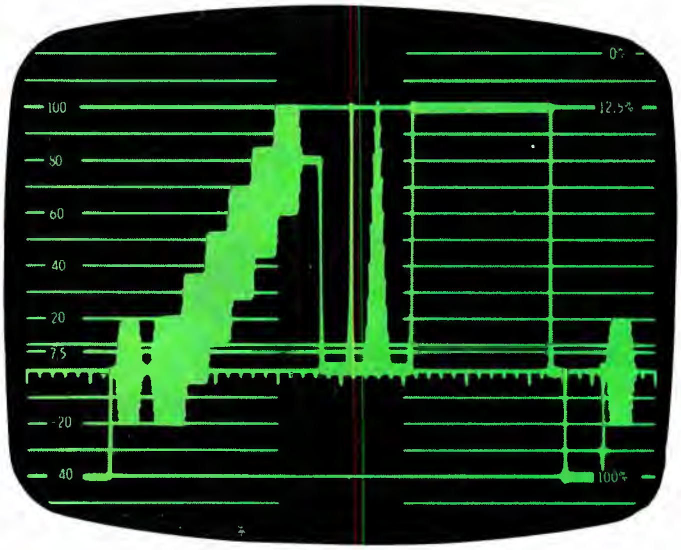
DECEMBER, 1971/75 cents

Broadcast Engineering

the technical journal of the broadcast-communications industry

A HOWARD W. SAMS PUBLICATION



FCC Explains New TV Remote Control Rules

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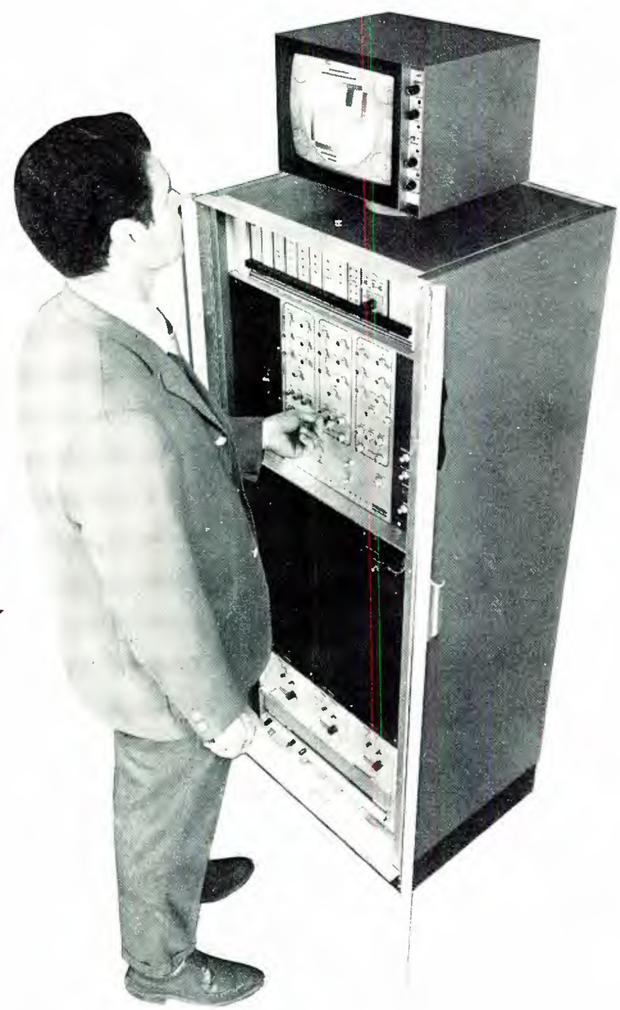

December, 1971 • Volume 13, No. 12

Broadcast Engineering

The technical journal of the broadcast-communications industry

in this issue...

ABOUT THE COVER

The cover this month depicts the theme of an FCC article on the new remote control rules. The article begins on page 20. An official and exclusive report on interpreting the new rules. Further coverage included in NAEB coverage in the Industry News section.

DEPARTMENTS

ABP AIA BPA

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DIRECT CURRENT FROM D.C.

December, 1971

Howard T. Head

Translators vs. CATV?

The Commission has rejected a protest by a CATV system in Colorado against a grant of five television translators to cover the community served by the cable system. The CATV operator had alleged that the translators would provide economic competition against the cable system.

The Commission noted that the available information indicated that both the CATV system and the translators would provide their own types of service. Cable subscribers would be able to obtain signals not delivered by the translators, and would serve areas where translator reception was inadequate. The translators, on the other hand, would provide TV service to areas beyond the reach of the CATV cables.

In another action, however, the Commission rejected a proposal by a UHF TV station in Massachusetts to operate a translator in the same city as the TV station to be programmed by "distant signals" from outside TV broadcast stations. One of the principal reasons cited in rejecting the proposal was the Commission's ban on overlapping signals under common ownership. Whether a different result would have been reached otherwise remains a good question.

EBS Closed Circuit Tests Suspended Indefinitely

The provisions of the Emergency Broadcast System (EBS) for random closed circuit tests have been suspended by the Commission until further notice. This suspension follows the confusion created by the closed circuit test of September 14, 1971 (See last month's DC column) which disclosed "a large number of additional deficiencies.

The Commission action is the most recent in a series of events pointing up the problems which have been encountered in the emergency notification system. Meanwhile, the Office of Civil Defense (OCD) continues with the planning of its Decision Information Distribution System (DIDS) which will employ a network of high power LF and VLF stations to transmit alerting and other warnings.

The White House Office of Telecommunications Policy (OTP) continues to keep the problem under close scrutiny.

(Continued on page 6)

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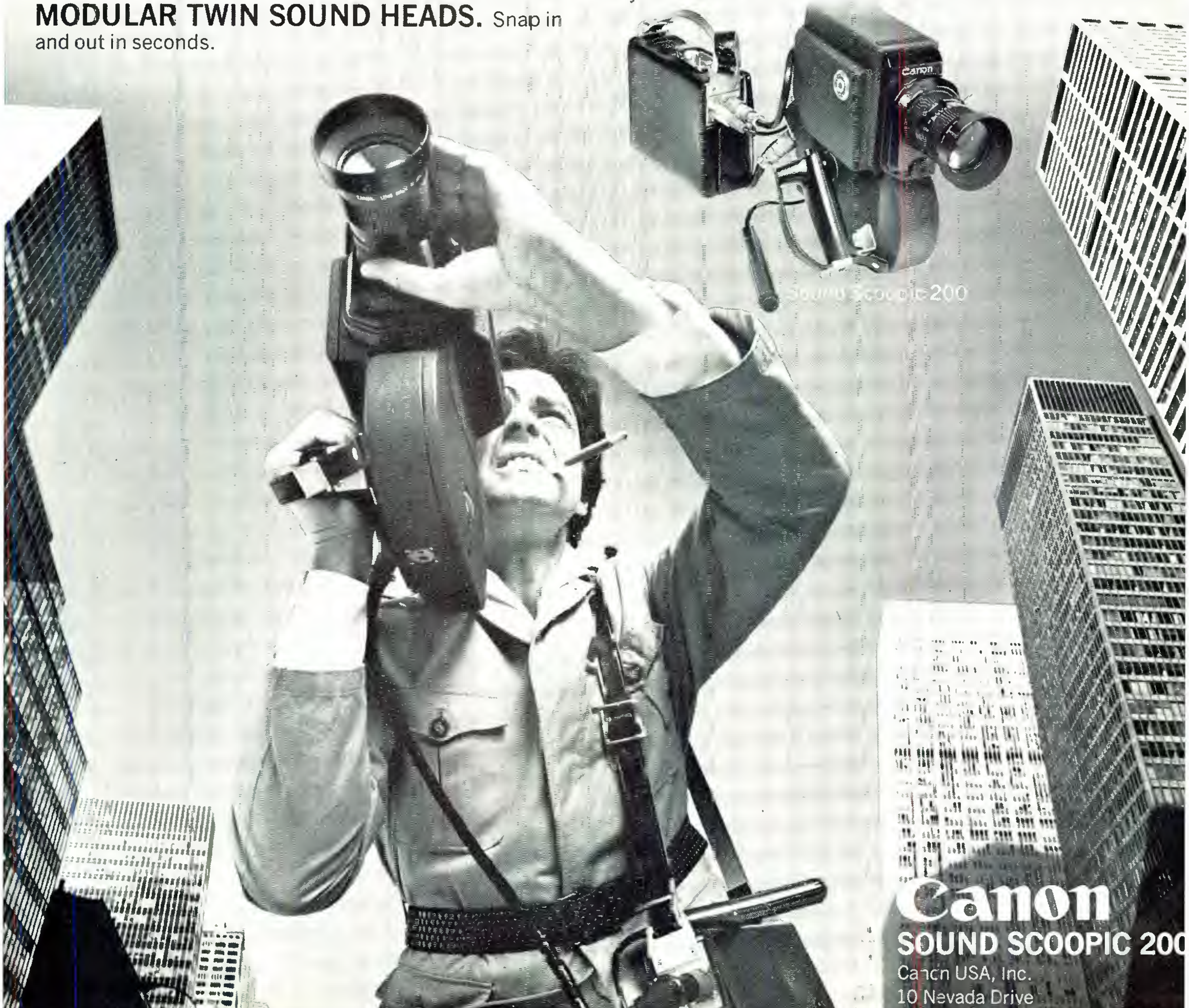

(Continued from page 4)

AM Freeze Nearing An End?
The Commission has accepted an application for a fulltime AM station in Iowa, notwithstanding the provisions of the current "freeze" on acceptance of new applications. During the freeze, the Commission has accepted only a handful of such applications, each of which has been characterized by the almost complete absence of other AM service.
The acceptance of the Iowa application is unusual for two reasons. First, the proposed station would be the second AM station in the city. The other station operates as a non-commercial educational station. Second, the rural surrounding area is served at night by only a clear-channel station 90 miles distant. However, the applicant argued that the Commission should not consider the distant clear channel signal to constitute primary service at night, an argument frequently made in the past but uniformly rejected.

