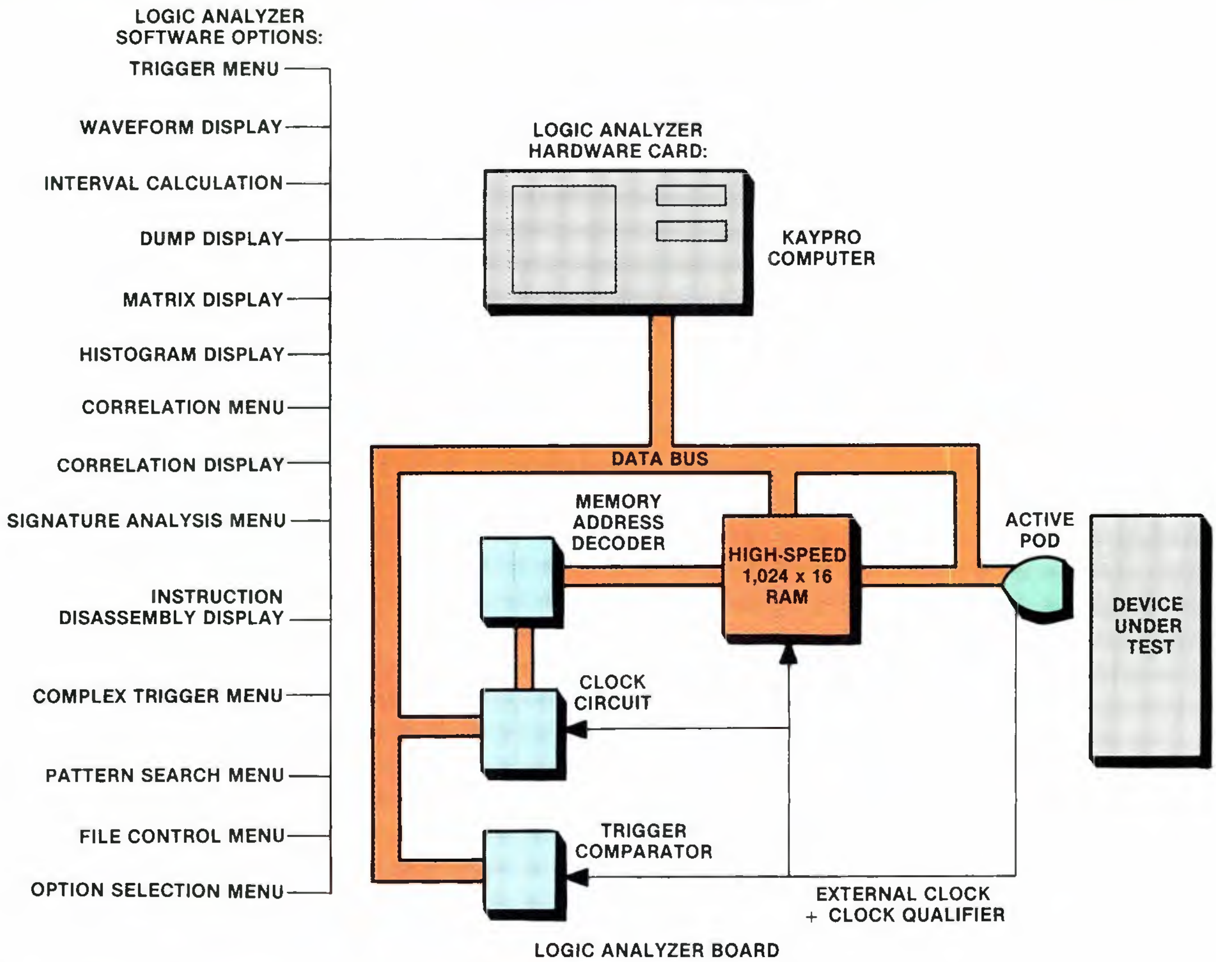

Figure 1. *Block diagram showing available menus and display options.*

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Anton/Bauer, Inc. ☐ One Controls Drive, Shelton, CT 06484 ☐ 203-929-1100 sometimes makes digital control circuits difficult to troubleshoot.

For years, the computer industry has realized the need to view multiple signals at once. It is only recently that broadcast engineers, faced with the need to repair complex equipment, have looked beyond the standard list of test equipment. One of the devices making its way into broadcast stations is the Omni 4 logic analyzer, made by OmniLogic.

The analyzer allows monitoring of numerous signal or data lines at one time. In one regard, it is much like a multichannel oscilloscope. However, the device goes far beyond what a scope could do for effective troubleshooting.

The analyzer is composed of a computer and sophisticated software that allows you to examine the internal workings of microprocessor-based equipment. Through the use of test probes, called *pods*, the device can monitor data lines to help isolate defective components.

Construction

The logic analyzer comes completely contained within a Kaypro brand 2-X portable computer. The computer contains the standard package of hardware: processor, detachable keyboard, high-resolution video display, two floppy disk drives, parallel printer interface and an internal 300-baud modem. A special logic analyzer also is added. Additional storage is provided under the disk drives for the diskettes, logic analyzer connectors and interconnecting cables. The complete assembly makes the logic analyzer portable, and it's only slightly more bulky than most portable scopes.

Software

The analyzer comes with all of the standard Kaypro software: operating system, word processor, spreadsheet, database manager and modem controller. Software manuals also are provided. Special proprietary programs are supplied to execute the analysis functions. This software is the heart of effective troubleshooting. (See Figure 1.)

The various tests are selected from a menu displayed on the CRT screen. Selection is made by pressing a single key. If you get confused or lost, the various functions are explained through a help command. By pushing "?" combined with the feature's letter, you bring up an explanation of the desired command.

Hardware

The logic analyzer board, mounted inside the computer, provides the interface circuitry and test circuits. Active circuitry is contained within the test pods, which connect to the device under test (DUT). Spring-loaded microclips provide the connections between the interface pods and the DUT. Where possible, dip clips can be attached to the DUT. The dip clips make the interconnection with the logic analyzer much easier.

The microclips use color-coded wire, which helps identify the individual leads. Even so, writing down the clip color-coding and IC pin numbers helps avoid confusion. It's not unusual to have 16 or 32 leads running around, which can lead to interconnection errors.

The interface pods use active circuitry to present a high-impedance load to the DUT. The impedance is greater than 1 MΩ combined with less than 5pF capacitance. Two pod types can be purchased. The standard pod uses TTL logic-level circuitry. A CMOS pod also is available. Most troubleshooting applications require the TTL pods.

The logic analyzer board relies on high-speed random access (RAM) chips and a programmable comparator. The comparator acts as the high-speed trigger circuit. The analyzer is capable of detecting pulse durations as short as 10ns.

The internal processor clock permits the analyzer to store the waveform timing information in 50ns increments, which is a 20MHz clock rate. The internal clock is capable of being set in a 1-2-5 sequence, much like an oscilloscope horizontal sweep rate control. The clock can be varied over a range from 50ns to 32ms. An external clock input allows the logic analyzer to store information in

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```
 CHANNELS                 F E D C B A 9 8 7 6 5 4 3 2 1 0   SIGNAL
1) ACTIVE PROBES                                0 0 0 0 0
2) ACTIVE GLITCH
 RECOG GROUPINGS         : ..Z.. : ..Y.. : ..X.. : ..W.. :
3) TRIGGER EVENT          X X X X X X X X X X X X X X X X
4) GLITCH EVENT (G)                                 X X X X