The Commission continues to plod along toward new AM rules that would end the freeze. A present target of new rules could be a Christmas "package". Unless new rules are adopted, exceptions of the type involved in the Iowa case are certain to become more and more frequent.

Cable Origination Channel Identification Proposed
The Commission has proposed that CATV systems be required to use standard identification of all programs originated by the system. The identification required would be "cable TV, Channel ____, (location)."

The proposal was made for two reasons. There have been complaints by cable viewers that some cable systems use call signs with their original programs which are sufficiently similar to TV broadcast calls to create confusion. Further, the Commission points out that the reservoir of remaining "K" and "W" call signs is becoming more and more limited. Also, the FCC's Field Engineering Bureau continues to receive complaints of interference to off-air TV reception caused by leakage and radiation from CATV systems. Most of these complaints appear to be associated with the use by cable systems of channels for local origination which could not be used for local broadcast carriage because of on-channel ghosting resulting from high ambient radiated signals.

Short Circuits
The Commission has proposed a substancial increase in the required minimum operating schedule of FM broadcast stations, who may now broadcast as little as 36 hours per week. . .The Commission approved the use of 72-76 MHz band for the control of all types of models, on a shared basis with other services. . .The FCC has approved the continued use of the 4 GHz and 6 GHz bands for Community Antenna Relay Systems (CARS) under special circumstances.

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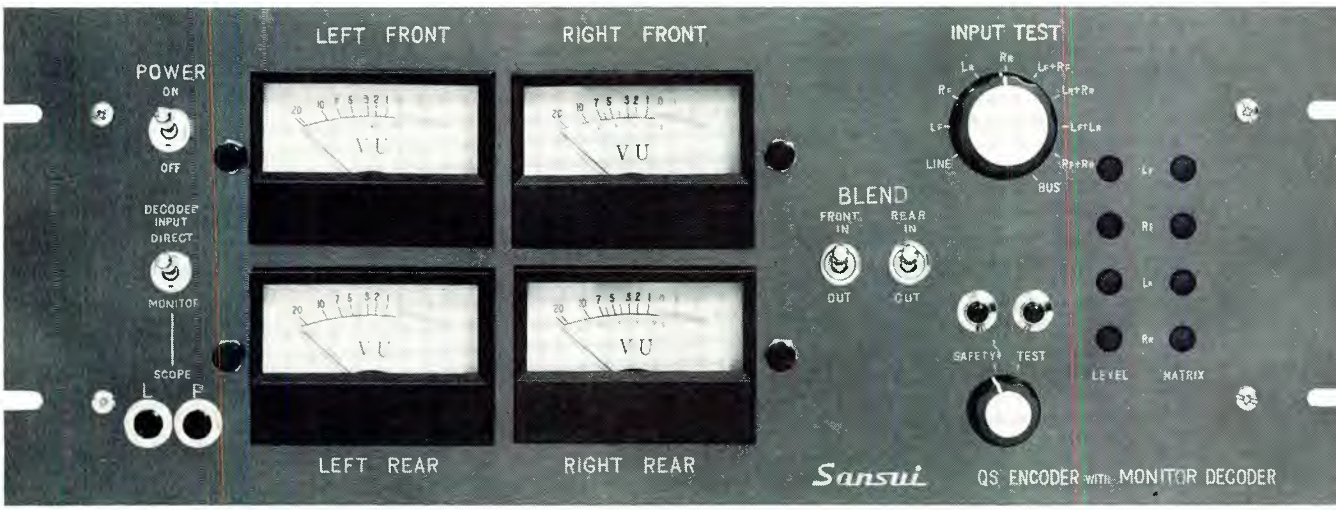

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Circle Number 7 on Reader Reply Card

LETTERS TO THE EDITOR

Automatic Leveling System

Dear Editor:

Let me extend thanks and compliment *Broadcast Engineering* for publishing the excellent and timely article on "Preventing FM Overmodulation", by W. J. Kabrick, in the September 1971 issue.

Having a very long engineering background in FM broadcasting, I certainly appreciate the value of Mr. Kabrick's analysis of the problem, and particularly his suggestions for solution.

KIKK-FM since 1968 has made use of an automatic leveling system consisting of a modern fast attack time conventional limiter followed by the selective peak clipping "Top Level" system as suggested by Mr. Kabrick.

The latter device does require knowledgeable calibration and competent regular supervision to see that accurate calibration is maintained. Other than that, however, it performs admirably in allowing a relatively high average modulation level. The KIKK-FM program material does not require a wide dynamic range.

The total main channel maximum modulation limit is 80 percent due to stereo and SCA service. Such clipping as occurs in the Top Level system at KIKK-FM does not result in any discernable distortion nor does it produce any audible crosstalk into the SCA service. Random excessively fast and high amplitude peaks do overshoot the deviation limit occasionally but the duration is so short and the energy content so low they pose no real problem. I feel it is a pretty fair solution to the FM overmodulation problem.

I have mixed emotions about Mr. Kabrick's suggestion that the long-time solution to the FM overmodulation problem is to dispense with the standard pre-emphasis/de-emphasis bit. I grant that this requirement does cause some problems. On the other hand it gives a 10 dB noise advantage to the FM broadcast system main channel. And I am not at all sure the industry can afford to give it up.

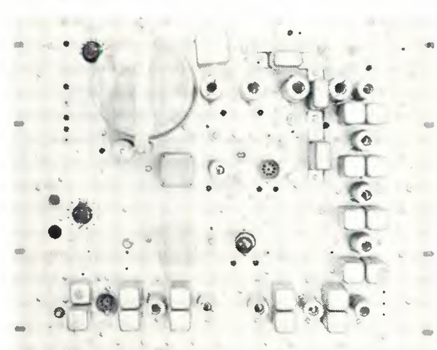
Gerald R. Chinski
Director, Engineering
KIKK/KIKK-FM
Houston, Tex.

Exciter Identification Help Needed

Dear Editor:

Below is a photograph of an FM exciter that was given to us that we are trying to identify.

The unit measures 19" X 15½", has no identifying marks, serial numbers, or trade names. The output tube is a 5686. It has provisions for stereo.



The unit is well built with quality components and cleanly laid out.

If anyone could help us to identify the manufacturer and/or obtain schematics, we will be very grateful.

Mark C. Worley
Transmitter Supervisor
KAMU-TV
College Station, Tex.

On Using A Diode For Transient Suppression

Dear Editor:

The letter to the Editor in the September issue concerning the use of a diode as a transient suppressor appears in error due to the fact that it is not the zener break-

(Continued on Page 10)

Gates' new BC-1H 1000 watt AM transmitter features reliable, long life 833A tubes, solid state oscillation, instantaneous power cut back to 250 watts, and 120% positive peak modulation capabilities. It will be operating reliably at your station for years to come. Get the details on tomorrow's transmitter today. Write Gates Radio Company, 123 Hampshire Street, Quincy, Illinois 62301.

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(Continued from page 8)
down of the diode that limits the transient voltage.

Since an inductor will tend to oppose any change in current, the transient current will be of the same polarity as the operating current, but the transient voltage will be of opposite polarity. This condition will then forward bias the diode and short the transient voltage.

Michael J. Simmons
Maintenance Supervisor
WMFE-TV
Orlando, Fla.

Editor's Note: We expected a bigger reaction to the original letter than we actually got. For this reason, in the Engineer's Exchange column you will find a detailed explanation of how the diode works as a transient suppressor. In fact, during the coming year we will be running a series of articles explaining the theory and use of several solid state devices.

For further information, we suggest you pull some of your copies of 1971 *Broadcast Engineering* and note the books listed in our Book Review columns. One we thought was particularly good: *Workshop In Solid State,* by Harold E. Ennes. This book should be on the bookshelf of every station. It is available through Howard W. Sams & Company, Indianapolis, Ind. 46206. Ind. 46206.

To clarify another matter—as a matter of fairness to several authors—telco remotes cannot be covered in one general article. The reports printed in this magazine have come from stations working through several different telephone companies. Therefore, the specifics in each case may be different from what exists in your area. We suggest you show these articles and exchange items to your telco contact. It might make a difference.

"I DIDN'T THINK IT WOULD END LIKE THIS."

Microwave Rules Change

Parts 2 and 21 of the Rules for licensing of common carrier microwave radio station to relay TV signals to cable TV systems have been modified by the FCC (Docket 15586), as of November 30.

The changes will allow limited use of the 4 and 6 GHz common carrier bands for the purpose of serving cable TV systems and to eliminate the conditional renewal of these facilities.

Under previous rules, with some exceptions, microwave facilities for transmission of TV signals to cable systems were limited to the 11 GHz band. Applications for new common carrier microwave facilities in the 4 GHz and 6 GHz bands to serve cable TV systems were not accepted and existing facilities could be renewed, after February 1, 1971, only under certain conditions.

The Commission said that use of 11 GHz frequencies would have no substantial adverse economic or other consequences on carriers primarily serving CATV systems. It pointed out also that, in view of the congestion in the lower bands and the heavy spectrum impact of cable TV service, the limitation is "reasonable" to meet the growing demand for terrestrial and satellite general communications.

The Commission said, however, it believed that some relief would be appropriate and that it would maintain the prohibition against the authorizations for new frequency paths in the 4 and 6 GHz bands to serve cable TV systems but would continue the policy of considering waiver requests under its February 3, 1970 Memorandum Opinion and Order (21 FCC 2d 284), and would eliminate the conditions on renewals of licenses granted after February 1, 1971. It said this is a "reasonable compromise," since the lower frequencies will be reserved in areas of greatest congestion, while waivers will permit cable TV use in areas where congestion is not a problem.

A carrier, which has been authorized to operate on a lower frequency for cable purposes, would not be subject to the uncertainty and financial risk entailed in an authorization which would be subject to pre-emption, the Commission pointed out.

Stations which supply cable service on the lower frequencies and which are located within 50 miles of one of the top 25 metropolitan areas are few in number and they have been made eligible for renewal, the Commission said. However, no waivers for new or additional 4 and 6 GHz facilities will be granted in these restricted zones without a showing of compelling and unusual circumstances.

The rule changes, which delete Footnote NG55 in Section 2.106 and amend Section 21.701(i), became effective November 30, 1971.

Action by the Commission October 14, 1971, by Memorandum Opinion and Order. Commissioners Burch (Chairman), Bartley, Robert E. Lee, H. Rex Lee and Wells with Commissioner Johnson concurring in the result; Commissioner Reid not participating.

Commission Wants Equipment Form Change

The Commission has specified FCC Form 723 for use by applicants for type acceptance of equipment. Use of this form is encouraged although, at the present time, its use is optional. Future amendment of the rules is planned to require that this form be submitted with type acceptance applications. A separate copy of Form 723 should be submitted for each equipment type number.

450-470 MHz Band

Mobile Requirements Relaxed

Parts 89, 91, 93 and 95 of the rules have been amended by the Commission to relax technical requirements for authorization and operation of control stations in mobile relay systems using frequencies in the 450-470 MHz band (Docket 18740). (Control stations permit communications from a fixed location to mobile units.)

The amendments permit the use, in certain situations, of bi-directional, cardioid, or omnidirectional antennas; allow certain required signal measurements to be made at one location, in cases in which a fixed station is used to control more than one mobile relay station; and permit an applicant to "certify" that the "output power of the proposed station transmitter will be adjusted to comply with the . . . signal level limitation." Licensees will also be required to maintain records of the necessary measurement data. Additionally, control stations will be allowed to operate with a frequency tolerance of ±.0005 percent, instead of the present tolerance (±0.00025). The tighter tolerance, however, is to be retained for all other fixed stations operating in this band.

In its Notice of Proposed Rule Making issued November 24, 1969, (34 F.R. 19034) the Commission also proposed to eliminate the requirement for coordination for control stations. The Commission said that the commenting parties opposed this, arguing, among other things, that in view of the proposal to relax regulations governing the use of directional antennas, there was "more reason than ever to require coordination; and overall, they conclude, the requirement makes possible the use of more effective and efficient assignment techniques." Its objective, the Commission noted, was to eliminate a requirement it felt was unnecessary, and lessen the burden on applicants for control station facilities in this class. Upon review of the comments, however, the Commission stated it would retain the coordination requirement, at least for the present.

The proposed amendments became effective November 8, 1971. This action terminates the proceeding.

Industrial Radio Affected By Latest Rules Amendment

Amendment of Parts 2, 21, 89, and 91 of the Rules with regard to the allocation of frequencies in the bands 35.19-35.69 and 43.19-43.69 MHz has been proposed in a rulemaking notice by the FCC. The proposal involves channel splitting of the two bands to allow for more assignable frequencies.

The action was in response to a petition by the Special Industrial Radio Service Association (SIRSA) requesting the Commission to reallocate to the Special Industrial Radio Service certain frequencies in the bands 35.2-35.68 MHz and 43.2-43.68 MHz presently allocated to the Domestic Public Land Mobile Radio Service for use by wireline common carriers.

The petition was opposed by Pacific Northwest Bell Telephone Company; American Telephone and Telegraph Company; Michigan Bell Telephone Company; Pacific Telephone and Telegraph Company; United States Independent Tele-

"SURE, I'M STATION ENGINEER. SURE YOU HAVE A BREAK-DOWN,- BUT I'M SNOWED IN."

phone Association; Ohio Bell Telephone Company; and New York Telephone Company.

SIRSA contended that the channels were being used very lightly by the wireline carriers while Special Industrial frequencies in the same general portion of the spectrum were becoming overcrowded, and concluded that its proposal would increase the utilization of these bands and that the same time help to relieve growing congestion in the Special Industrial Service. It requested that the separation between assignable frequencies in these bands be reduced from 40 kHz to 20 kHz in line with other land mobile operations in this same region of the spectrum.

Pointing out that the technical standards contained in the rules specify a maximum authorized bandwidth of 20 kHz for this range of the spectrum, the Commission proposed to split-channel the bands 35.2-35.68 MHz and 43.2-43.68 MHz which would provide 46 assignable frequencies. The center frequencies of the existing channels would be retained for assignment and the 10 kHz splinters at each end of the bands would be combined with existing 10 kHz splinters in adjacent bands to produce 4 additional 20 kHz channels. This would result in a total of 50 assignable frequencies in the larger bands 35.19-35.69 and 43.19-43.69 MHz in place of the present 24.

Recognizing the needs of the Special Industrial Radio Service for additional frequencies in the lower UHF band, the Commission also proposed to allocate to that service, 14 of the newly assignable frequencies to be derived through the channel splitting. These new channels would be intended for regular two-way base and mobile communication.

The Commission said further that it would retain for common carrier one-way signaling service the presently assignable common carrier frequencies plus 8 additional one-way channels.

Four of the newly acquired channels would be allocated to the Special Emergency Radio Service for one-way signaling exclusively to meet the growing need for signaling service to doctors and other medical personnel.

Prime Time Rule Proposal

In response to a request by Camellia City Telecasters, licensee of KTXL-TV, Sacramento, Cal., for a declaratory ruling concerning the applicability of Section 74.1103 (g)(2) of the rules (non-prime time exception to the program exclusivity rule for network programs) the Commission has proposed amending the rule to make it apply also to nationally syndicated programs released on a same-day basis.

Section 74.1103(g)(2) now provides that the CATV system need not delete a network program scheduled between 6 and 11 p.m. Eastern Time, but broadcast by the station requesting deletion, outside of the Prime Time period for network programming in the time zone involved.

The Commission proposed to amend Section 74.1103 by inserting a Note I after 74.1103(g)(2) to read: The term "network program" includes programs nationally syndicated for release on a same-day basis.

Camellia City said that viewers may be deprived of the opportunity to watch many popular nationally syndicated programs in prime time because a higher priority station on the CATV system may schedule the program later in the day, and under the rules, may require the CATV system to delete any other presentations of the program, the same day on another station on the system.

The Commission said it found Camellia City's argument "quite persuasive", noting that in the **Second Report and Order in Docket No. 14895,** (2 FCC 2d 725, 749-750) it had stated that the reason for the non-prime time exception to the program exclusivity rule for network programs was to ". . . insure that such programs are available to the CATV subscribers in maximum viewing hours."

Reid Joins Commission

United States Representative Charlotte T. Reid, one of 12 women in the House of Representatives, has been sworn in as a Federal Communications Commissioner in a ceremony at the White House.

Mrs. Reid was appointed on July 2, 1971 to a full seven year term by President Nixon and confirmed by the Senate on July 29. She succeeds Commissioner Thomas J. Houser, who was appointed on January 5, 1971 to finish the unexpired term of Commissioner Robert Wells. Commissioner Wells was named by the President to a full term as Commissioner on January 5, 1971.

She studied music and voice with Louise Gilbert in Chicago for seven years. During that period she sang on radio stations in the Chicago area and from 1936 through 1939 was a featured vocalist with the National Broadcasting Company and on Don McNeill's "Breakfast Club," appearing under the professional name of Annette King.

Understanding Zoom Lenses

*Part 1 of 2 parts By Frank Bemish**

The advent of color and the plumbicon color camera has resulted in the television zoom lens coming of age. One of the important links in the video chain, it is probably the least understood. When properly used, this lens can become a valuable production tool.

A zoom, or variable focal length lens, consists of a marriage of fine optics with good mechanical design. Each element is equally important to the correct operation of the lens.

Zoom Lens Basics

The optics includes five basic groupings of lenses. (Figure 1) Starting from the front, the first group of elements is used for objective focusing. These elements compensate for the distance from the front of the lens to the subject to be focused upon and perform the objective focusing. Generally, they are mounted so they move in or out with relationship to the rest of the lens elements. The closer the subject is to the lens, the further out the focusing elements will be from the rest of the lens.

The focus elements are normally controlled by the cameraman's focus control and represent the operational focus on a color camera. Directly behind the focusing elements are a set of condensing optics that essentially colluminate the light, making the light rays perfectly parallel. Thus, an image is presented to the moving zoom elements that is always in focus, no matter what the position of the zooming elements.

The third and fourth groupings of elements are the main working parts of the lens. The third are the zooming elements and the fourth the back focus compensation group. These two lens groups must move in definite relationship to each other so that the lens will track focus throughout the zoom range. The zooming elements act, in essence, as a magnifying glass. As the lens is moved away from the objective focal point, this point is magnified. For example, the closer a reading or magnifying glass is held to the page of a book, the smaller the print appears. Move the lens away from the page and the print appears larger or closer to the viewer.