5) TRIGGER QUAL:        X           D) RECOG MODE: UNLATCHED
6) TRIGGER POINT:       512         E) RECOG FUNCTION: 6
7) OCCURRENCE #:        1              1-ZYXWG                 .........
8) DELAY:               0              2-(ZYXW) + G       :    Z = FEDC :
9) TIMEOUT:             0              3-(ZY) \ XW        :    Y = BA98 :
A) CLK QUALIFY:         X              4-(ZY) + (XW)      :    X = 7654 :
B) EXT CLOCK:           X              5-ZY(X + W)        :    W = 3210 :
C) SAMPLE RATE:         1.0ms       -> 6-EXTERNAL         (1)  .........
```

Figure 2. *Trigger menu set to display channels 0, 1, 2, 3, 4. The display will be triggered by an external pulse and the clock rate is 1ms.*

synchronization with the DUT. The external clock mode is used when performing instruction disassembly or when capturing data from externally clocked logic circuits.

A total of 1,000 16-bit samples can be captured per test. This data, along with all of the setup information, can be stored on floppy disk for later analysis. Each floppy disk can store up to 40 sets of data, including all of the appropriate setup information.

Features

When troubleshooting digital circuitry, it may be necessary to study a lot of information about the circuit under test before actually connecting the test equipment. For example, when we faced repairing a parallel-to-serial converter circuit in our transmitter, we had to review the circuit schematic and theory of operation, and then look at TTL data books to obtain pin numbers and signal names for the suspected ICs. A list of the necessary interconnections between the logic analyzer and the DUT also was made. Only then were we ready to begin running some tests.

Digital circuits use timing pulses to keep the information in sync, much like video waveforms. However, unlike video, which relies on a single sequential sync pulse, digital circuits typically have several signals all occurring at the same time. As many as 18 simultaneous signals may be used to trigger the analyzer.

The trigger setup panel, shown in Figure 2, provides 15 triggering categories, with multiple choices available within each category. When using the analyzer, you can call up onto the video display detailed explanations about each of the 15 categories by pushing the "?" key and the category number. This self-instruction feature helps you get quickly into actual circuit analysis.

Even though we had some idea about

how the circuit worked in the remote control, we first had to derive a valid trigger configuration. The data analyzer's display works in real time. Therefore, it was necessary to modify the triggering inputs until we were correctly capturing the data. The trigger setup was then stored on disk so it could be called back at any time quickly and reliably.

When the logic analyzer is properly connected and the trigger is programmed, the operator pushes "G" to begin capturing the data. As soon as the trigger occurs, and 1,000 samples have been collected, the logic analyzer displays the DUT waveforms. The *names* option permits the operator to create individual names to identify each line of data. The displayed waveforms can be printed for later examination, as shown in Figure 3. A movable cursor permits scrolling through the data. You can calculate the timing intervals between signals by using the calculate command.

The logic analyzer provides a powerful correlation feature, which can be used to locate differences between the data of a known-good unit and a faulty DUT. Tests can be performed on a working piece of equipment with the results stored on disk. Later on, if that equipment fails, the previously stored good data can be compared bit by bit with the current bad data. Any differences can then be easily spotted and analyzed to discover likely circuit failures.

Other features

The analyzer will display data in numerous forms using the option menu and the dump display. For example, data can be displayed in hexadecimal, octal, decimal or binary. (See Figure 4.) Instruction disassembly can be performed on microprocessor programs. Histograms that show the addresses being used by software also can be displayed as shown in Figure 5. Data can be searched for various patterns using the locate command.

Several broadcast equipment manufacturers are producing equipment that permits the device's microprocessor to *free run* through its address space. This hardware feature permits the owner to apply the powerful techniques of *signature analysis* to troubleshooting. The device's signature analysis feature stores up to 14 circuit signatures at once. By capturing and storing signatures from known-good equipment and then comparing these signatures with signatures from a bad board, a technician can quickly narrow down a circuit fault to a small region on the printed circuit board. The test also could be used to easily generate and store fresh signatures each time a circuit board is updated.

Continued on page 140

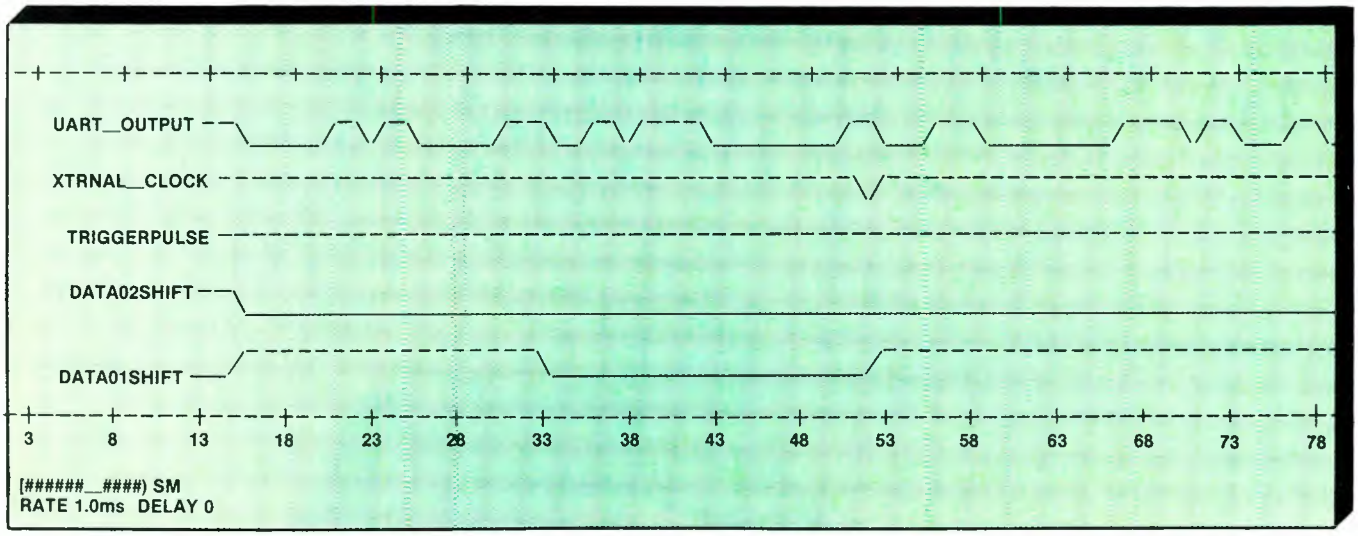

Figure 3. *Printout of waveform display with operator-programmed names for each channel.*

0111	0110	0001	0001	0111	0110	0011	0010	1100	1000	1011	1110
0111	0110	0011	0010	0111	0110	0011	0010	1100	1011	1011	1111
0111	0110	0011	0010	0111	0110	0011	0010	1101	1001	1000	0000
0111	0110	0011	0010	0111	0110	0011	0010	1110	1101	1000	0001
0111	0110	0011	0010	0111	0110	0011	0010	0100	111	1000	0010
0111	0110	0011	0010	0111	0110	0011	0010	1111	1011	0001	0011
0111	0110	0011	0010	0111	0110	0011	0010	1110	1001	0001	0100
0111	0110	0011	0010	0111	0110	0011	0010	0111	0110	0001	0010
0111	0110	0001	0010	0111	0110	0011	0110	0111	0110	0011	0011
0111	0110	0011	0010	0111	0110	0011	0010	0111	0110	0011	0011
0111	0110	0011	0010	0111	0110	0011	0010	0111	0110	0011	0011
0111	0110	0011	0010	0111	0110	0011	0010	0111	0110	0011	0011
0111	0110	0011	0010	0111	0110	1001	0010	0111	0110	0011	0011
0111	0110	0011	0010	0000	1101	1011	1000	0111	0110	0011	0011
0111	0110	0001	0010	1100	0010	1011	1001	0111	0110	0011	0011
0111	0110	0011	0010	0100	0101	1111	1010	0111	0110	0011	0011
0111	0110	0001	0010	0000	0000	1111	1011	0111	0110	0011	0011
0111	0110	0011	0010	1110	0001	1011	1100	0111	0110	0011	0011
0111	0110	0011	0010	1001	0010	1111	0000	0111	0110	0011	0011
0111	0110	0011	0010	1100	0000	1111	0001	0111	0110	0011	0011
0111	0110	0011	0010	0000	0101	1011	1101	0111	0110	0011	0011

(####__######) SM
RATE EXTERNAL DELAY 0
FIRST: – 50 LAST: 12

Figure 4. *Typical dump display of binary data.*

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THE BATTLE OF THE BANDS.

in excess of 94dB. Well within the realm of wired microphone performance.

The Sony system is also designed to withstand the rigors of live recording. Besides being lightweight, it's also extremely sturdy. Including everything from the microphones, to the body pack transmitter, to the tuners, to the shock-resistant portable cases and rack-mounting brackets.

An arsenal of equipment designed to be invaluable to you in the battle of the bands. And to be an exceptional value

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SONY
Professional Audio

in Part 74 subpart H of the FCC regulations and requires an appropriate license.

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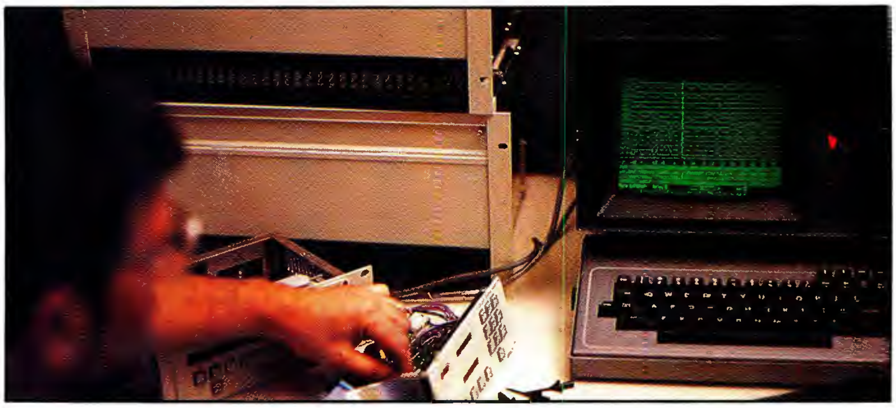
Continued from page 136

The analyzer comes complete, and no options are required to immediately begin learning about digital circuitry. A pattern-generator option is available, which can be used to provide digital patterns to exercise a circuit. An EPROM programmer also is available for those wishing to make backup copies of the EPROM used in much of today's equipment.

The analyzer's computer portion can be serviced by local Kaypro repair depots. The logic analyzer portion can be repaired by the owner or returned to the company for servicing. The logic analyzer card is mounted on the top of the computer boards and is easy to install and remove. Replacement microchips and active circuit pods also are available from the company.

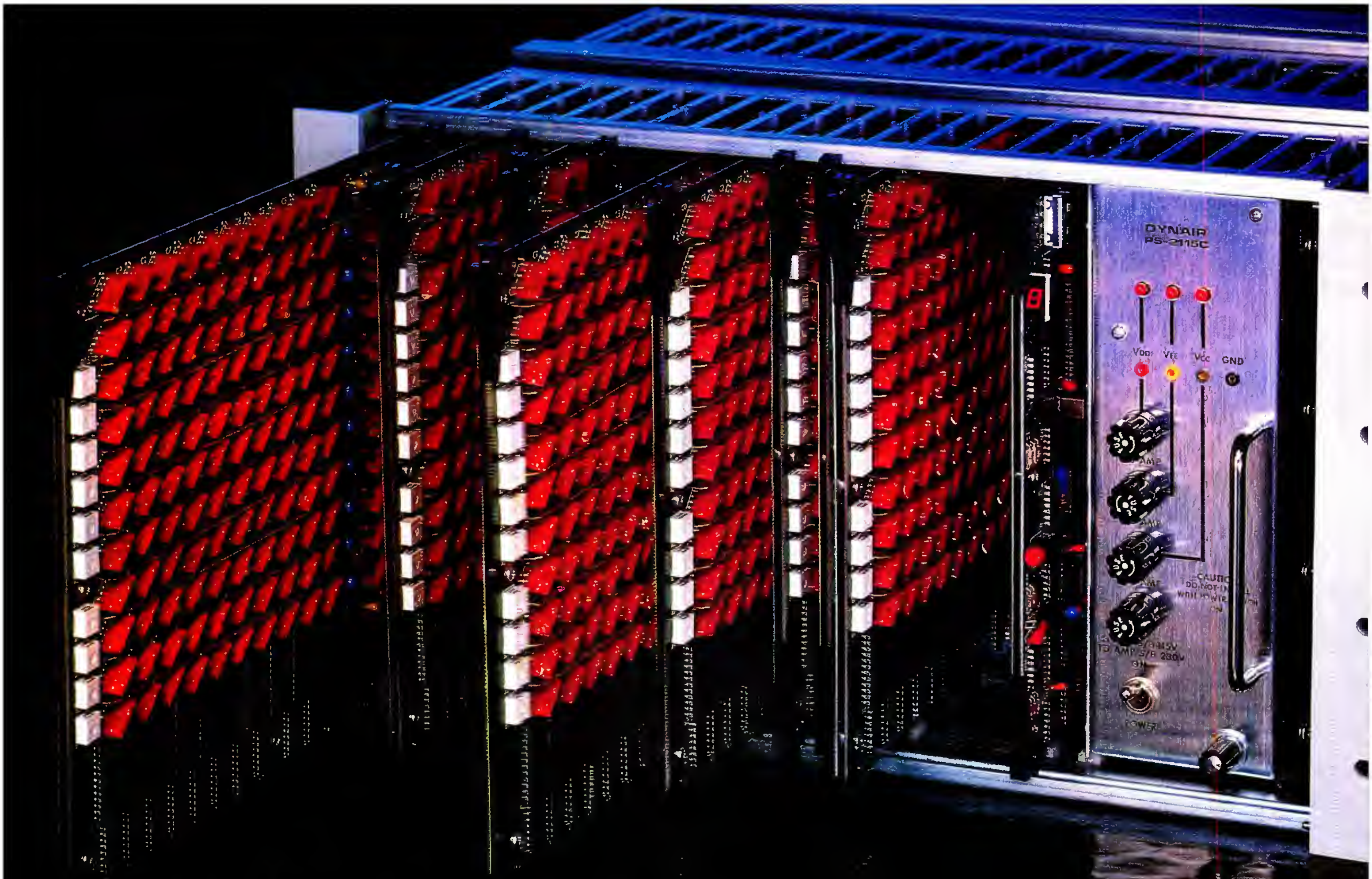
Instruction manual

The instruction manual is nearly 200 pages long. The instructions are clearly written and contain numerous illustrations. The manual is designed with edge-stripes that can be used to open the book to the appropriate heading. In addition to the detailed instructions, a quick-start chapter gets a new operator up and running within minutes. For example, our staff was able to begin capturing data from a camera microprocessor card in less than 20 minutes after receiving the logic analyzer.



Logic analyzer is shown connected to a routing switcher for troubleshooting.

The technician is performing tests with the analyzer. Note the two impedance interface pods that connect the analyzer to the equipment under test.



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1) START OF RANGE: 0 1111
2) END OF RANGE: 1 1111
3) NUMBER OF ACCUMULATIONS: 1
4) RANGE SCALING FACTOR: 5

SAMPLES	% FREQ OF LAST SAMPLE	% CUMULATIVE FREQUENCY
100 +		
40-99	47 ##########	47 ##########
20-39		
10-19		
5-9		
4		
3	7 ##	7 ##
2	45 #########	45 #########
1		

Figure 5. Histogram display showing percent of activity of circuit under test.

Operator training

Some engineers may be intimidated by the prospect of using such a device to troubleshoot their equipment. Most other troubleshooting techniques require only one or two test leads and maybe a couple of traces on a scope. The prospect of looking at eight or more scope traces or a display filled with binary or hexadecimal digits might send the engineer running to the phone for help.

However, because today's equipment is becoming so complex, different troubleshooting techniques have to be learned. These new techniques often require sophisticated test equipment. The key to repairing the new broadcast gear is to get this new generation of test equipment into the hands of maintenance engineers and give them a chance to learn how to effectively use it.

If you have ever been faced with repairing a complex microprocessor device, you have some idea of how difficult it can be. Scopes, logic probes and counters are often insufficient to effect repairs. On the other hand, if you learn how to use a logic analyzer, you can drastically cut that repair time. In some cases, repairs may be impossible without such a device. To be effective, however, the engineer needs time to become thoroughly acquainted with the equipment.

The Omni 4 logic analyzer provides troubleshooting capability not available in other devices. It's not a simple device. Modern test equipment seldom is. However, properly used, it can help you repair complex broadcast equipment.

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.

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Extending multigeneration limits

By Michael Arbuthnot

Twenty-three generations with a type C VTR? It sounds impossible (and is not necessarily recommended) for an analog machine, but it is possible. The problems of multiple analog generations stem from several factors. Understanding and controlling those factors can extend the format's capability.

Sources of degradation

Conventional wisdom holds that today's 1-inch type C videotape recorder can deliver only five to eight generations of broadcast-quality images before the signal becomes unusable. Most people believe noise is the chief cause of picture degradation.

Whenever a videotape is reproduced, noise is present. That noise becomes part of the video signal, which is rerecorded in post-production. With each playback, the image is degraded to some extent. After a number of dubbing passes, the result becomes objectionably obvious.

Some control over noise is possible. Filtering can reduce the amount of noise in the reproduced video, but to do an effective job, high-frequency filtering takes a toll on the signal components responsible for picture detail.

Other factors affect the signal-to-noise ratio, too, such as recording levels and track widths. These parameters have already undergone a good deal of optimization for the C format. Little, at present, can be done to improve on that.

Although noise has been considered a prime culprit of multigeneration degradation, other controllable factors have had a more significant impact. Accumulated errors in the setup of the VTR, TBC and other production equipment are one source. Accumulated uncorrected velocity errors are another form of degradation. Both are frequently mistaken for noise.

Setup errors