You will note that as you move the reading glass away from the paper you must also change the distance from your eye to the reading glass in order to maintain focus. In the same way the fourth group of lenses, the back focus compensation elements, work in relationship with the zooming elements. This relationship is controlled by a cam mechanism and it is this mechanical cam that is the heart of the successful lens operation. (See Figure 2.) This, more than any other single element, determines how well the total optical system will perform.

The fifth and last general grouping of optical elements is known as the rear element and it determines the back focal length and image format size. This is an adjustment for the distance from the rear of the lens to the image plane of the tube or film.

Range Extenders

Range extenders, when used, act

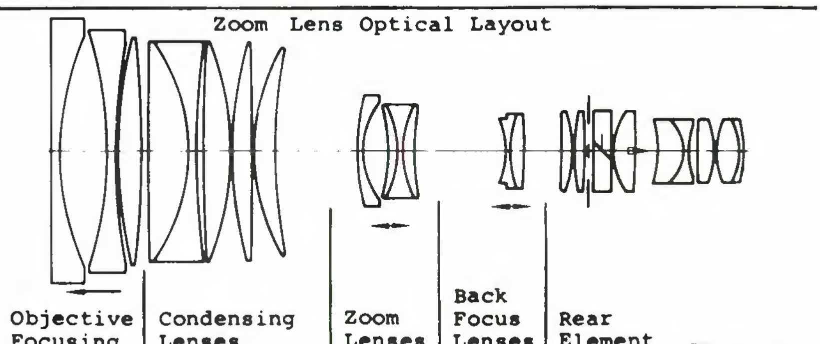

Figure 1

*Tele-Cine Corp.

as a magnifying glass increasing the rear format size of the lens. Since the format size with a range extender becomes larger while the useable format remains constant, the end result appears the same as increasing the focal length, i.e. the picture appears to become closer to the viewer. The disadvantage of range extenders is that each time the magnification is doubled, the light is halved. For example, 18 to 200mm f2.1 lens with a 2.0x range extender becomes a 36 to 400mm f4.2. In general, application light loss becomes so severe in magnifications greater than 2.5x that their practical use with color TV cameras is limited.

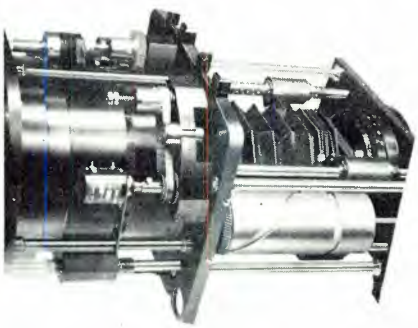

Figure 2

Zoom lens are designed to focus track from minimum working distance (28", 4.0', 6.0', etc.) to infinity. This generally means that anything further from the specified minimum working distance of the lens will be capable of being in focus through the zoom range.

Lenses with long minimum focal length will sometimes resort to a racking focusing movement or sliding the entire lens away from the image plane in order to focus on an object closer than the rated minimum working distance. This works; however, the lens will be in focus at only one point on the zoom range and cannot be zoomed. A zoom lens used in this way becomes a fixed focal length lens.

Reducing Minimum Focusing Distance

One method of reducing the min-

Figure 3

imum focusing distance is by the use of a close up adaptor. (Figure 3) This is an additional front lens element that is attached to the front of the zoom lens to reduce the minimum focusing distance. Three things happen when a close up adaptor is used. The minimum focusing distance is reduced by some factor (0.5x). The zoom lens loses infinity focus, and you lose some light transmission. If a lens has a normal minimum close focusing of 28″ to infinity, when a 0.5x close up adaptor is used, the working distance now becomes 14″ to 28″ so you note that a close up adaptor is not used beyond its normal close working distance.

Manual Control

It is normal practice to control the lens from the operator position at the rear of the color camera. This is accomplished by interconnecting the camera controls and the lens by means of a flexible shaft similar to a speedometer cable. Normally, manual control gives the

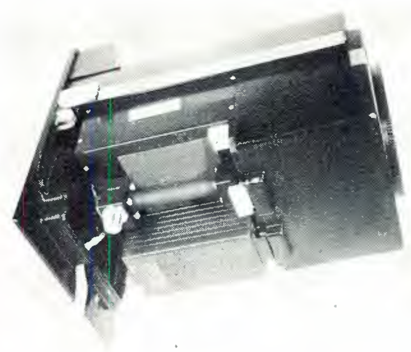

Figure 4

operator adequate flexibility with a minimum of effort. There are, however, limitations. Mechanical linkage, friction and operator physical limitations show up when extremely slow or fast zoom movements are attempted. The only practical way of overcoming these problems is by motorizing or servoing the lens.

Servo lenses have, in the past, been large and cumbersome and the inability to have a manual backup meant that servo down time forced the loss of the camera. When the plug-in servo module concept applied, a new era in servo lens use appeared. Now lenses could be converted from manual to servo and back in the field. (See Figure 4.) Newly designed DC servo systems give operational zoom speeds from one second to 12 minutes end

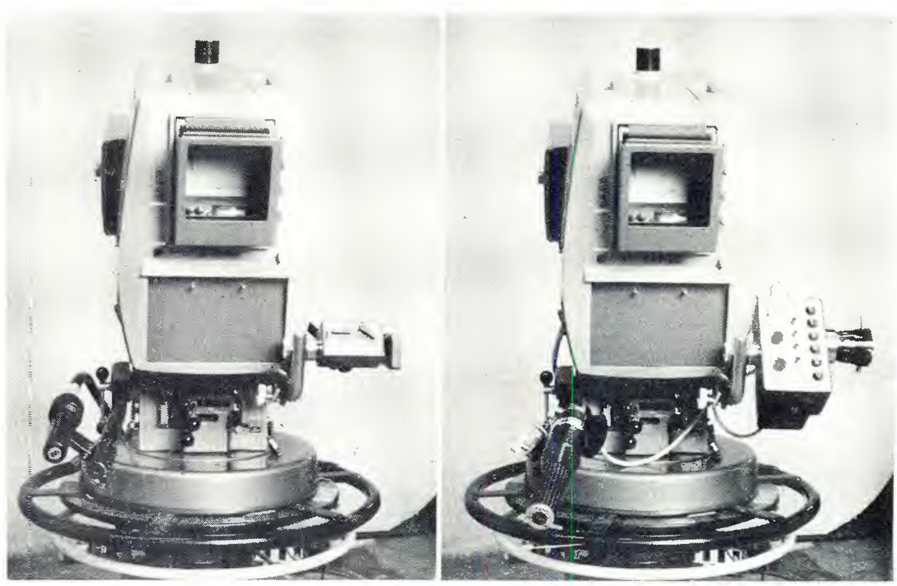

Figure 5

to end; and coupled with a shot box which allows precise pre-setting of shot framing and zoom speeds as well as focus in some cases, any operator can easily perform movements that would be impossible with a manually controlled lens.

In the next article, we will discuss technical setup procedures, maintenance and operating techniques that will give you the maximum performance from your lens and color camera.

Business and Finance

Commission Adds CATV Forms

Final versions of two report forms that must be filed by CATV operators, FCC Form 325 (general information, CATV services and ownership information) and FCC Form 326 (financial information), have been adopted by the Commission (Docket 18397). Form 325 will be due March 1, 1972 and Form 326 will be due April 1, 1972. The action amends Parts 0 and 74 of the rules.

The Commission issued a rule making notice and a notice of inquiry on December 13, 1968 proposing that CATV operators file annual reports providing current information on such matters as location of the CATV systems; number of subscribers; channel capacity; broadcast signals carried; extent and nature of program originations; any other operations conducted on the system; financial data; ownership and interests in other CATV systems; broadcast media and other businesses.

The Commission said that it was issuing its present order so the annual reporting requirement could be implemented as quickly as possible, even though the forms themselves will not be ready for several weeks. Copies will be mailed to all known CATV operators early in November, so they may study well in advance of the filing deadlines, the Commission stated.

For both forms, the first reporting period will be calendar year 1971. Form 325 must be filed on or before March 1 of each year, for the preceding calendar year, and Form 326 must be filed on or before April 1 of each year, for the preceding calendar year. A CATV system that begins operation before December 1, 1971 may report financial information on a fiscal year basis and must file annually not more than 90 days after the close of the system's fiscal year. If a CATV operator is using a fiscal year basis for Form 326, his first report should cover the fiscal year that began on or after January 1, 1971.

Form 325

In the case of Form 325, only non-operating CATV systems will be exempt from filing an annual report. Program origination questions have been incorporated into the CATV services section so that a separate program origination form is no longer necessary. Instead of requiring a separate Form 325 for each CATV system, composite reports may be filed when CATV systems are under common ownership and all the services and ownership information requested by the form is identical.

The CATV services section of Form 325 asks about program sources (local, automated or video tape), types of programming and number of hours of each during the "specified week" for reporting. The specified week is defined as the seven-day period beginning at 12:01 a.m. on December 1, 1971 and ending at midnight on December 7, 1971.

If it is impossible for CATV systems to use the specified week, they may use any seven consecutive days of the 60-day period immediately before the date of filing of Form 325, as long as they explain the reasons for not using the specified week and indicate the dates that are being used instead. A proposed rule requiring CATV systems to maintain program logs will permit future reporting to be based on a composite week, the Commission stated.

Adoption of Forms 325 and 326 became effective November 22, 1971.

The New Remote Control VIT Signal

This new ruling will still require a First Class Operator for the remote monitor. If properly used, this method could improve the TV signal quality.

By Bruce Longfellow / Rules and Standards Div., FCC.