Typically, an operator adjusts the VTR for a recording while monitoring color bars. In accordance with the waveform and vector monitors, black level, white level, chroma amplitude and phase, differential gain and phase and record

currents are adjusted.

Although the setup may *look* accurate, absolute accuracy is difficult to achieve, even for the experienced operator. A slight error in a setup parameter will ad-

Figure 1. A split-screen presentation of seventh- and 23rd-generation video recorded with a VPR-3 and Zeus shows little difference in the image. The arrows indicate the line between the two signals.

versely affect the recording. What is not immediately obvious, for example, is that a 1IRE error in black level accumulates into 10IRE units of error by the 10th generation. In the same way, a 1° error in the chroma phase adjustment becomes a 10° error by the 10th generation. Other errors are similarly compounded.

Fighting fate

Dubbing degradation is a future problem. It compounds with each generation, and only becomes obvious after the damage has been done. One solution would be to see into the future, while adjusting parameters in the present. That possibility would allow reduced setup errors before they occur. But how do you see into the future?

A means to look into the future was one of the goals of Ampex design engineers. With a VPR-3 VTR and Zeus video processor, an operations menu selection called *M GEN* (multiple generations) places the machine into the insert mode. The electronics are set for playback, but armed for recording.

When the M GEN function is activated, the VTR displays 10 generations of color bars in a real time continuous loop. Starting from a first-generation recording of a color-bar signal, the operator can see the evidence of accumulated errors.

The mechanism for seeing into the future is based upon automatic scan tracking with a playback head mounted on piezoelectric material. The VTR plays a field of the original generation of a color-bar signal and passes it to the video proc-

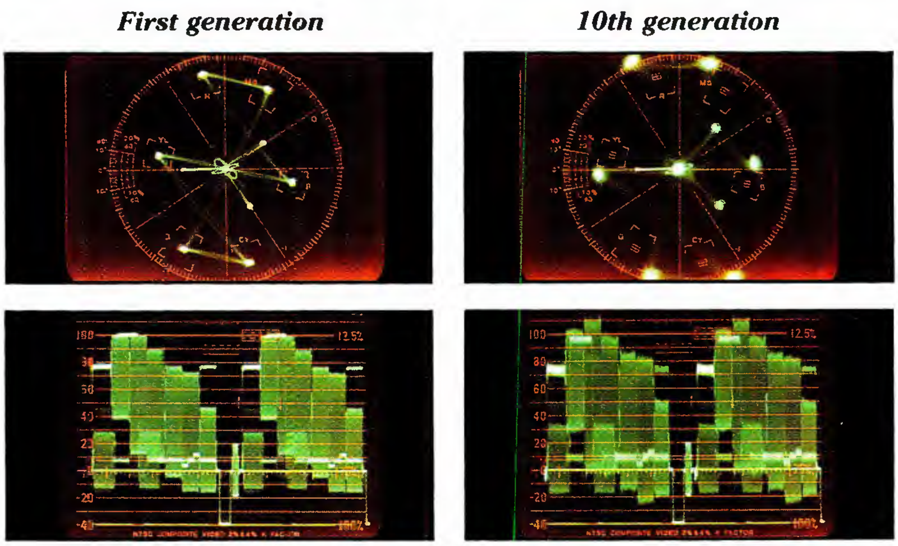

Figure 2. In a side-by-side comparison of first- and 10th-generation color bars, vector and waveform monitor displays indicate the accumulation of uncorrected errors.

Arbuthnot is product manager for the VPR-3 and Zeus video processor, Ampex AVSD, Redwood City, CA.

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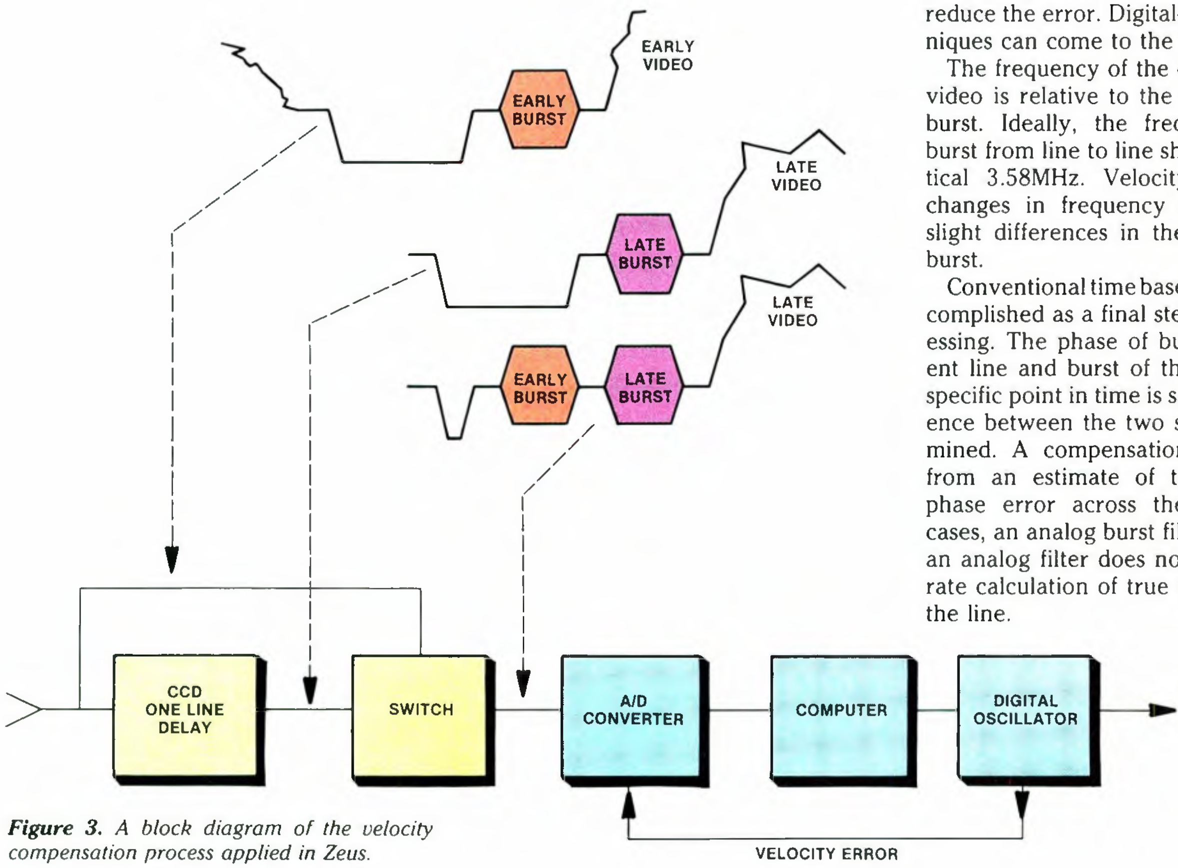


***Figure 3.** A block diagram of the velocity compensation process applied in Zeus.*

essor. The signal is routed back to the VTR and recorded again. The newly recorded track is now the playback information. This loop repeats until the 10th field.

After the 10th field, the VTR exits record mode for one field in order to read one field of the original first-generation test-bar pattern. This cycling through 10 field-by-field generations is repeated three times per second.

Beyond the VTR

With the look-ahead feature, VTR parameters can be fine-tuned for a minimum degree of variation between the first and 10th generations. These parameters include black, video and chroma levels, chroma and equalization burst phases, record current and differential gain and phase. Eliminating accumulated setup errors in the VTR is only part of the solution.

All other devices in the video signal path are equally suspect in producing errors, from the TBC and machine distribution amplifier to the routing or production switcher. Unseen setup errors in the signal path of associated production equipment eventually become obvious.

The 10-cycle sequence described for the VPR-3 and Zeus processor may be used for other studio equipment. Instead of returning directly to the VTR, the output of the processor passes through the routing switcher, for example. When the routing switcher is properly adjusted, the signal is routed through other individual units and adjustments are made for each.

Improving VEC

Eliminating setup errors alone, however, will not significantly improve multigeneration capabilities. Another pseudo-noise degradation, the result of velocity errors, also exists.

Velocity error refers to compounded slight variations in the speeds of the tape moving along its path and in the rotation of the video head scanner. The result is a variation in the way information is recorded on the tape. That is, the minute changes in the speed at which the signal is written to tape will cause minute changes in signal frequencies. During playback, a different set of variations will occur, introducing even more error.

As playback progresses, variants in speeds and frequencies introduce a shift in color. Like setup errors, velocity errors compound with each generation, the previous record and current playback errors mixing with current record errors. By the 10th generation, massive color shifts can result.

Velocity error compensation is not new and nearly every TBC provides some degree of compensation. For multiple-generation work, however, an extra degree of compensation must be used to reduce the error. Digital-processing techniques can come to the rescue.

The frequency of the color in a line of video is relative to the frequency of its burst. Ideally, the frequency of each burst from line to line should be an identical 3.58MHz. Velocity error creates changes in frequency and subsequent slight differences in the phase of each burst.

Conventional time base correction is accomplished as a final step of signal processing. The phase of burst on the present line and burst of the next line at a specific point in time is sampled. A difference between the two samples is determined. A compensation can be made from an estimate of the accumulated phase error across the line. In most cases, an analog burst filter is used. Such an analog filter does not allow an accurate calculation of true velocity error of the line.

Working in the digital domain, velocity compensation can be accomplished at the beginning of processing. A line of input video is routed to a 1-line delay holding area. As the following line is received, burst from the new line is gated into the delayed line, yielding a line with two bursts.

After the A/D conversion, 32 samples taken from each of the two bursts are compared. The error is a precise measurement of the phase difference between the present and future bursts. The difference controls a digital oscillator used for the A/D clocking process. Because the oscillator frequency now includes the same error as the line of video being converted to a digital stream, the error is removed during digitization. Subsequent processing will deal only with velocity error-free data.

Combining two worlds

There has been speculation that the type C format must yield to digital-recording systems when more than a few generations of material are necessary for post-production. Noise will still exist, but in the absence of setup and velocity error, its effect is far less apparent.

Through digital and digitally controlled processing, an increase in type C generations by a factor of two can be achieved without significantly increasing signal degradation.

Enter the world of CAD PC boards

By Marvin C. Born

Many engineers have faced the problem of designing special, one-of-a-kind circuits. Constructing the device is one of the first decisions made. Most of the time, unfortunately, the circuits end up looking like a rat's nest with point-to-point connections. Although a printed circuit board design might be preferred, it is often too difficult, time-consuming or expensive for one-of-a-kind projects.

For simple projects in which the circuit is not complex, the advantages of using a printed circuit board are numerous. A PC board makes the installation and replacement of parts easier. The completed circuit also may be more reliable because of the stability provided by the PC board. Finally, a PC board is cleaner looking than point-to-point wiring. The drawback of using PC boards in typical construction projects, though, is the laborious process of making the board.

Usually, the engineer is forced to use manual paste-up methods to construct an acetate model of the desired circuit. The process is complex and time-consuming. For the inexperienced engineer, it also can be expensive because tape material is wasted in trying to develop a perfect acetate circuit drawing.

After the acetate is completed, a photographic process is required to generate a properly sized negative for exposing the circuit board. Because few stations have access to the equipment necessary to expose and develop the negatives, outside help is required.

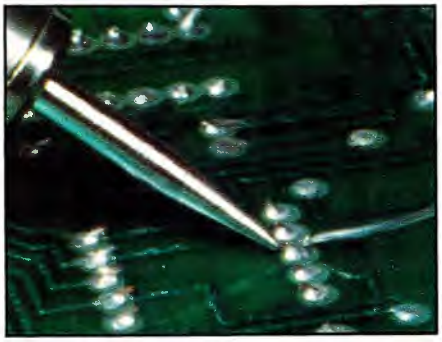
CAD approach

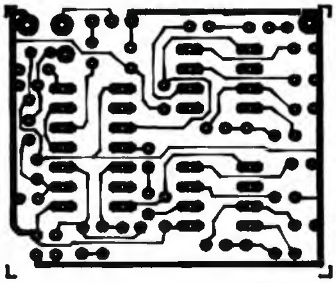
There is now a faster and more accurate method of making circuit boards. Through computer-aided design (CAD) software, a desktop personal computer, and printer or plotter, the typical radio or TV station can develop custom PC boards.

Although CAD software and hardware have been around for several years, the process generally referred to large-scale computers working on complex design problems. Until recently, CAD also meant big-buck expenses—far beyond what most stations could afford.

That has now changed. With the proliferation of personal computers, printers and plotters, several CAD packages have been developed to help solve this problem. One recently developed software package, ProDesign II, makes it possible for a station to inexpensively enter the world of CAD PC boards. The combination of CAD software and a plotter allows you to move from the schematic phase to the construction phase in a matter of hours, not days.

Born is director of engineering for KRIS-TV, Corpus Christi, TX.





The actual-size plotted output for the CAD-designed printed circuit board.

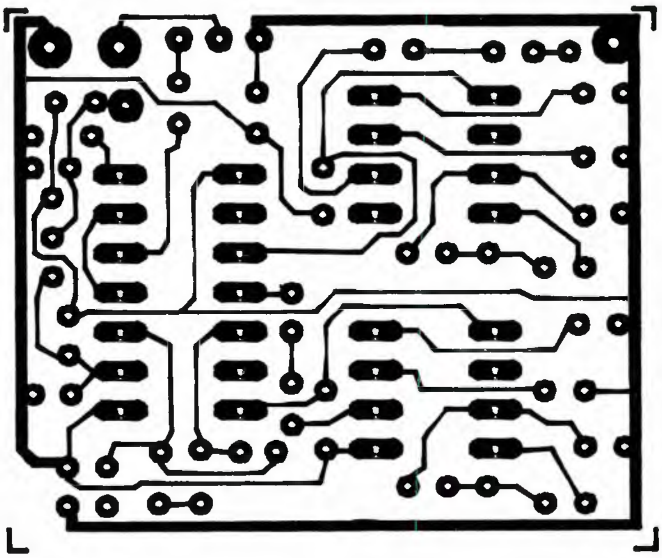
How it works

Today's small electronic components don't lend themselves to point-to-point wiring like circuits of years past. Although wire-wrap circuits are easy to construct, they are difficult to troubleshoot, sometimes unreliable and definitely not attractive. The only really reliable construction method is the PC board.

The key to successful implementation of any computer-aided design process is the user interface. With CAD software, the operator lays out the PC design on the video screen. The screen acts as a large piece of paper where the various elements can be easily located, erased or moved. Any solder pads, interconnecting wires or terminals are simply figures on the screen.

The first step to using the software is the installation. As with any program, be sure the software will work properly with your hardware. Most installation routines allow you to select from a menu of devices. The program then installs the appropriate drivers to interface the software to your specific hardware.

After the software has been installed, the next step is learning to use the program. Although it takes a while to learn to lay out any PC board, there is no wasted material with CAD. It's been my experience that an engineer can spend a lot of time and use up expensive supplies just getting the first working circuit off the drawing board. The CAD approach allows the operator to design, print and check circuits in a matter of minutes. If a



Drawings by Steve West, KRIS-TV

The enlarged (2X) plotter output demonstrates how much easier it is to troubleshoot an enlarged CAD-produced PC board before it is constructed.

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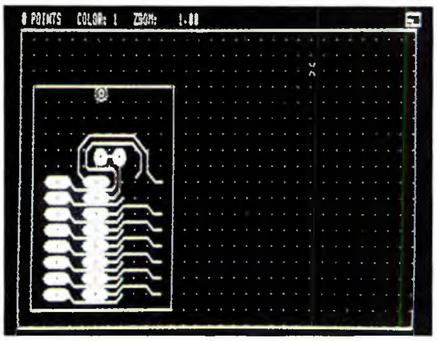
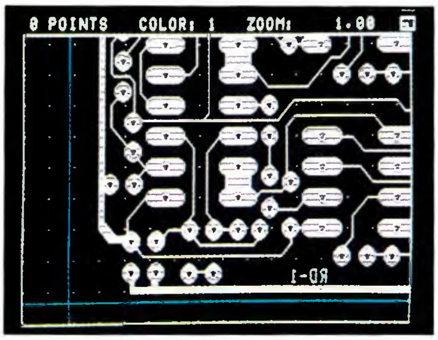
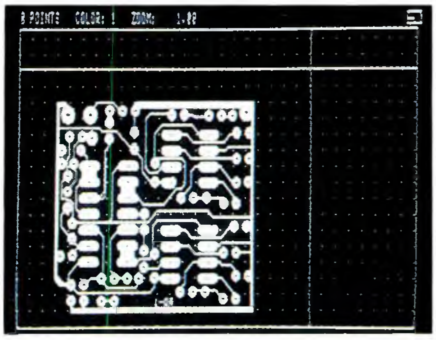


A simple 16-pin IC is shown on the CRT. The IC pads are laid down, then interconnected with lines.



Any portion of the circuit can be expanded on the CRT. This makes drawing the interconnections much easier.



A complete audio circuit displayed on the CRT. The circuit is now ready to plot.

mistake in the layout is discovered, just go back to the computer and make the necessary changes.

The program

Our program uses 1/10-inch dot spacing on the screen. When the program begins, a portion of the screen is filled with just dots. They become the reference for all of the drawing that will take place. The 1/10-inch spacing is convenient because it accommodates most of today's components. Almost any device can be mounted on 1/10-inch-spaced solder pads. Let's walk through a typical design step to see how easy it is.

First, draw a solder pad using the arc, half circle and line commands. Copy this pad again into a double pad. Repeat the process, developing four pads, each spaced 1/10-inch apart. Copy this assembly alongside the original pads, and you've constructed a circuit pad for an 8-pin dip chip. If you copy the drawing again, you get the pattern for a 16-pin dip chip.