Commission experience in authorizing the remote control of television transmitters—extending from the first actual UHF remote control operation in 1963 through extensive VHF testing by NAB and others—has emphasized the pressing need for improved control over the quality of the transmitted picture.

The almost complete conversion to color since remote control was first authorized has added an entirely new dimension to the problems of transmitter operation and maintenance, while the separation of the operator on duty from his transmitter and control console has made it plain that more, not less, attention to the quality of the transmitted picture is needed.

The Commission has concluded that, in order to best achieve this rededication to highest possible technical quality, appropriate means must be provided for the station's engineering staff to be kept fully aware of transmitted signal characteristics at all times. Consequently, in authorizing VHF transmitter remote control operation, the Commission determined that suitable locally-generated test signals in the vertical blanking interval would be required for all transmitters—UHF as well as VHF—when operated by remote control. After receiving comments from all segments of the industry as to the nature of the test signals, the Commission in its Second Report and Order in Docket #18425 adopted the new test signal requirements. This article will describe the new test signal, discuss the basis for its choice and explain what the Commission does and does not expect of television licensees who employ it.

The adjustment of a television transmitter for proper operation requires the employment of test signals of controlled characteristics. These signals normally are utilized only during maintenance periods, and are transmitted over the full picture raster. However, the ability to transmit test signals along with picture information has a recognized value for detecting and identifying performance deficiencies occurring during regular operation.

Such signals may be generated locally and transmitted in the vertical blanking interval during regular programs under an FCC rule on its books for a number of years.[1] Generally, however, the only test signals radiated in the vertical interval have been those generated by the networks, used in the maintenance of long network lines, and intended for observation at the line terminals. Under the rule, these signals need not be erased before transmission, and in the usual case, the television station radiates the network test signals along with the picture. Although these test signals may be observed at the transmitter output to assess transmitter performance, the degradation they suffer in traversing the network lines makes them of limited value in transmitter testing. Moreover, the relative and absolute levels of the signals are not in all cases the best choices for transmitter surveillance.

New Requirements

The new remote control rules require the transmission of test signals of specified characteristics in the vertical interval during all periods of regular programming. With one exception discussed below, these test signals are to be inserted in the vertical interval at the remote control point, and, after radiation, to be received and observed there, with the results of observations logged at half-hour intervals. At the remote control point, the transmitter operator has control over these signals, and may whenever desired compare the input test signal with the output signal as received over the air.

If the remote control point is not at the studio, this requirement poses obvious problems, since the STL input ordinarily would not be accessible at the remote control point. Since a single location for performing all of these functions is desirable, the remote control location should be chosen with due regard for this problem. Remote control applications specifying a remote control location other than the main studio (Question 5(c) of FCC Form 301-A) require an explanation of the choice of location. If the test signal is inserted at such a location, a waiver of the Commission's rules is required. Any such proposals should include full justification, including the provision of

NOTES:

1. A breezeway, as shown between bursts, is recommended. Each burst = 60 IRE units peak to peak.
2. T_0 = Nominal start of active portion of line 18, field I.
3. Rise and fall of white bar shall have risetime of not less than 0.2 μs.

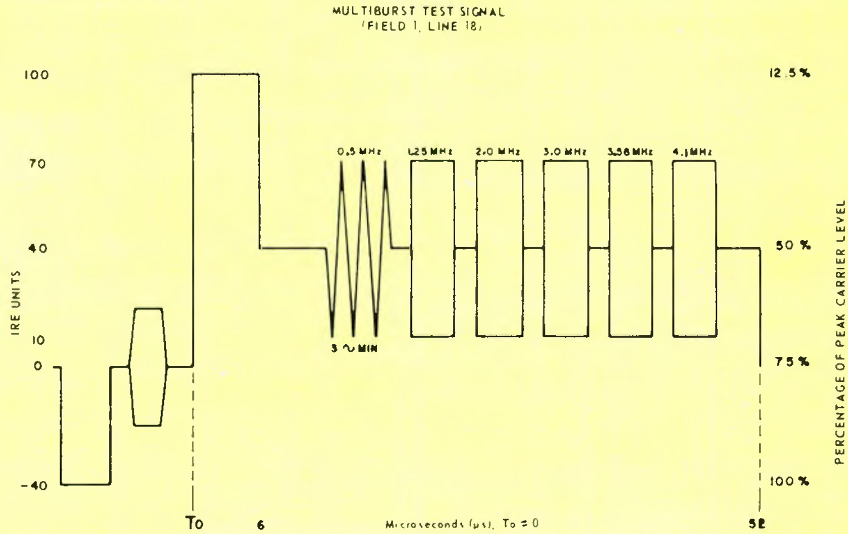

Fig. 1 VIT waveform required for field 1, line 18.

NOTES:

1. Phases and amplitudes of the colored bars are in accordance with the FCC Rules and Regulations for 100% saturated colors of 75% amplitude.
2. White flag (bar) at reference white precedes the colored bars.
3. A black bar at setup level follows the colored bars.
4. Each bar 6 μs minimum duration.
5. T_0 = Nominal start of active portion of line 18, field II.

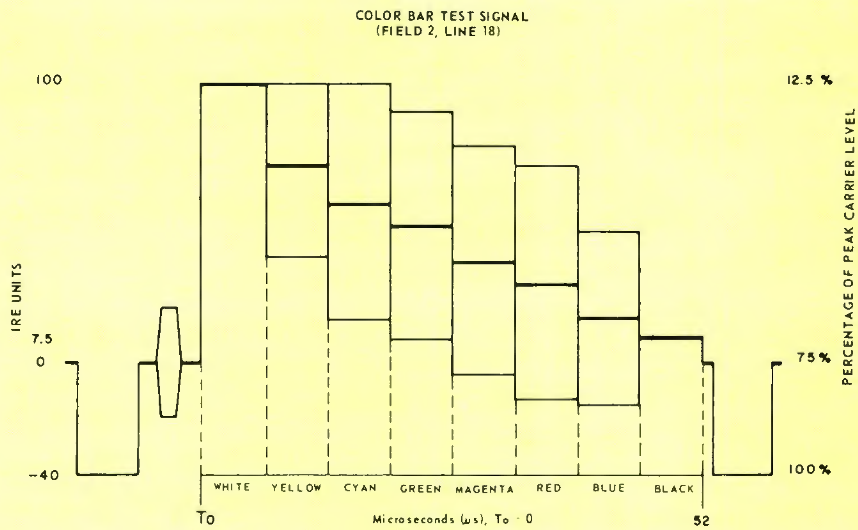

Fig. 2 VIT waveform required for field 2, line 18.

NOTES:

1. Sub-carrier of staircase in phase with burst.
2. Rise and decay of all luminance signals not less than 0.2 usec. Rise and decay of envelope of sub-carrier component of stair-step signal shall be approx. $\sin^2$ shaped and risetime .375 μsec.
3. T_0 = Nominal start of active portion of line 19.

*half amplitude duration

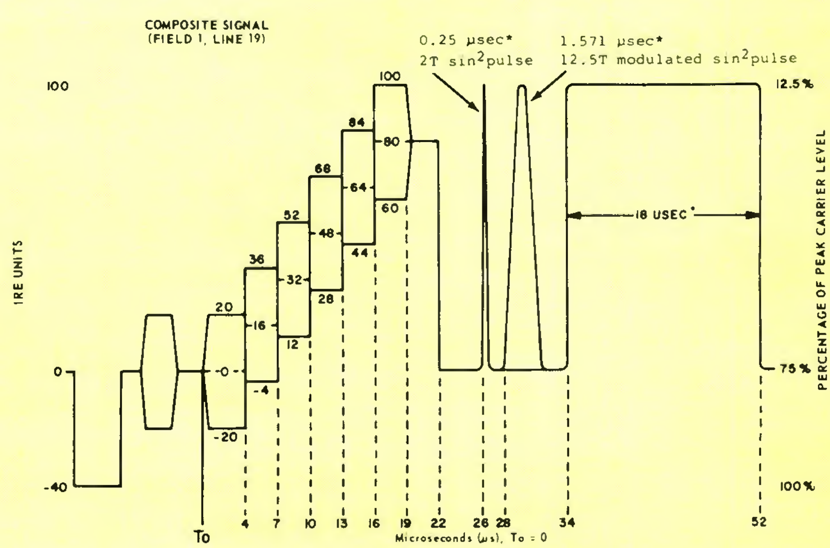

Fig. 3 VIT waveform required for field 1, line 19.