Various sizes of transistor, resistor and capacitor pads are also easily constructed. You may need to experiment with different pad sizes to find ones that fit all of the components you'll need in your circuits. After you have designed several pad sizes, print out a copy. Because a standard plotter can be used for rough-drawing outputs, it's easy to get samples to try on the components. After you have developed the correct sizes and shapes, store them on disk. They can then be called up as necessary for your designs.

Connect the dots

After you have located all the pads in the correct places, it's time to connect the dots. One method allows you to lay down a series of points between the two pads. The computer then connects the points together, forming a single line. If the completed line does not go where you want it to, simply *undo* it. The program will then erase that one line. Replace the points where you want the line and try again. That's the beauty of CAD. If the first attempt is unsuccessful, it's easy to try again.

In order to make the interconnection process as easy as possible, most CAD programs allow you to zoom in on various parts of the circuit. By expanding a small portion of the circuit, it is much easier to develop interconnecting lines.

Most CAD programs support color monitors. This allows different types of traces and pads to be drawn in different colors. Red might be used for power lines, black for grounds and cyan for signals. The different colors help verify the accuracy of the drawing against the schematic. Of course, the plotted output is done in black.

Labeling

Commercially made boards are always labeled. This makes the board easier to troubleshoot and repair. Usually, a silk-screen process is used for labeling. However, the CAD process can do something that's almost as good.

Most of the CAD programs allow you to select from a variety of labeling type fonts. You can use the labeling to mark components, values and signals on the board. Other information such as the date and engineer's name also can be added. It's surprising how much pride engineers take in their work if their names appear on the finished circuits.

If double-sided boards are used, the circuit can be located on one side and the labeling on the other. Let's face it, documentation is always the last step in a project. Documentation is, unfortunately, not always completed. At least if you've labeled the components and the interconnecting leads, it would be possible to successfully repair the circuit.

Plotted diagrams

You begin to appreciate a CAD program when the output is sent to a plotter or printer. When the circuit design is complete, first plot it on paper. Check the circuit board carefully against the schematic. Now is the time to correct errors.

It may be easier to check the circuit if the pattern is plotted in a larger scale. Many CAD programs allow this option. It's amazing how much easier it is to identify wiring errors when the final circuit is drawn larger than standard size.

When the circuit board drawing is correct, replace the plotter paper with transparency material and load the special black transparency pens. When plotting the final copy on transparency material, the program will slow down the plotter commands so the thin lines are perfectly drawn.

The resulting drawing is a direct positive of the desired PC board. No photo processing or reversal is needed. Simply place the transparency against the photosensitive copper-clad board and expose it to light. In a matter of minutes, you have a ready-to-etch PC board.

The typical photographic process for PC boards costs about $20. A single sheet of transparency material costs about $1. Obviously, there is a significant savings here. However, it's the speed with which circuits can be designed that makes the entire CAD process so attractive. The reduced production cost is just another advantage.

There are several CAD packages available. The one I use costs about $300. I've seen others that are more expensive. The higher-priced packages may have features that make them attractive to your particular application. Carefully examine the software package before you make your final selection. Two of the most critical elements of the program are the printer and plotter driver subroutines. Be sure that the program you select will interface properly with the hardware you will be using.

After you've made several circuits, you will wonder how you ever operated without CAD PC boards. The flexibility, low cost, reliability and appearance all make the process worth considering.

TV innovators receive Emmys

The coveted Emmy statuettes were recently awarded to several manufacturers and industry leaders in recognition of outstanding achievements in engineering development at separate ceremonies held in New York and Pasadena, CA.

The 36th annual Academy Awards ceremony was held by the Academy of Television Arts and Sciences in Pasadena, Sept. 6. The academy, most commonly known for its Primetime Emmy awards, presented an Emmy statuette to Stefan Kudelski for his work in the development of the Nagra recorder. The academy recognized the importance of the Nagra recorder to the TV industry because of its combination of portability, sonic quality and its capability to record and play stereo sound synchronous to the picture source.

Sony, CBS and Cinedco also were honored with statuettes for their design and implementation of electronic editing systems for film programs. Development of an electronic editing system without cutting or splicing, which would be comfortable for film editors, began in 1977. By 1979, an operational prototype without the traditional knobs and buttons of a video editing system was complete. The system uses only a picture monitor, a data monitor and a light pen. The commercial appearance of products based on this design technology such as EditDroid and Montage underscores the importance of this development to the film community. CBS currently uses its system with Betacam sources to edit its weekly *Twilight Zone* TV series.

In New York, the National Academy of Television Arts and Sciences held its 9th annual Engineering and Scientific Awards ceremony on Sept. 10. The academy is best known for its Daytime Emmy awards. There were several recipients of this year's Engineering and Scientific Emmys. They include:

- Abekas Video Systems for its achievement in engineering development for the Abekas A62 digital videodisc recorder.
- Ampex was awarded two Emmys for the development of the VPR-3 microprocessor intelligent production videotape recorder and for its development of advanced digital picture processing and time base correction techniques used in the Zeus.
- dbx for its research, development and implementation of the multichannel sound system (MTS) used in the voluntary broadcast TV standard (BTSC).
- The Electronic Industries Association for its administration of the development, testing and documentation of a single voluntary technical standard (BTSC) for multichannel stereophonic TV broadcast sound.
- JVC for its development of a consumer videotape recorder that makes it possible for the consumer to time shift recording and viewing.
- Matsushita (Panasonic) for the manufacturing and marketing of a consumer videotape recorder making time shift recording and viewing possible.
- M/A-Com for its contribution to satellite TV encryption and scrambling technology. M/A-Com's VideoCipher encryption system is used by Home Box Office, Showtime, Cable News Network and other TV programmers who use satellites to distribute programming.
- NBC for its work in developing and implementing MTS stereo sound for broadcast television.
- Quantel was awarded two Emmys for its painting and graphics generation with the Quantel Paintbox and for achievement in digital video mixing, processing and compositing for the Quantel Harry.
- RCA received two Emmys for its development and implementation of BTSC and its pioneering efforts in the development of component video recording technology for broadcast television.
- Sony received two Emmys for its Betacam format video recording system and for its design and manufacture of a consumer VCR that makes time shift recording possible.
- Zenith Electronics for its research, development and implementation of the MTS system used in BTSC stereophonic TV broadcasting.

Each Emmy was the result of recommendations of special committees, and was voted on by the board of governors of each respective academy.

Accepting Emmy s for the design and implementation of electronic editing systems for film programs are (from left to right) Adrian Ettlinger, Cinedco; William Connolly, Sony Communications Products Company; and Joseph Flaherty, CBS.

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SBE comments support NAB position

The Society of Broadcast Engineers has filed comments in support of the National Association of Broadcasters' filing, in opposition to the further sharing of UHF spectrum by private land mobile radio users.

In the initial proposed rulemaking, the FCC contended that sharing by land mobile users would result in minimal impact on UHF reception. The SBE filing affirmed the NAB's disagreement with this conclusion, citing the susceptibility to interference of new, synthesized, frequency-agile receivers to second and third-adjacent channel interference, an issue not addressed in the notice of proposed rulemaking on Docket 85-175.

The SBE urged the commission to deny land mobile type services shared use of the TV UHF band, allow sharing for broadcast aural STL, and to come down in favor of spectrum-efficient techniques, such as amplitude-companded sideband and spread spectrum technology, and stringent prior coordination requirements. |:[:-)))]

Statement of Ownership, Management and Circulation (Act of August 12, 1970; Section 3685, Title 39, United States Code).

1A. Title of publication: Broadcast Engineering

1B. 338-130

2. Date of filing: Sept. 30, 1986

3. Frequency of issue: Monthly except in the fall, when 2 issues are published.

3A. Number of issues published annually: 13

3B. Annual subscription price: ______

4. Complete mailing address of known office of publication (Street, city, county, state, zip code): 9221 Quivira Road, Overland Park, Johnson County, KS 66215.

5. Location of the headquarters or general business offices of the publisher (not printers): 9221 Quivira Road, Overland Park, Johnson County, KS 66215.

6. Names and complete addresses of publisher, editor, and managing editor. Publisher (Name and Address): Duane N. Hefner, 9221 Quivira Road, Overland Park, KS 66215. Editor (Name and Address): Jerry Whitaker, 9221 Quivira Rd., Overland Park, KS 66215. Managing Editor (Name and Address): Dan Torchia, 9221 Quivira Road, Overland Park, KS 66215.

7. Owner (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual must be given. If the publication is published by a nonprofit organization, its name and address must be stated.) Intertec Publishing Corp., a Macmillan Inc., company, 9221 Quivira Road, Overland Park, KS 66215.

8. Known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages or other securities (If there are none, so state): None.

	Average No. Copies Each Issue During Preceding 12 Months	Single Issue Nearest To Filing Date
A. Total No. Copies Printed (Net Press Run)	40,088	42,000
B. Paid Circulation		
1. Sales through dealers and carriers, street vendors and counter sales	--	--
2. Mail subscriptions	35,804	36,050
C. Total Paid Circulation	35,804	36,050
D. Free Distribution (including samples) by mail, carrier delivery or other means	2,338	3,995
E. Total Distribution (Sum of C and D)	38,142	40,045
F. Copies Not Distributed		
1. Office use, left-Over, unaccounted spoiled after printing	1,946	1,955
2. Return from News Agents	--	--
G. Total (Sum of E and F should equal net press run shown in A)	40,088	42,000

I certify that the statements made by me above are correct. (Signature of editor, publisher, business manager, or owner.)

DUANE HEFNER
Publisher

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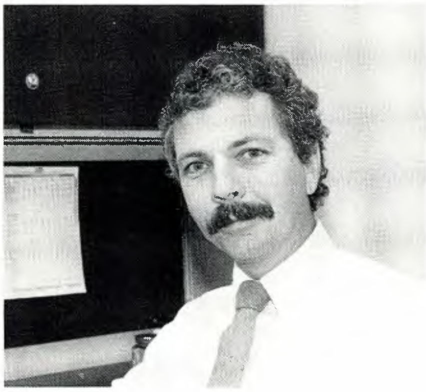
Circle (98) on Reply Card

BE names new video technical editor

By Jerry Whitaker, editorial director