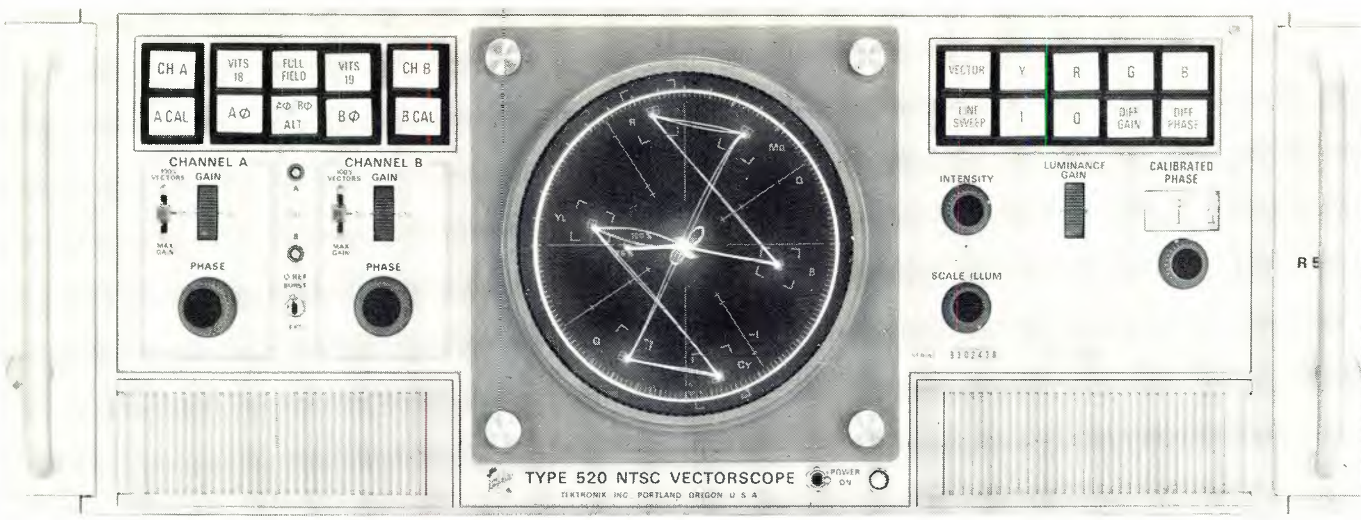

Fig. 4 Vectorscope display of color bar test signal on line 18, field No. 2, showing color bars in proper amplitude and phase.

complete system surveillance from the remote control point.

Signal Insertion

The test signals are to be inserted on lines 18 and 19 in the vertical interval and will occupy line 18 in both fields and line 19 in field No. 1. The signals to be employed and their characteristics are those proposed by EIA in the rule-making proceeding.

In summary, these signals are: **Field No. 1, line 18. Multiburst, preceded by white flag (See Figure 1).**

Field No. 2, line 18. Color bars, preceded by white flag (See Figure 2).

Field No. 1, line 19. A composite signal, consisting of the sequential transmission of a five-riser staircase, each tread added to color subcarrier phased locked to the color burst, with a peak-to-peak amplitude of 40 IRE units, a 2T sine-squared pulse, a 12.5T pulse modulating color subcarrier, and a white flag of 100 IRE units in amplitude and 18 μs in duration. (See Figure 3).

Normally, the line 19 composite test signal would also be inserted on field No. 2 at the remote control point, but it may be inserted at the transmitter input if a station licensee desires to make a separate determination of the effect of his transmitter and studio-transmitter link on system performance. Alternatively, the licensee is permitted to insert test signals of his own choosing on line 19 of field No. 2 either at the remote-control point or at the transmitter, provided that the insertion levels and other characteristics of the signals result in no interference with the observation of the required signals or with the transmitted picture.

The levels are standardized as shown in Figures 1, 2, and 3. The average picture levels (APL) of the signals have been balanced for each field, and the components are so arranged as to reduce the possibility of interference between test signals. For monochrome transmission, the chrominance component of the color bars is removed.

Lines 18 and 19 were selected for the locally-generated test signal transmissions to protect tentative commitments for the use of other lines which are available under existing rules. Line 17 is being considered for the transmission of test signals accompanying programs intended for international distribution, and line 20 may be occupied in the future by a vertical interval reference (VIR) signal which is being developed by an industry committee (See January, 1971 BROADCAST ENGINEERING). The VIR signal would accompany a color program from its source, and would be used to detect distortion introduced at any point in the transmission path which might adversely affect color quality.

Television engineers are generally familiar with all of the test signals described, and employ some or all in the testing and adjustment of transmitter during maintenance periods. The primary uses of these signals are well-known: the multiburst for transmitted video amplitude vs. frequency response measurements, color bars for ascertaining the ability of the system to transmit color components in the correct relative amplitudes and phases, the staircase for the measurement of dynamic gain, and differential gain and phase, the 2T pulse for the observation of transient response, and the white bar for low frequency phase characteristics.

The 12.5T pulse is used for chrominance/luminance delay measurements in lieu of the more familiar 20T signal, since the frequency spectrum of the 12.5T pulse more closely approaches that of the NTSC 525-line color signal than does the 20T pulse. The signal for each field includes a white bar at 100 IRE units, which may be used as a reference level.

Employing Test Signals

The rules do not specify the way in which particular test signals are to be employed, and each licensee is expected to develop his own procedures. For example, the multiburst signal may be employed to observe the video amplitude vs. frequency response while for color transmission the color bar test signal may be displayed on the vectorscope (Figure 4).

Likewise, appropriate use may

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8812	6.25	8.75
8813	12.5	17.5
8915	17.5	25.0

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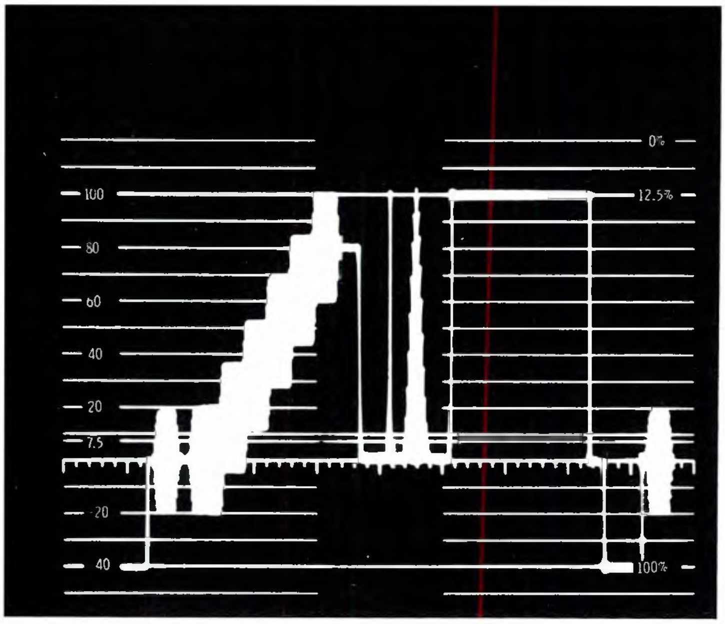


Fig. 5 Waveform display of composite signal on line 19. The 12.5T pulse shows correct amplitude response at 3.58 MHz, with negligible envelope delay.

be made of the other elements of the test signals to determine a wide variety of transmitting system parameters. Examples of typical insertion and test equipment, together with oscilloscope displays are shown in Figures 4 through 6.

Test signal observations are required to be made immediately after commencement of operation, and during operation at intervals not exceeding one-half hour. More frequent observations are to be made if necessary to insure proper performance of the transmitter and associated equipment. The date and time of each observation of the test signals must be entered in the operating log, together with notations as to the results of these observations.

Test Signal Distortion

The received test signals may be distorted to some extent because of limitations in the monitoring system itself, and not necessarily as a result of transmitting system deficiencies. Concern was expressed by some persons commenting in the rule-making proceeding that the FCC might use test signal observations as a basis for issuing notices of violation although observations based on the test signals might not necessarily accurately reflect the performance of the transmitting system. This was cited by some of the parties as a reason that specific test signal requirements should not be set by rule prior to extensive testing.

The FCC recognizes that such distortions may occur, but does not believe that this substantially lessens the utility of the test signals for surveillance of the transmission system. This does require, however, that the monitoring system be carefully designed and installed, and the rules require that the waveform monitor at the remote control point be periodically calibrated against a monitor maintained at the transmitter.

Multipath propagation of the signal between the transmitter and the remote control point is an obvious source of distortion. At the remote control point, its effects may be minimized by the proper selection, sitting, and orientation of the receiving antenna. On the other hand, this would not always be possible when the monitoring of test signals is undertaken with a mobile unit. Thus the FCC would not rely solely on off-the-air observations of test signals in detecting deficiencies in television station operation, but would follow up apparent deviations with observations at the transmitter.

In any event, the test signal requirement is not being adopted as an enforcement tool, but to give the television station licensee a more effective and meaningful method for monitoring the daily operation of his transmission facilities.

The other major source of distortion may be in the demodulator which feeds the waveform monitor or vectorscope for test signal observations. Quadrature distortion is produced in an envelope detector when the portion of the television signal which is transmitted in the single sideband region (this includes the color subcarrier) is demodulated to baseband, and is more severe the higher the level of the signal component relative to the carrier at the demodulator input. It is manifested, among other things, in inaccurate indications of differential gain and phase at the color subcarrier and distortion of the chrominance/luminance relationship.

The effects of quadrature distortion on a test signal may be minimized by reduction of the amplitude at which the test signal is transmitted. The specified multiburst signal is limited to a peak level of 70 IRE units primarily for this reason. The reduced amplitude of this signal also lessens the possibility that intercarrier buzz may result from its transmission.

How serious a problem this kind of distortion will present depends largely on the demodulator characteristics. A number of demodulators of recent design incorporate features intended to limit quadrature distortion. A "state of the art" demodulator, which the FCC rules require be installed at the remote control point, should include such features as a minimum. Likewise, where a signal frequency amplifier must be used to raise the level of the off-the-air signal delivered to the demodulator, it must be of such quality as not to limit monitoring system performance.

Residual distortions normally would be identified and accounted for by appropriate calibration procedures. While the rules do not require it, this procedure may be simplified if the waveform monitor at the transmitter output against which the remote monitor is calibrated is fed by a demodulator of characteristics identical to those of the demodulator at the remote control point. This is particularly true, since both demodulators should have the same degree of quadrature distortion, and for regular operation must be operated with the sound notch in, which will modify the indicated response from that of the visual transmitter itself.