We at **Broadcast Engineering** endeavor to lead the industry and our readers with the most up-to-date and accurate technical information available. This not only requires dedication, but a staff that has hands-on experience with the challenges, frustrations and needs of engineers and managers. Toward this end, we have again expanded our editorial staff to include the new position of video technical editor.

Our new video technical editor is **Ned Soseman**. He will be sharing editorial responsibilities with Carl Bentz, special projects editor and Brad Dick, radio technical editor. Soseman brings to **BE** a diversified background in broadcast engineering, production management and professional video and broadcast equipment sales.

Soseman, a Kansas City native, returns to the area from Santa Monica, CA, where he was vice president of engineering and market development for Master Digital Inc. Soseman oversaw the design, construction, training and operations of Master Digital's on-line 1-inch and interformat editing facility. He designed and implemented a Betacam field-production unit and off-line A/B roll VHS editing, bringing the company into full-service in-house production, duplication and fulfillment. He also created and initiated new marketing concepts to take advantage of these new capabilities.

Prior to Master Digital, Soseman was a consultant with Broadcast Technology Consultants (B-T-C), Mission, KS. B-T-C works with owners and CEOs of broadcast TV and teleproduction facilities in remodeling and new construction management.

Soseman worked with many network affiliates and helped start up two, new full-power UHF stations: KLJB-TV, Davenport, IA, and KSAS-TV, Wichita, KS. While with B-T-C, he purchased more than five million dollars worth of TV equipment for clients.

Soseman spent more than 12 years as an engineer with WDAF-TV, Kansas City, starting as vacation relief in 1966. In 1976, he saw his first sit-down editing system, Sony VO-2850s and an RM-400, and jumped at the opportunity to introduce these new products for Sony's Video Products division as a district sales manager.

Following several years at Sony, he started and managed a local professional video dealership in Kansas City, and later left the world of sales to rejoin the WDAF-TV engineering department in 1982. He was promoted to engineering operations supervisor at WDAF, the local NBC affiliate that also operated the only C-band uplink in the area. While operations supervisor, he developed many training programs for engineers and operators, and created a zero-discrepancy program for interdepartmental feedback at the station.

Soseman began his career in broadcasting in 1964 at KXTR-FM, Kansas City, as an engineer, for $1 an hour, at the suggestion of a fellow amateur radio operator.

He attended Pittsburg State University, Pittsburg, KS, and the University of Kansas, Lawrence, where he majored in journalism, broadcast news and broadcast management.

Charles A. Steinberg and **Robert L. Wilson** have been appointed positions with Ampex, Redwood City, CA. Steinberg is president and chief executive officer of Ampex Corporation. He was executive vice president. Wilson is vice president and general manager of Ampex Magnetic Tape Division.

Kenneth R. Schwenk has been appointed president and chief executive officer for Rohde & Schwarz, Lake Success, NY. Schwenk is a former president of product management and development of Harris Broadcast Division.

John Parke has rejoined Acrodyne Industries, Blue Bell, PA, as vice president of sales and marketing. Parke is responsible for directing all marketing efforts aimed at increasing awareness and sales of high-power TV transmitters, and low- and medium-power broadcasting equipment. Parke was director of TV sales and marketing for Harris from 1983 to 1986, and before that was with Acrodyne as vice president for 14 years.

Jerald C. Murphy has been appointed president and chief operating officer for Utah Scientific, Salt Lake City. Murphy founded Digital Logic Corporation and M & M Computer Industries, and for the past several years has been a partner with Leider, Murphy & Associates.

Gary Kimball, John Preston and **Peter Nehl** have been appointed positions with Advanced Video Systems, a new company. Kimball, a former VEA president, is president; Preston, the company's founder, is general manager of engineering; and Nehl, NCEC vice president, is vice president of engineering.

William J. Nanney has been appointed plant manager at the Eimac division of Varian Associates, Palo Alto, CA. He is responsible for research and development, production, inventory, quality, marketing and sales strategies, and program management.

Colin J. Brown has been appointed executive vice president of Rank Cintel, Ware Herts, England. He joined Rank Cintel Inc. in a senior management position at the company's corporate head office in the United Kingdom.

Donald A. Carlsen has joined Aurora Systems, San Francisco, as Western regional manager. He will be responsible for marketing operations in the 13 Western states and will be located in southern California.

John Nash has been named regional sales manager for the Midwest for Lenco Electronics, Jackson, MO. He will be serving the Midwest area from his office in Minneapolis.

Sony forms organizations, marketing program

Sony Corporation of America, Park Ridge, NJ, has formed two divisions to handle all sales and marketing of the company's non-consumer products.

A new Communications Products Company will assume responsibility for all sales to the broadcast, institutional video and professional audio markets.

The second group, the Information Systems Company, is responsible for information products, government systems sales and new business development.

A promotional marketing program for computer animation products also has been announced by *The Sony Communications Products Company*, Teaneck, NJ, and *Integrated Technologies*, Greenboro, NC. Sony's broadcast sales organization in the U.S. and Canada began selling ITI's line of Ani-Maker and Image-Maker 3-D computer animation products in broadcast and TV post-production applications on Sept. 1.

EECO acquires Acquis

EECO (ASE/EEC), Santa Ana, CA, has acquired 100% of the stock of privately owned Acquis Corporation and its wholly owned subsidiary, Convergence Corporation. The company, headquartered in Irvine, CA, will become a wholly owned subsidiary of EECO and will continue to develop, manufacture and market videotape editing systems and related equipment. EECO's existing video products division will be merged into the company and will operate under the Convergence Corporation name.

Amek receives Greene Street order

Amek Consoles, North Hollywood, CA, has announced the sale of the first APC1000 console to Greene Street Recording, New York. The desk is expected to be operational in December.

Ampex receives equipment orders

Ampex, Redwood City, CA, has received several equipment orders. KPIX-TV, the CBS affiliate in San Francisco, has purchased two ADO 2000 digital-effects systems and two AVC-33 switchers.

Video Tape Associates, Atlanta, has purchased six VPR-3 type C 1-inch videotape recorders linked with six Zeus advanced video processors and three ADO digital-effects systems with a concentrator.

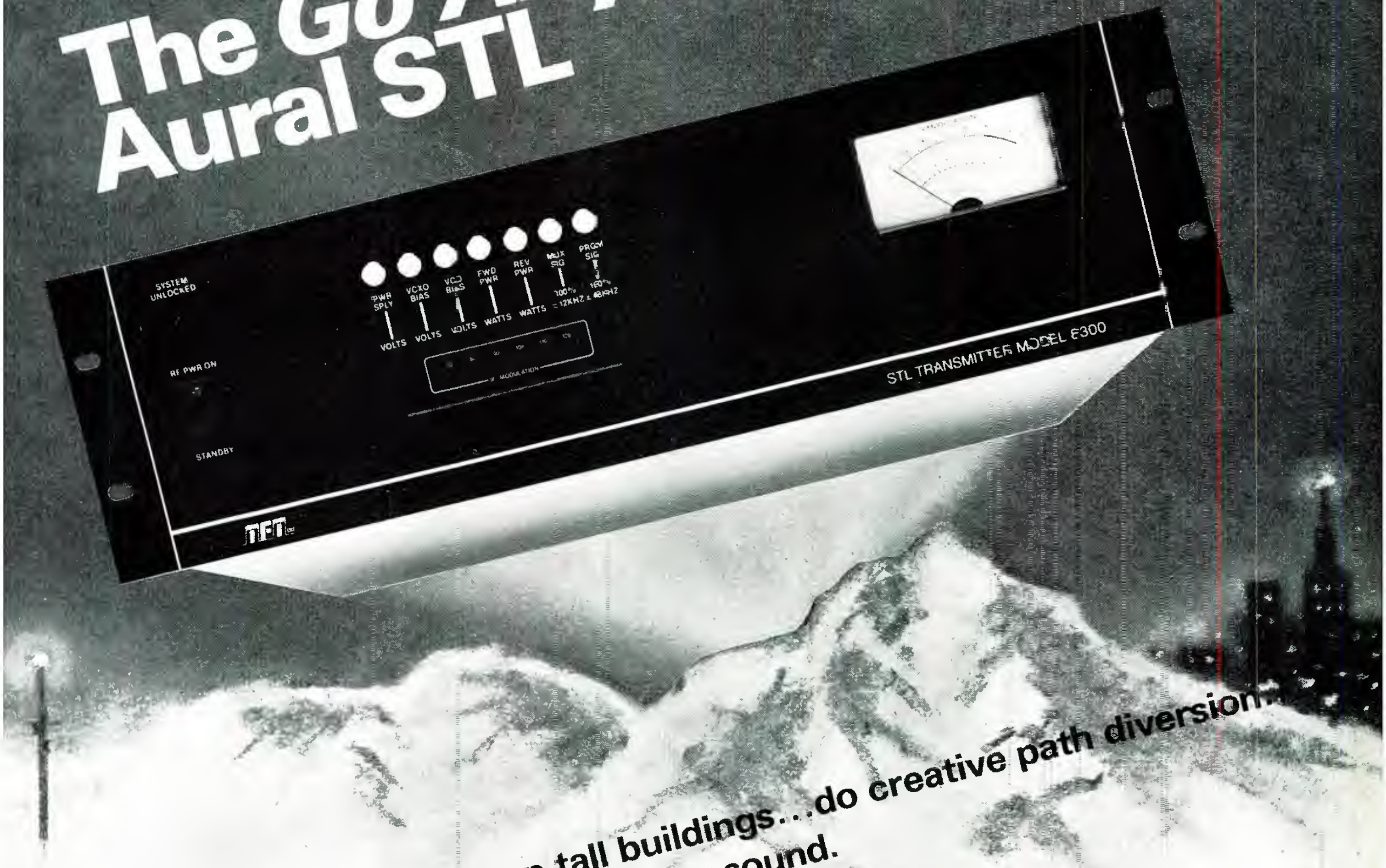
Thames Television is installing an Ampex major edit suite. The equipment is comprised of four VPR-3 videotape recorders, an ACE computer editing system, a dual-channel ADO digital optics system with the infinity package, and an audio mixer.

Fountain Television, London, has ordered two VPR-3 videotape recorders with Zeus 1 advanced video processors, which will be added to its existing Ampex-based system.

Quantel demonstrates Paintbox

Quantel, Kenley, England, demonstrated its Paintbox at IBC. The unit was shown in stand-alone form and in conjunction with a digital library system. Paintbox was also seen on the Sony stand at IBC working in conjunction with the BVH2500 stop-frame recorder via a

The Go Anywhere Aural STL



Go around corners...leap tall buildings...do creative path diversion without affecting the purity of your sound.

TFT's 8300 Series Aural STL with its unique, innovative IF Repeater approach keeps your on-air audio sounding as it does at the studio...several hops later.

The TFT IF Repeater technique is unique. At relay points, we don't take your aural signal down to audio baseband. We use the 63 MHz IF instead.

Results? How about 55 dB stereo separation even after a few 10, 20, or 25 mile hops? Or ±0.1 dB frequency response from 30 to 15,000 Hz?

Plus, we offer a selectable IF bandwidth (SAW Filter) to minimize adjacent channel interference.

The 8300 Series is available in Composite, or Dual "Hot Standby" Composite configurations.

AM Stereo? Go FM composite to your transmitter and our Stereo Decoder Option will give you left and right signals to drive your AM Stereo Exciter.

If your frequency is one of those listed by the FCC,* we guarantee delivery within 2 weeks after we accept our dealer's order.

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Get to the top of the hill, cleanly. Go TFT. Contact your favorite TFT dealer for more details.

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Lyon Lamb controller to produce full-frame animations and retouching work.

Also, the BBC will take delivery of its 15th Paintbox.

Quantel also has received three awards. Two Emmy awards, one for Paintbox and one for Harry, were awarded by the National Academy of Television Arts and Sciences. The third award, the BDA Industry Service Award, was awarded by the Broadcast Designers Association.

McMartin relocates

McMartin International has relocated to P.O. Box 4500, Gunnison, CO 81230; 303-641-5500. The new plant is located at 111 Camino Del Rio, Gunnison, CO 81230. McMartin has hired an entire new staff, two design engineers, production managers, sales managers and electronic assemblers.

Harris awarded NBC contract

Harris Corporation, Melbourne, FL, has been awarded a contract by NBC to provide a voice and data satellite communications system linking NBC's Skypath and Skycom satellite control center in New York City with the news-gathering trucks of NBC's network affiliates. The system will consist of a Harris Ku-band satellite hub, situated in Melbourne, FL; network control terminals at NBC in New York; and a network control system, including video data terminals, computers, telephone circuits and software. Also, NBC has named Harris the exclusive supplier of the communications control package used aboard the satellite news-gathering trucks of NBC affiliate stations.

Microdyne installs Ku-band satellite

Microdyne Corporation, Ocala, FL, through its Canadian distributor, Incospec Electronics, has delivered a fixed, Ku-band satellite video uplink to Pathonic Communications, Quebec. This will be the first privately owned Ku-band uplink in Canada. The uplink, which will employ a Microdyne scrambling system for fully encrypted audio and video signals, will be used for intra-network communications and news broadcasts. It was installed and put into operation Sept. 8.

Also, Microdyne's QuickLink, a Ku-band satellite news-gathering vehicle, has been approved by GTE for use with GTE News Express satellite network service.

Midwest acquires Bennett

Midwest Communications Corporation, Edgewood, KY, has acquired Bennett Engineering, Seattle, WA. Stan Bennett, Bennett Engineering's owner, will remain with Midwest in a management role. This acquisition is Midwest's first West Coast office.

NewStar adopts new company name

Dynatech NEWSTAR, Madison, WI, formerly the NewStar division of Color-Graphics Systems, has become a separate company. L. Sanders Smith, previously vice president and general manager of the division, is company president. Dynatech NEWSTAR is a wholly owned

Continued on page 166

Panasonic® brings you M-II. The broadcast recording system our competition can't seem to duplicate.

Now you can shoot, edit and broadcast with 1" quality—on ½" cassettes.

When it comes to broadcast systems, it appears our competition has been erased. Because no other format can match the spectacular performance of M-II from Panasonic.

With M-II's metal particle tape system, you can use the same compact 90- or pocket-size 20-minute cassette from ENG/EFP right through editing to on-air broadcast. With 4.5MHz bandwidth (-3dB), 50dB S/N and burst signal insertion for phase alignment and jitter correction, M-II is the single solution to all your broadcast needs.

In fact, each unit in the M-II line offers some pretty uncommon common features like four audio tracks (two linear and two FM), an integral longitudinal and vertical interval time code/time date generator with presettable user bits and Dolby*-C noise reduction. And M-II products utilize a standard edit control interface, so you can upgrade gradually if you like.

AU-650 Studio VCR. This compact, rack-mountable VCR has all the advantages and functions of conventional recorders with the benefit of the M-II format. The AU-650 provides video and audio performance as good as—if not better than—that of 1" VTRs. In a ½" cassette format that lends itself to station automation. It records and plays either 90- or 20-minute cassettes, and provides smooth action, variable slow motion as well as freeze frame. And the AU-650 can perform frame-accurate automatic editing with multi-generation transparency. There's also an internal TBC to assure on-air quality playback.

AU-500 Field Recorder. The AU-500 offers the portability and functions demanded by ENG/EFP users, while providing picture quality comparable to 1"—all on either a 90- or 20-minute cassette. This small, ruggedly designed unit is equipped with confidence field color playback, automatic backspace editing, TBC/DOC connection, search function and warning indicators that alert the operator should recording problems arise and the AU-500 accommodates NTSC composite or various component input signals.

The AU-400 Camera Recorder. This lightweight, compact camera recorder provides ENG users with more than 20 minutes of recording, and a picture quality that rivals that of 1" VTRs. The AU-400 also features B/W video confidence playback through the camera's viewfinder, a chroma confidence indicator and audio confidence output through a speaker. There's even an automatic backspace editing function and warning indicators. And the AU-400's rugged construction provides excellent resistance to dust and moisture.

M-II, it's the only broadcast system of its type in the industry. And it's available now. Two of the best reasons to go with M-II from Panasonic.

To get the complete picture, call or write Panasonic Broadcast Systems Company, One Panasonic Way, Secaucus, NJ 07094. (201) 348-7671.

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Panasonic
Broadcast Systems

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subsidiary of Dynatech Corporation, Burlington, MA. The decision to split NEWSTAR away from ColorGraphics was made because of the diversity of market and product lines.

The independent company's first installation of the NEWSTAR Discovery system was completed in late June at WAJR-AM/WVAQ-FM, Morgantown, WV. Selkirk Broadcasting also has ordered the newsroom system.

CompuSonics relocates

CompuSonics Corporation and *CompuSonics Video Corporation* have consolidated their operations at a new national headquarters in order to better enable both companies to use and access the latest developments in digital technology available in the Silicon Valley area of northern California. The companies are located at 2345 Yale St., Palo Alto, CA 94306. CompuSonic's new telephone number is 415-494-1184; CompuSonics Video's new telephone number is 415-494-2308.

Logica receives TVS order

Television South (TVS) has ordered two Gallery 2000 TV digital still-picture systems from *Logica*, London. The order will be delivered and installed in late 1986 at TVS's production centers at Maidstone and Southampton.

California Microwave receives Herald-Sun order

California Microwave, Sunnyvale, CA, has announced that its subsidiary, Satellite Transmission Systems, has received a contract from Herald-Sun TV PTY Limited, Melbourne, Australia. It will supply the electronic equipment and assume overall turnkey responsibility for Herald-Sun's new 13m Ku-band video uplink satellite earth station. STS will provide redundant up- and downlinks with 2kW high-power amplifiers, automatic uplink power control and a remote monitor and control system.

CBS buys Marconi NewsHawks

Marconi Communication Systems, Chelmsford, England, has been awarded a contract to supply CBS in New York with two rapid deployment earth terminals (RADETS) based on the NewsHawk design. The equipment will be in addition to the RADET in service with CBS.

Leaming Industries delivers SCPC equipment

Leaming Industries, Costa Mesa, CA, has delivered its program audio SCPC equipment to Scientific Atlanta's International Division for use in Gabon, Africa. This equipment order includes KM731 and 811D frequency-agile modulators and demodulators.

Orion relocates

Orion Research, Cleveland, has relocated to 4650 W. 160th St., Cleveland, OH 44135. Sales and service call phone number is 1-800-82-AUDIO. In Ohio and outside the continental United States the telephone number is 216-267-7700.

"We wanted the best standards converter on the market. In side-by-side tests, SATIN was clearly superior."

Gerry Citron (left), President of Intercontinental Televideo; Nigel Toovey (right), Vice President.

Gerry Citron, President of Intercontinental Televideo, the oldest and one of the largest conversion facilities in the country, knew exactly what he wanted: "The very best, the latest, the finest converter available." Here's why he bought the Quantel Satin:

"We made our own demo tape," Gerry said. "A very difficult tape, with lots of graphics and movement. We converted that tape on Satin and on the leading competitor..."

Everybody picked Quantel Satin. "We asked knowledgeable people from the Broadcast Industry to view the tapes side-by-side in a split screen test. Everybody picked Satin."

"In signal-to-noise ratio, color imagery, resolution and movement interpolation, Satin was significantly superior," according to Intercontinental's Vice President, Nigel Toovey.

"We were also attracted by Satin's all digital design," Toovey continued. "Digital VTR is the next thing, and Satin, with its direct 4:2:2 interface, will put us in the forefront of that movement."

And price? "We didn't buy on price," stated President Citron. "We bought on performance, reputation, technology and support. But the price was competitive. Quantel's Satin offers much more than early systems for almost the same cost."

Satin's superior picture quality and outstanding price/performance will convert you, too.

For information, contact Intercontinental Televideo at (212) 719-0202, or write to Quantel, 3290 West Bayshore Road, Palo Alto, CA 94303, (415) 856-6226.

Step into the digital studio **QUANTEL**

Circle (106) on Reply Card

Soundcraft receives SAC2000 orders

Sales of the SAC2000 stereo on-air console from *Soundcraft*, Borehamwood, England, have more than doubled in the last year. Radio Rhema Incorporated, New Zealand, a Christian Radio Broadcasting Network, purchased four consoles. The desks are intended for a new studio complex under construction in Christchurch. Ranson Audio, London, has just sold a SAC2000 to Tube FM, Dunkirk, France. The console is part of a major refurbishment package and will be the main on-air console. An SAC 2000 has been purchased from Soundcraft Canada by the Instituto Cubana de Radio y Television (I.C.R.T.) and will be installed in Radio Progresso Havana Cuba.

Camera Mart generates power for Liberty weekend

Camera Mart, New York, supplied the units that generated energy for virtually all of the video and lighting equipment on Governors Island for the Liberty weekend centennial. There was insufficient power available to handle the additional power load, and only one generator could be used.

The generator supplied power to NBC, WOR-TV, WOR Radio, United Stations, UPI, AP, WMAL, WNYC, WINS, Visnews/Conus, Independent Network News, WNBC, WNYW and Gannett Newspapers as well as Telco dishes and microwave uplinks. A backup unit stood ready to come on-line in a matter of seconds if the main unit failed.

Equipment provided ranged from tulip cranes and dolly to walkie talkies for the media and the Coast Guard, plus more than 40 monitors for David Wolper's opening ceremony.

Camera Mart has relocated to 1900 W. Burbank Blvd., Burbank, CA 91506. This division of Camera Mart/NY will be known as CMTV. It will have its own sales, rental and maintenance departments.

Proposed merger of AMS and Calrec

A proposed merger between *AMS Industries plc*, Burnley, England, and *Calrec Audio Limited*, Hebden Bridge, England, has been announced. A meeting of AMS shareholders was held Aug. 20 to consider the acquisition of all capital shares of Calrec.

AMS and Calrec address the professional audio recording and broadcast marketplaces with different but complementary products. Both companies are involved in research and development of digital audio techniques. The merger would allow Calrec to relocate its operations to the new AMS headquarters 14 miles from Calrec's existing premises.

EMI Abbey Road Studios, St. John's Wood, London, has purchased a Calrec UA8000 music console for installation in studio 3. This console will be the first UA8000 supplied in England and also the first Calrec by AMS music console to be delivered. The desk is a 48-channel format and installation is scheduled for this month.

Mitsubishi becomes limited partner

Conus Communications, Las Vegas, has announced that Mitsubishi will become a limited partner in Conus. Mitsubishi is involved in media and telecom-

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munications-related projects in Japan, including a subsidiary, Space Communications Corporation, which will offer domestic telecommunication services to Japanese customers through its own satellite network. Through Mitsubishi, Conus hopes to export its products. Although no Ku-band broadcast satellites are presently in orbit over Japan, the first such satellite is scheduled for launch in 1988. It will be stationed in a geosynchronous orbit.

Audio Kinetics installs equipment

Audio Kinetics, Borehamwood, Herts, England, has installed its Eclipse audio editor at the ITN studios in London. Other installations include five systems in Canada, including two at CFTO and one each at Service Audio Mixon, Pierre-Daniel Rheault and Pathe Films. Another system has been installed in Switzerland.

Audio Kinetics has also sold a Mastermix console automation system, for Audio International's 48-channel Cadac console. Olympic Studios has purchased its second Mastermix, for its 32-channel Trident console at its new studio in Chelsea.

GEC receives order from Taiwan

Three video conference studios have been ordered from *GEC Video Systems*, Port Chester, NY, by the Republic of Taiwan. Add-on equipment has also been ordered.

Advanced Video Systems is formed

A new company, *Advanced Video Systems*, San Francisco, has been formed to provide video system consultation, design, installation, maintenance and repair, and documentation. The company is formed through the consolidation of Video Engineering Associates (VEA) and the Northern California Engineering Cooperative (NCEC).

Studer/Philips form joint CD venture

A joint venture by *Studer*, Switzerland, and *Philips*, the Netherlands, encompassing research and development in CD systems, has been established. The agreement specifies that each partner holds a 50% share in the new company, designated Studer and Philips CD Systems AG. The new company will be located in Regensdorf, Switzerland, with management formed on an equal share basis. Dr. Willi Studer will be chairman of the board, with Dr. Pieter Berkhout of Philips serving as managing director.

Also, *Studer Revox America* has moved its New York City field office to 161 Avenue of the Americas, Suite 901. The telephone number is the same.

Basys delivers newsroom systems

Basys, Mountain View, CA, has received orders for three electronic newsroom systems. The BBC Television News signed a contract to buy a 100-plus terminal electronic newsroom system that began operation in October.

The Finnish Broadcasting Company (YLE) will install a Basys computerized newsroom system in its radio and TV operations, with the installation of 82 devices at YLE's Helsinki studios. More than 200 devices will be installed by 1989.

CKNW, a Vancouver radio station, has installed the Basys system to facilitate news broadcasts of the 1986 World Transportation and Communication Exposition.

UEI consolidates

UEI, Kenley, England, has consolidated Link Electronics and Quantel in order to increase market penetration and efficiency of operations. Link's camera and other video product development and manufacturing will move to Newbury to integrate with Quantel's operation. Link's system business will remain at Andover and become a center for systems engineering and installations specializing in studio and OB vehicle design.

Thomson receives equipment orders