In some cases there may be significant differences in the performance of a transmitter when handling vertical interval information as compared to program material. These differences should be identified by full field/vertical interval test signal comparisons in the calibration procedure.

Since lines 18 and 19 may be occupied by network signals, and excess noise may be present, erasing facilities must be employed before the locally-generated test signals are inserted at the input to the studio-transmitter link.

New Equipment Coming

To permit station licensees to obtain the necessary signal generating equipment, the FCC has postponed the implementation of the test signal requirement until April 1, 1972.

The FCC expects that well before the effective date of the test signal rules, signal generators capable of providing all of the required test signals will be available. Such generators will incorporate facilities for erasing incoming signals and noise from lines 18 and 19, and for inserting the test signals directly on these lines. While these generators would seem to offer the simplest and perhaps most economical method for providing the required test signal input, the television licensee is not precluded by the rules from employing any combination of separate signal generators and auxiliary equipment which will produce test signals of the specified characteristics.

Off-the-air test signal observations are not expected to provide an absolute measure of transmitter performance, but rather are relied on to indicate departures from normal transmitter performance determined at the time the off-the-air monitor is calibrated. Thus, the broadcaster is not expected to make a detailed evaluation of the characteristics of the test signals when they are observed and logged each half hour—only significant deviations from normal transmission need be specifically noted and analyzed.

The FCC has no immediate intention of establishing standards for type approval of vertical interval test signal generators, or for other items of equipment, such as demodulators, whose performance characteristics may affect test signal transmission and observation. The development of standards, and particularly the subsequent testing of various manufactured units for compliance with these standards, can be extremely time-consuming and would unduly delay the implementation of the test signal rules.

The broadcaster can best assure that the apparatus he acquires is of satisfactory quality by a careful study of detailed specifications, which any reputable manufacturer will supply, of any piece of equipment he has under consideration, with due regard to the requirements of the rules.

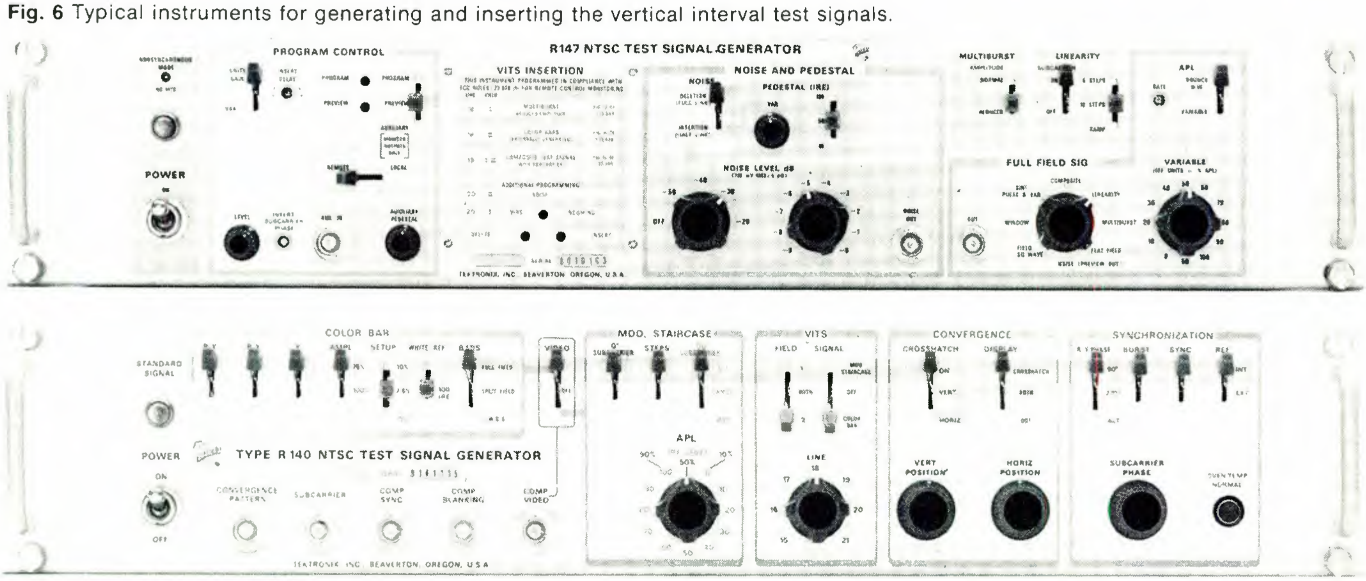
In adopting rules requiring the regular transmission and observation of vertical interval test signals by television stations operating by remote control, the FCC is providing a new, and it believes, more effective means for the continuing supervision of television transmission systems. As the broadcaster gains operating experience under these rules, the need or desirability for their modification may become apparent. The FCC would appreciate suggestions from the broadcaster, or reports in problems encountered.

If, as is hoped, this method of transmitter supervision becomes firmly established and accepted for use by television broadcast stations operating by remote control, consideration may be given to the extension of the requirement to all television broadcast stations. At that time, it may be appropriate to consider the relaxation of rules which require the half-hourly logging of the traditional operating parameters. ▲

Footnotes

[1]73.682(a) (21): "The interval beginning with the last 12 microseconds of line 17 and continuing through line 20 of the vertical blanking interval may be used for the transmission of test signals . . ."

Fig. 6 Typical instruments for generating and inserting the vertical interval test signals.



Multiplying, mixing and modulating with IC's

Part 2 of a two-part series *By Walt Jung*

Last month we talked of the balanced modulator in IC form as exemplified by Motorola's MC-1596/1496 chips. The balanced modulator by itself is certainly an important enough IC development, but it is more than that. It also forms the basis for a completely linear **four quadrant multiplier,** a circuit which performs circuit functions previously impossible or economically unfeasible.

The four quadrant multiplier operates with two linear voltage inputs (X and Y) in the range of ± 10 Volts and generates an output signal which is the product of these two inputs times a scale factor, "K". Therefore the output is of the form Eo=K Ex Ey where K is the scale factor and Ex and Ey are the X and Y inputs. As in the balanced modulator, the device is termed four quadrant, because the output will always possess the correct algebraic sign with any combination of Ex and Ey polarities.

This month we'll look inside this type of IC to see how it works and also explore a few applications useful to the broadcast engineer. Among the applications of the four quadrant multiplier are: modulation and demodulation, phase detection, frequency multiplication, electronic gain control, audio or video switching, voltage tunable filters, and power computation.

Heart of the Four Quadrant Multiplier

Last month we described how a monolithic balanced modulator performs the process of multiplying two inputs. This is accomplished by the two inputs to the device, termed the "signal port" and the "carrier port" on the MC1596/1496. In Figure 1 you will note a very close similarity to the MC1596/1496 contained in the left hand portion of the circuit. This circuit is of course a balanced modulator also, the only difference being the addition of Darlington connected drivers to Q5 and Q6. The biasing network of Q7-Q9 is identical to the MC1596/1496, and the collector currents of Q5 and Q6 feed a quad set of current mode switches, Q1-Q4, just as in the MC1596/1496. But note the base drive for Q1-Q4 —not from the external world, but from another circuit (the right hand portion).

The reason for this additional circuit is the difference in concept between the basic balanced modulator (as typified by the MC1596/1496) and a fully linear four quadrant multiplier such as the MC1595/1495 (which is what the schematic of Figure 1 shows).

Last month we discussed the signal handling capability of the MC-1596/1496 carrier input or the quad transistor set of Q1-Q4. These transistors only exhibit a linear voltage input/current output transfer for small signal levels; 50mv or less. For signals much beyond, linearity suffers, and compression of the transfer characteristic begins to occur. Further increases cause more signal compression, until beyond a certain input signal level, full limiting occurs.

The distinction we are making here is that the basic balanced modulator (MC1596/1496) is best suited as a switching mode type of multiplier because of this natural limiting characteristic of the carrier input transistors Q1-Q4. To realize

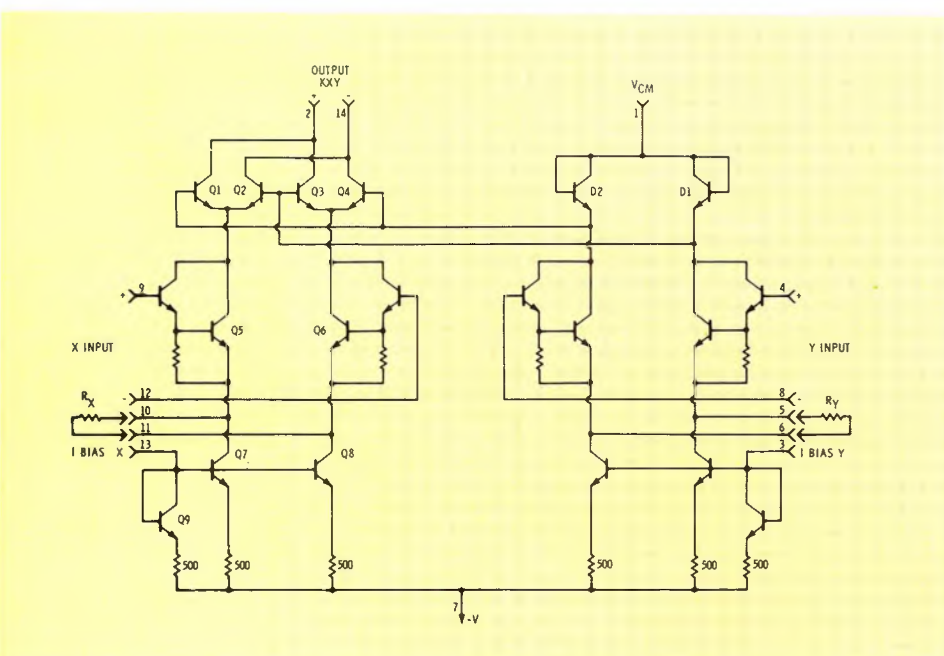


Fig. 1 The MC1595/1495, a linear four quadrant multiplier.