Bonneville International Corporation's flagship station, KSL-TV, Salt Lake City, has purchased its second Vidifont V graphics and animation system from *Thomson*, Stamford, CT. The dual-channel system will be used both for internal production and by KSL-TV's Video West production division for animation of retail and corporate commercials. Thomson also has received from France an order for the TTV 1530 production camera.

Otari forms support group

Otari Corporation, Belmont, CA, has formed an engineering support group. The group will study the applications of Otari's machines and orient them to fit the U.S. market, including the implementation of any machine modifications, design accessories, and software changes and updates. The group also will design quality control and service guidelines for new machines.

WDR orders Neve mixing system

Neve Electronics, Bethel, CT, has delivered a DSP sound mixing system to WDR, a German broadcast network. The console will be installed in the concert hall of the new cultural center built by the city of Cologne.

Brown Boveri delivers radio transmitter

BBC Brown, Boveri & Company, Baden, Switzerland, has supplied a 300kW medium-wave broadcast transmitter to Cameroon. The station was installed at Bamenda, the capital of Cameroon's northwestern province. Brown Boveri also supplied the omnidirectional antenna, the power equipment fed from the 30kV network and the standby generator.

COMSAT designs satellite network

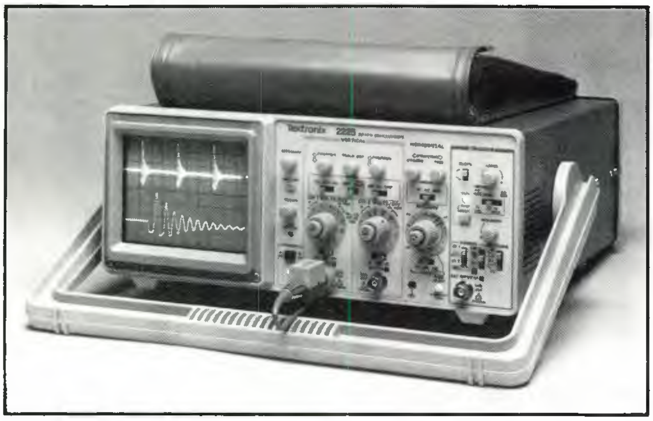
COMSAT Corporation, Washington, DC, has been awarded a 5-year contract by the United States Information Agency to design and implement for the Voice of America (VOA) a satellite network capable of interconnecting VOA broadcast stations around the world. COMSAT will provide four U.S. earth stations, operational in 1987, that will be used to transmit overseas VOA's daily radio broadcasts. VOA may also contract for two more U.S. earth stations and 16 new relay stations around the world.

New products

Portable oscilloscope and picture monitor

Tektronix has introduced the following products:

- The 2225 dual-channel portable oscilloscope is the latest addition to the 2200 series. It features 50MHz bandwidth, alternate magnification, 500μV sensitivity, peak-to-peak auto trigger mode and high-frequency/low-frequency trigger filtering. The oscilloscope's TV trigger comes with the capability of selective triggering on TV lines or TV fields.
- The 651HR-C picture monitor combines a measurement quality decoder and direct component inputs, allowing the user to view picture quality before and after encoding to PAL. The monitor is compatible with RGB, SMPTE parallel, Betacam and M format. A front-panel switch allows the operator to monitor the working component analog format and to make comparisons of the same signal before and after passing through a PAL encoder.



Circle (350) on Reply Card

Cartridge monitor

ITC/3M has introduced the DCM-1 dynamic cartridge monitor that continuously verifies audio broadcast cartridge performance before and during on-air broadcast. When used in conjunction with a station's cartridge machine system, the cartridge monitor assists in identifying worn out or problem cartridges so operators can remove them from an active library before they can fail on the air.

The monitor evaluates small changes in cartridge tape speed by monitoring a special reference tone located on a previously unused portion of the cue track. When speed changes, which are displayed on an LED indicator, reach a limit predetermined by the station, the operator can remove the cartridge from service.

Circle (351) on Reply Card

Stereo cartridge recorder

Pacific Recorders & Engineering has introduced its stereo cartridge recorder to its MICROMAX Series.

The electronics feature: low-noise DC-servo feedback head preamplifiers, active audio/bias summing record head drivers that eliminate bias traps, adjustable record phase compensation, and CMOS control logic with replay lockout.

The compact stereo recorder comes equipped with the MAXTRAX half-track format tape heads that yield higher tape output and less tape noise. Optional NAB format quarter-track heads are available.

Circle (352) on Reply Card

Broadcast transmitter

Broadcast Electronics has introduced the FM-30A single-tube, 30,000W FM broadcast transmitter. It uses the same folded half-wave cavity as the FM-30. This design eliminates plate-blocking capacitors and sliding contacts. Other features include: modular slide-out IPAs, automatic power control, and an air-cooling system. The transmitter also contains the provision to add the optional microprocessor video diagnostic system.

Circle (353) on Reply Card

TV stereo test generator

RE Instruments has introduced the RE540 programmable TV stereo generator for testing the audio circuits of stereo TV sets conforming to the BTSC multichannel sound recommendation. The generator can produce a dbx-encoded stereo signal with greater than 60dB of separation and <0.03% distortion. Other features include: baseband RF outputs; SAP channels; programmable synthesized modulation sources for both main channels and SAP with distortion <0.03%; selectable noise reduction and pre-emphasis; composite video input for phase locking of pilot frequency; and multitone signal generation. All features are fully programmable via an IEEE-488 bus.

Circle (354) on Reply Card

Spectrum analyzer

Hewlett-Packard has announced the HP 8590A portable RF spectrum analyzer with a 10kHz-1,500MHz range. The analyzer is fully programmable and has many of the data-processing and measurement functions of the HP 8568B. The analyzer is intended for bench applications in R&D and manufacturing, and for on-site measurements at remote locations. The analyzer has an optional cover that protects the front panel from dust, moisture and impact, and provides storage for the operating guide or a hand-held computer. The unit features dedicated pushbuttons and menu-labeled softkeys for manual operation.

Circle (355) on Reply Card

Satellite video source identifier

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

Circle (356) on Reply Card

Monitoring system

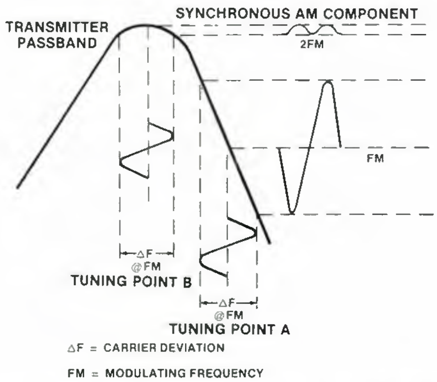
Marconi Instruments has introduced a broadcast newtork monitoring system that offers an integrated system for monitoring TV and radio signal quality. Its modular design combines signal analyzers, audio and visual test insertion instruments, and switching and routing equipment. These are computer-controlled via the GPIB to allow system control from a central site. The system uses insertion test signals, added to the spare lines of TV transmissions to assess the quality of video signals. The system checks regularly acquired broadcast data and monitors signal loss every second.

Circle (357) on Reply Card

Corrections

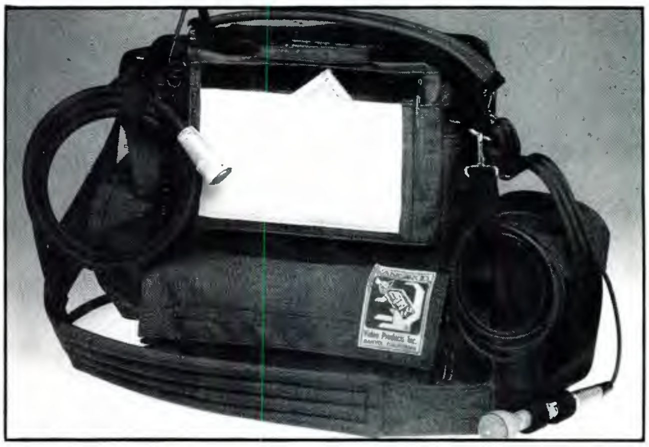
The k factor or Boltzmann's constant relates molecular activity with temperature. The k relationship, discovered by the physicist Boltzmann, does include temperature in degrees Kelvin (°K). This led to some confusion in the September "Satellite Technology" column.

A typographical error was made on a diagram in the August "Circuits" column. The legends, *Tuning Point A* and *Tuning Point B* were transposed on Figure 1 (page 16). The corrected Figure 1 is shown below.



Video packs

Kangaroo Video Products has introduced the KVP-25 case designed for the Sony BVW-25 Beta format recorder and the BVW-21 playback unit as well as Thompson models VT-624 and VT-626. Features include detachable Kangaroo Klips that offer versatility in organizing camera and microphone cables, and a combination pocket that holds up to three Beta cassettes or two cassettes and, in a padded section, a BP-90 battery. The case loads from the top and is cradle-designed to prevent the loss of the deck through the bottom of the case.



Circle (358) on Reply Card

Yamaha introduces microphones for every instrument we make. And the one we don't make.

Designed to reproduce both vocal and instrumental music, the MZ Series of professional microphones were a long time in the making.

For nearly 100 years, Yamaha has been building musical instruments. Everything from piccolos to grand pianos to synthesizers.

We took this musical heritage and combined it with our expertise in electronics and acoustic engineering. The result is a line of five microphones that, unlike others, go beyond mere transducers.

The diaphragms in the three MZbe models are the first to use beryllium. This rare metal's low specific gravity and exceptional rigidity permit an extended high frequency range for a sound that is both crisp and sweet at the same time.

A specially developed damping and three-point suspension system for long-term stability and durability is used throughout the line. As are gold-plated connectors.

But because of Yamaha's musical experience, the real accomplishment of our new microphones is certainly greater than the sum of the parts. You might even think of them as musical instruments in themselves.

For complete information, write Yamaha International Corporation, Professional Audio Division, P.O. Box 6600, Buena Park, CA 90622. In Canada, Yamaha Canada Music Ltd., 135 Milner Ave., Scarborough, Ont., M1S 3R1.

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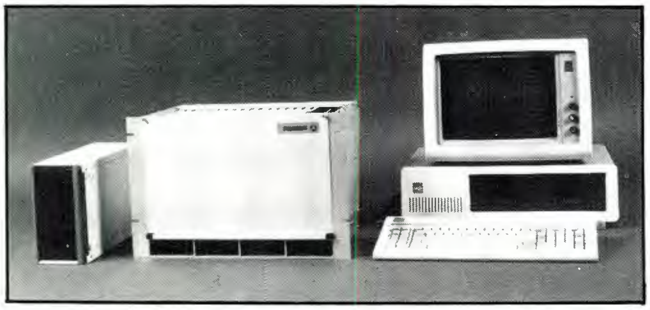
Circle (116) on Reply Card

Digital slide store/paintbox



Thomson Video-Equipment has introduced the following products:

• The ANDI TTV 3100 digital slide store is a digital system for still-picture archiving, corresponding to digital broadcast standards and based on WORM-type laser recording techniques. A central unit stores pictures on-line or off-line and can transmit those pictures to local units for consultation or broadcast. The picture management system runs on IBM PC/AT or compatible and retrieval is possible through key words or by category.

• The MINIPAINT paintbox is an anti-aliasing system that reduces sawtooth lines when tracing curves and diagonals. Its workstation configures a graphics pad with an IBM PC compatible computer. The unit is appropriate for reproduction of pastels, charcoal drawings, watercolors and transparencies.

Circle (359) on Reply Card

Equipment protectors

MCG Electronics has introduced the Surge-Master Avalanche 3200A and 4200A series. Equipment damage is prevented by clamping ac line transients directly at the equipment input. The unit's backup consists of 2,000J of metal oxide varistors separated by a fuse. The varistors are in standby mode ready to protect equipment from a catastrophic power surge. The unit consists of matched, heavy-duty diodes to directly shunt transients around the sensitive load, in less than 1ns. The unit also employs a triple redundant approach.

Circle (360) on Reply Card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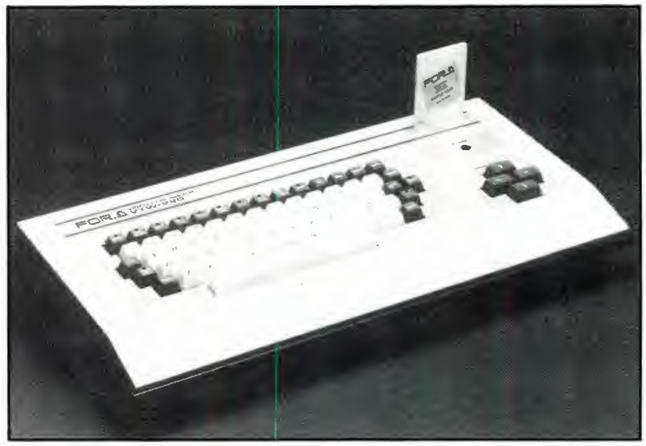
Camera support

Visual Departures has introduced the Steadybag camera support. It combines the stability of a tripod with the flexibility of hand-held shooting. The beanbag support ensures steady imaging and balance on every surface in the studio or on location. It is lightweight and filled with polypropylene beads that are double bagged in a waterproof and spill-proof Parapac nylon casing. The fittings are made of non-scratch nylon. The bag is compatible with all ENG-EFP and film equipment.

Circle (361) on Reply Card

Video character generator



For-A has introduced the VTW-220 video character generator with built-in performance. The unit integrates into any video system to produce characters in four different sizes. The character generator provides 512-color selection with a 14-color palette, character-by-character underline, 9-speed roll and crawl, adjustable matte, text-editing capabilities, 32-page memory, expandable to 64 pages, and an RS-232C port for computer interface.

Circle (362) on Reply Card

Condenser microphone

Sennheiser Electronics has introduced the MKH 20 P48 transformerless omnidirectional studio condenser microphone. Optimal resistive loading of the microphone diaphragm results in a highly linear frequency response and an inherent noise level. The microphone responds to both high and low sound pressure levels, and is suited for the reproduction of acoustic string and wind instruments.

Circle (363) on Reply Card

Effects and animation stand

Euro Equipment Service has introduced the Magstand Automatic Plus 2 system. The dual- or simultaneous-use film and video stand is available with five stepping or five dc motors. The carriage itself has a maximum north/south movement of 400mm and an east/west range of 700mm. The stand is designed to take flip and circle elements and also can be equipped with an aerial image and can accommodate a black-and-white video camera for permanent monitoring. The stand is equipped with a floppy disk capable of storing a 20-minute real time program. The system also has 64K of free memory for special programs available from the custom-designed library.

Circle (364) on Reply Card

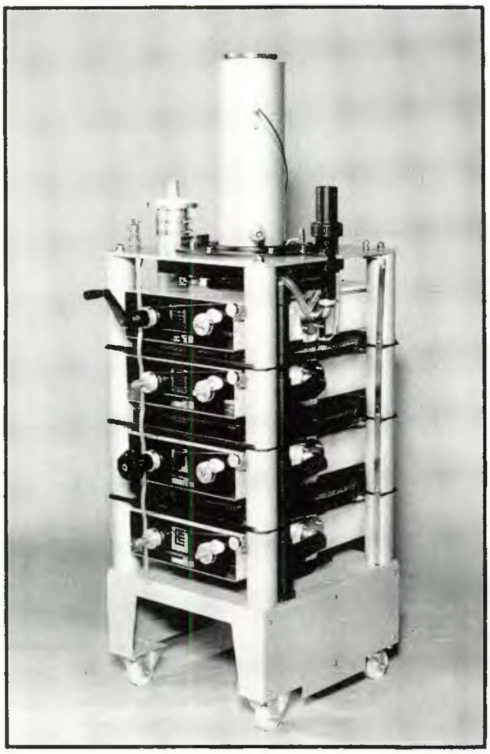
DTMF remote control

Monroe Electronics has announced the 5001 DTMF remote control that answers DTMF-coded inquiries and generates alarm reports in English using synthesized speech. The device monitors 16 on/off type logic inputs and controls 16 outputs through built-in Form C relays. Communication with the unit is through DTMF signals from any touch-tone telephone or over any other voiceband link equipped with a touch-tone keypad.

Circle (365) on Reply Card

Wideband klystrons

EEV has introduced wideband, high-power TV klystrons and circuit assemblies covering the power range of 5kW to



60kW at frequencies ranging from 470MHz to 860MHz. The klystrons use external cavities to cover the U.S. frequency range and offer simplified installation, easy tuning, and reductions in spares inventories. The klystrons feature a beam control device that enables operating efficiencies in excess of 70% to be achieved by pulsing the klystron.

Circle (366) on Reply Card

ADP script archive system

Dynatech NewStar has introduced the attached database processor system (ADP). It was developed to augment NewStar by having database-oriented newsroom applications processed on a separate but attached computer. The ADP model 1 version is implemented on an IBM-PC/AT, and offers script archive, tape library and Rolladex applications.

Circle (367) on Reply Card

Pedestals and tripods

Vinten has introduced the following products:

- The MIDI PED is a lightweight pedestal. It incorporates an adjustable pneumatic center elevation column and can be separated into two units for portability. The center column can be pressurized to counterbalance pan and tilt heads and ENG/EFP cameras, and usually does not require external charging. Brake and friction controls also are incorporated. The tracking base provides two fixed positions for the column. The wheel units can be individually locked in position or all three can be locked for straight-line tracking.

• The Vision range consists of three tripods and three pan and tilt heads designed for ENG and EFP use. It incorporates calibrated fluid drag control, external rotary control to give balance through 180° of tilt, and pan and tilt brakes. The tripods consist of ENG models in both 1- and 2-stage formats and an EFP 2-stage tripod.

Circle (368) on Reply Card

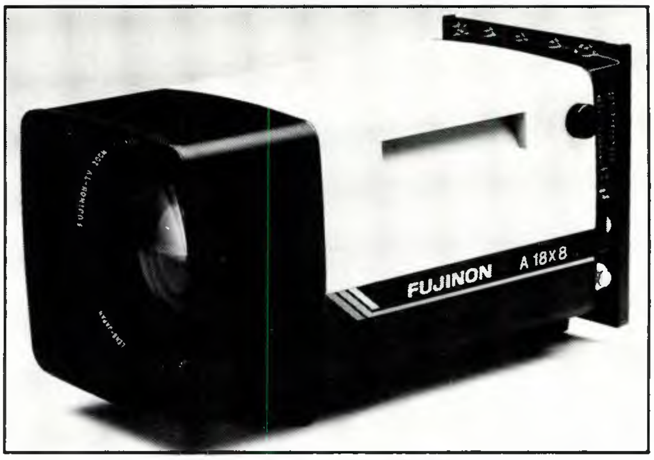
Aural modulator

ITS has announced the ITS-27 aural IF modulator. It is designed to convert the RCA G-line VHF transmitter for stereo and multichannel TV sound. The product is housed in a single 19-inch rack-mount tray. It contains a 41.25MHz IF oscillator that is modulated by incoming audio and subcarriers. The oscillator is phase-locked to the G-line via a 10MHz reference input that comes from the transmitter. This maintains the 4.5MHz aural to visual separation. The aural IF output connects to a BNC connector on the existing exciter, and the modulator becomes the aural IF source.

Circle (369) on Reply Card

Lenses

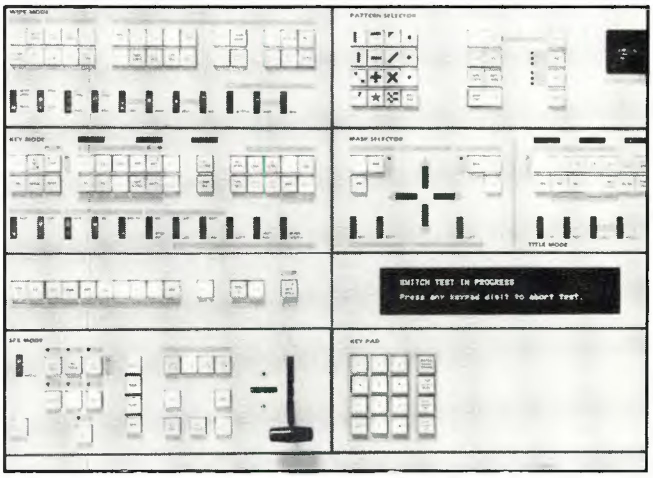
Fujinon has introduced the A15 x 8ESM and A18 x 8ESM studio zooms and offers modular design concepts in ⅔-inch formats, resulting in improved performance, reduced size and weight and increased reliability and serviceability. Major components are modular and interchangeable. Controls and adjustments, accessible with the shroud in position, include back-focus adjustment and lock, servo/manual switch for the built-in 2X extender, pattern projector color levels and chart positioning, and tally light switch. LEDs on the side of the lenses provide information such as focal height and aperture.



Circle (370) on Reply Card

Video production switcher

Central Dynamics has introduced the Strata-7, a 7-signal level processor that uses microprocessor control to process up to seven different video levels simultaneously. The unit features a range of key title level source and level modifiers, plus fill selection. Other features include: level priority transitions; five transition linearity modes; three full-facility pattern generators; 10 matte generators; four mask generators; two independent, full-facility, 1- to 4-line analog keyborder generators addressable to four levels; review selector; and RS-422 communication.



Circle (371) on Reply Card

Gain control amplifier

Learning Industries has announced the AGC622 audio automatic gain control amplifier. It is designed to maintain average program levels within a reasonable range without reducing the dynamic range to the extent that quiet passages are no longer quiet and loud passages are no longer loud. The amplifier includes a gated-chain compressor and a peak limiter. When the program level falls over 20dB below normal, the compressor assumes that there is a pause in the program and holds its gain setting for 10 seconds. If the program level has not come back above the threshold after 10 seconds, the compressor slowly resets its gain to 0dB. The limiter is used to keep sudden peaks from causing overmodulation. The AGC may be defeated for testing by a front-panel switch, or remotely. There are two pairs of left and right inputs (A and B) that may be selected by remote or local control. The stereo synthesizer may be activated by selection of input B. Up to three amplifiers may be mounted in one PMS600 19-inch rack-mounting frame.

Circle (372) on Reply Card

Battery accessories

Anton/Bauer has introduced the following products for use with video cameras:

• The DataTap measures and displays camera power consumption, permitting full discharge of a battery. The system sandwiches between the camera snap-on bracket and battery. The LCD readout displays ampere-hours consumed.

• The ADM (automatic discharge module) fully discharges any 12V to 14V snap-on battery, ProPac 90 VTR battery and the PowerStrap. It is equipped with a dc output for optional digital voltmeter/chart recorder to detect shorted or low capacity cells. ADM's load device and automatic cutoff circuit takes batteries through a full discharge cycle.

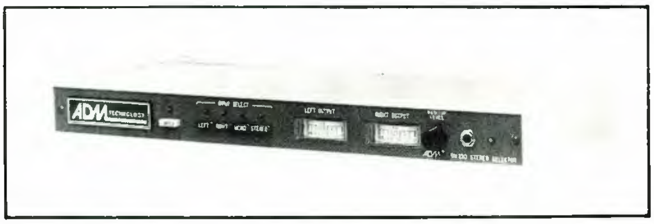
• The PowerStrap is a 12V, 4AH battery strap. It is designed for use with all portable video recorders and low-voltage lighting equipment. The unit mounts directly to the existing VTR shoulder strap or can be worn as a conventional belt.

• The 1-hour Mobile Fast Charger (MFC) provides overnight charge capability from most vehicles with or without the engine running. An integral protection circuit disconnects the charger from vehicle power if the voltage drops below 10.5Vdc. The MFC is a single-position charger that accepts all 12V to 14V snap-on and VTR nicad batteries and operates on 11V to 18V input.

Circle (373) on Reply Card

Switch matrix

ADM Technology has introduced the RM1010 active switch



matrix. It is designed to select the audio track output of any 2-channel source and distribute the output as a stereo signal. The matrix includes a selection of left only, right only, stereo or mono. A left channel phase reverse switch has been added to solve the mono sum problem associated with out-of-phase stereo program material. The matrix includes a stereo monitor circuit that consists of stereo analog metering, a line level monitor output with level control and a stereo headphone jack.

Circle (374) on Reply Card

Digital storage oscilloscope

Kikusui International has introduced the COM 7101 4-channel, dual-time base, digital storage oscilloscope. It features a 50Ms/per second sampling rate, digitizing of 100MHz repetitive signals, 20MHz transient capture, full CRT readout, and front-panel control. Standard equipment includes the 7101 built-in, bi-directional GPIB interface bus. The unit is suited for waveform analysis in production, field service, engineering, ATE and R&D environments. The oscilloscope has no keyboards and there are no menus. Other features include an on-screen DVM and frequency counter. The scope also doubles as a full-feature 100MHz analog oscilloscope.

Circle (375) on Reply Card

Tripod cases and chart

Nalpak Video Sales has introduced the following products:
• The Tripaks are a line of rotationally molded tripod cases and light stands. There are three heights in the 11-inch diameter from 23 inches to 49 inches; four heights in the 9-inch diameter from 26 inches to 52 inches. The cases are molded from crosslinkable polyethylene and they include twin handles, telescoping caps and a roll resistant shape.
• The Mini-Chart consists of a color reference chart, registration chart and logarithmic reflectance chart in a 4½" x 6" size in a spiral bound book.

Circle (376) on Reply Card

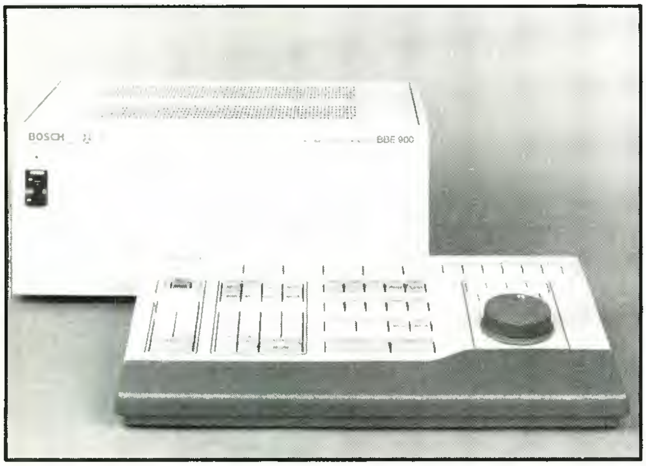
Personal computer/archiving system

Basys has introduced the following products:
• The BRAT, a high-performance PC AT with 1Mb of internal memory and up to an 85Mb Winchester disk drive. The PCs will be linked via Ethernet for complete fault tolerance in both data and hardware. The network also will be used to support concentrators that will provide an extra eight serial ports for each CCU added.

• An on-line archiving system that provides TV and radio newsrooms with high-speed access to their own library of data. Material can be fed in at archive terminals or transmitted from the newsroom system and automatically indexed. Searches can be performed involving logical operators, date ranges, alphanumeric ranges and precedent, and can be done from terminals on the newsroom system. Access also can be restricted by user or terminal. Storage capacity can be expanded by boosting disk capacity or with expansion units.

Circle (377) on Reply Card

Recording equipment/editing system



BTS has introduced the following products:

• BCB 21 is a compact and lightweight field player with a versatile power supply. Features include search mode with monochrome picture, available at ±3.5 times normal speed; 2-channel audio with noise reduction; optional time-code reader; and plug-in RF modulator.

• BCB 25 portable Betacam recorder/player has all the features of the BCB 21 plus composite and component input/output, built-in time-code generator/reader and external TBC connection. Back-space editing gives continuous recording without a picture break-up at the transition point.

• BCB 15 player is a studio component for the recorder camera family. It offers built-in EBU/SMPTE time-code reader, color composite video signal, component signal and compressed time division multiplex, and still-frame picture capability.

• BCB 40 recorder/player has built-in editing allowing insert and assemble edits to be performed in video, audio 1 and 2 and time code; automatic edit simulation; and edit monitoring. The unit also has a time base corrector and a built-in EBU/SMPTE time-code generator/reader.

• KCB 1 is a combination of KCF 1 color camera and a recorder. The camera is equipped with three ½-inch Plumbicon pickup tubes. The component signal recording system consumes only 10W of power and has a maximum of 36 minutes recording time. Features include EBU/SMPTE time-code generator, independent time-code track, two audio channels with noise reduction and automatic assembly editing.

• BBE 990 is a post-production editing system. Up to four VTRs can be controlled in an A/B roll edit. Any VTR can be controlled while an automatic event involving the other VTRs is taking place.

Circle (378) on Reply Card

Circle (128) on Reply Card

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MAINTENANCE ENGINEER—For stereo TV station, production facility and satellite uplinking facility. Experience in TCR-100, TR-600, Sony 1", GVG Switchers, and Sony ¾". Good salary, benefits, M/F, E.O.E. Send resume to Jim Moore, KPLR-TV, 4935 Lindell Boulevard, St. Louis, MO 63108. 11-86-1t

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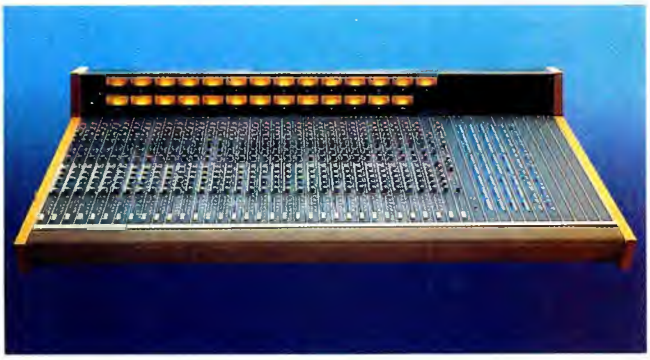

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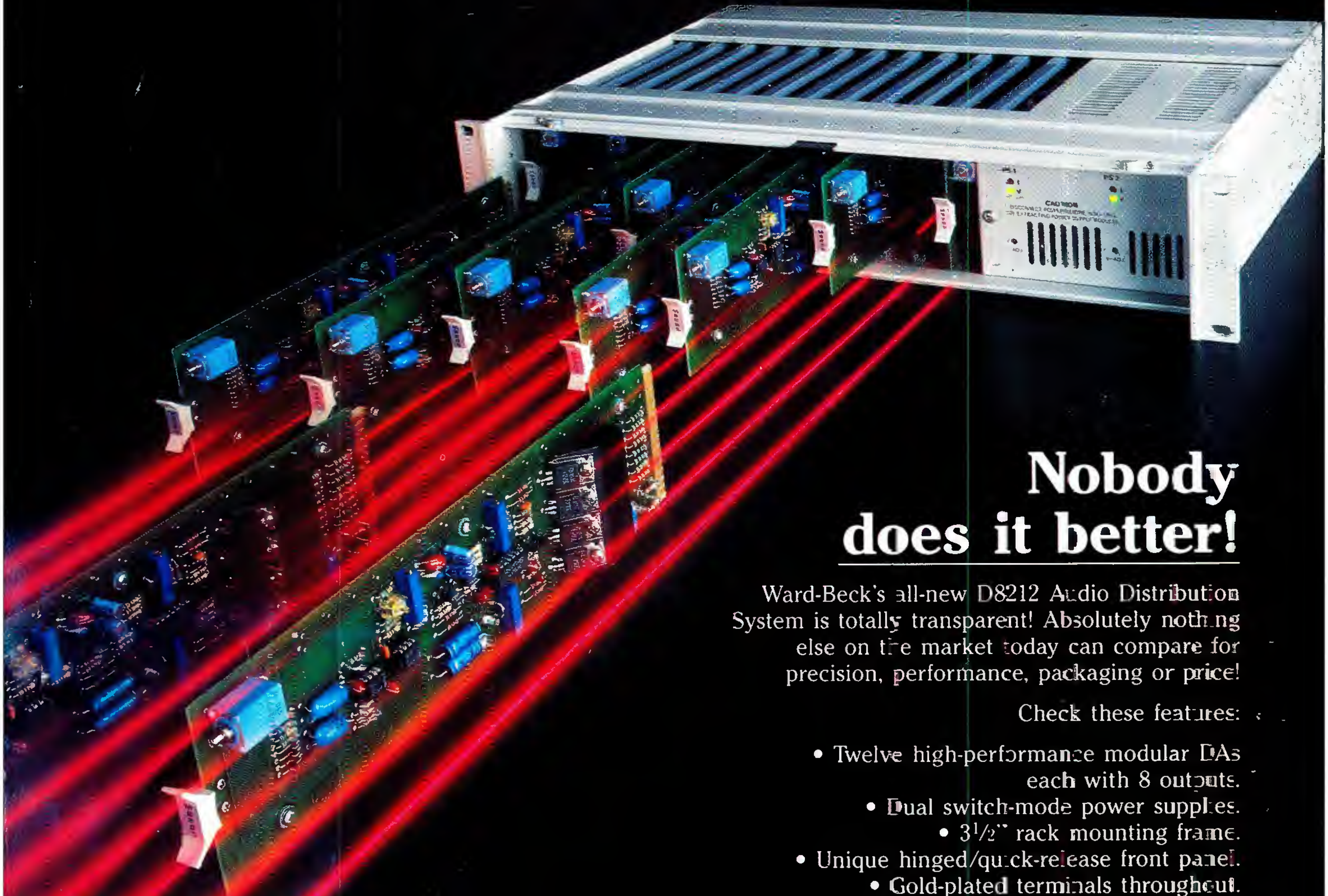

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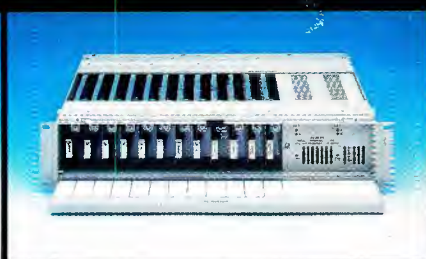

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