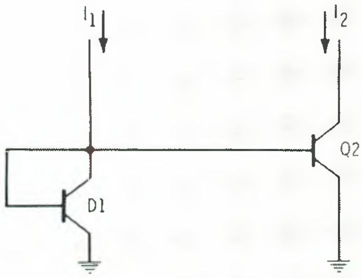


Fig. 2 Illustration of linear current control through non-linear processing.

a completely linear transfer characteristic through this port, some additional monolithic matching tricks are brought into play.

Linear Current Transfer Through Non-Linear Processing

If we consider a pair of identical transistors (such as those readily available through monolithic matching) we will note some very basic properties which can be brought into play in a highly useful manner. In Figure 2, D1 and Q2 are a matched pair of transistors with D1 diode connected and in shunt with the base of Q2. It is a well known property of a semiconductor diode that its forward voltage drop is logarithmically related to the current flowing through the junction. In Figure 2, D1 is such a diode and will exhibit a drop (which is also its Vbe) which is logarithmically related to I1. Note that for linear current changes in I1, the Vbe of D1 will vary in quite a non-linear fashion, since it is logarithmically related.

But now consider the effect of Q2. The collector current of a transistor is exponentially related to its base voltage. This also is non-linear; the voltage changes required in Q2's Vbe for linear collector current changes are very small and not related in a linear fashion.

Now relate these two phenomena to the original assumption of identical transistors for D1 and Q2. For a given Ic the Vbe's of the two transistors will be identical. Stated another way, if a current I1 is fed into D1 it will naturally develop a Vbe across D1 which is logarithmically related to this current. But since Q2 receives this same base voltage, its collector current will be an exponential function of it. Since the two are ideally matched, I2 will be equal to I1!

It also follows that equal changes in I1, will result in corresponding equal changes in I2. So we can see how two non-linear transistor properties can be utilized to realize linear current transfer through the use of matched transistor properties which cancel the non-linearieties in complementary fashion.

Now we can relate this property to Figure 1 in a couple of steps and see how a complete linearization of the Y channel signal input takes place. First, refer to Figure 3, which is a simplified model of the multiplier with the non-linear processing. Diodes D1 and D2 represent the logarithmic elements similar to D1 to Figure 2. These two diodes receive the equal and out of phase currents from the Y channel input differential pair. These two signals are shown as +Iy and –Iy. So far this stage operates just as the signal port we discussed last month for the MC1596/1496, with the exception that loads for this stage are the diodes D1 and D2.

Now you will also note that D1 and D2 are in parallel with the upper port quad transistors (Q1-Q4) of the balanced modulator. And just as we talked of matched transistors for the development of Figure 2, here we will consider all of the Q1-Q4 set and D1-D2 identical. It is quickly apparent what happens now. The differential logarithmic voltages across D1 and D2 exactly complement the drive requirements for non-linear voltage control of Q1-Q4. As a result the currents +Iy and –Iy control the relative conduction of the Q1-Q4 set in a linear manner, although the means of control is decidely non-linear.

Let's review what has been accomplished in this process. We have two linear input signals, Ex and Ey which are converted into corresponding currents proportional to Rx and Ry. These currents appear differentially as ±Ix and ±Iy. ±Iy is processed logarithmically and used to control one input of a balanced modulator (Q1-Q4). The other input to the modulator is ±Ix. These two inputs are multi-

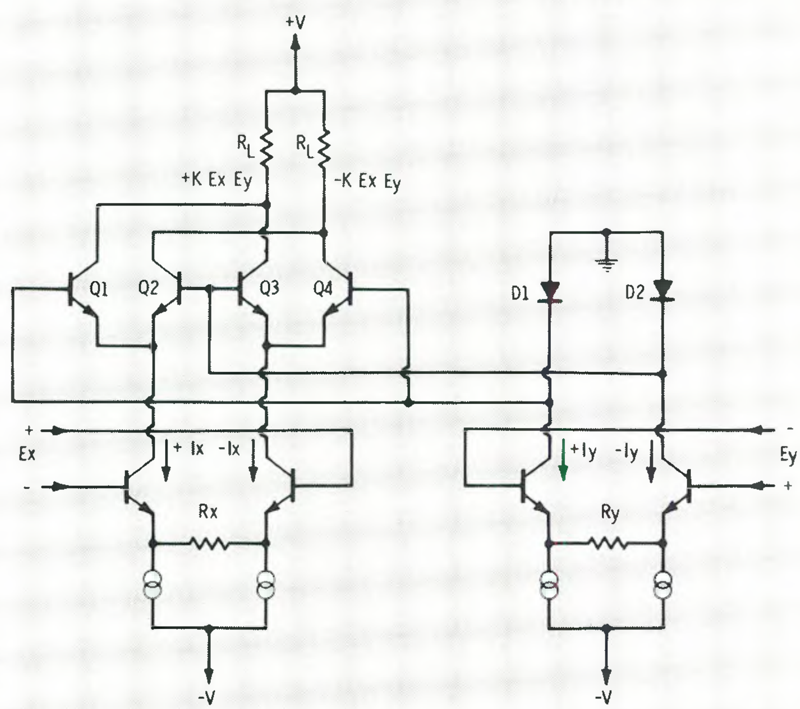


Fig. 3 Basic model of a four quadrant multiplier.

Here are eight problems that cost you money

no control track

bad electronic edit

control track out of phase

head not locked to video

unstable capstan

non-synchronous switches

60 cycle drum error

low-band color played in hi-band

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To prove our point, Ampex engineers have prepared the *"World's Worst Videotape Recording."* It took our best engineers to make a recording this bad. A tape containing eight recording faults in an exaggerated degree. We're sure these errors are never made in your operation, but other people make them and you have to play them. And you can with an AVR-1; with less operator time, too!

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Join us in our world of profit-producing picture perfection with the AVR-1.

Get more fron

Improved monitoring and test facilities

In addition to the standard *pulse-cross video* monitor, the AVR-1 is provided with dual waveform monitors for display of both signal and system waveforms. Audio monitoring includes a new high-quality acoustic-suspension speaker and amplifier with audio and cue level controls. A dynamic microphone is provided, as are selector push-buttons and two true VU meters.

New tape timing accuracy

Dependable, repeatable accuracy in tape timing is provided by the new Ampex Electronic Tape Timer. Counting either elapsed or remaining time in hours, minutes, seconds and frames, this timer can freeze a reading to locate a position on tape and is accurate to the frame. Displays are large and easy to read.

he AVR-1

Functionally separated controls

Logical AVR-1 control groupings provide for the ultimate in operating flexibility. Primary transport controls can be remoted to production areas. The secondary controls are divided into three sections: set-up panel, standards control panel and maintenance panel. Set-up and standards control panel can also be remoted.

New Mark XX video head assembly

Changing a video head assembly on the AVR-1 is push-button easy. A single precision lock permits the operator to push the button and lift the Mark XX Video Head from its preamp subbase. The vacuum guide automatically withdraws from the head for tape threading and for easy cleaning.

Improved tape handling

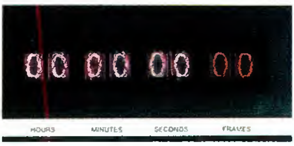
Six features of the AVR-1 provide for improved tape handling: Vacuum columns, air guides, vacuum capstan, glass transport cover, retracting vacuum guide block and tape shuttle control.

...and profit fron

More from the incredible AVR-1

Instant video

The AVR-1 achieves stable operation in less than 200 milliseconds after startup. When picture break-up occurs, the AVR-1 fades to black, stays in black during disturbance, then comes up on a stable picture when the disturbance is over.



A fully-framed video output occurs in less than 6 frames; 6 frames easily cued by means of the AVR-1 timer display and a convenient knurled capstan grip.

Fully synchronous operation

Reference sync, blanking and color burst from station composite sync are added to the AVR-1's signal—its output can be switched and mixed like that of a camera.

Stability

The AVR-1 computer-type circuitry offers something new: once you set them, control adjustments *stay put.* Optimum conditions are set to occur at a zero volts DC level; to set up, simply zero the knobs on the secondary control panels.

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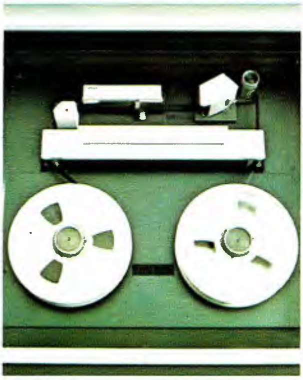

Rapid loading

Tape reels mount conveniently at waist height. Threading is a simple, sweeping motion. And a high-speed, continuously-variable shuttle control speeds work at the machine.

Vacuum columns

Vacuum columns, combined with outstanding servo systems and the wide range time-base correction, give the AVR-1 its 200-millisecond lockup. And help clean and preserve tape, by eliminating mechanical tensioners. The oxide surface of the tape touches only the heads.

Wide range time-base correction

The AVR-1 takes a new approach to the problem with an extended range of ±32 microseconds. Servo systems control tape speed, tape tension, and head-wheel positioning to bring the error within this correctable range.

Check the full story with your Ampex Sales Representative, or write: National Sales Manager, Video Products Division, Ampex Corporation, 401 Broadway, Redwood City, CA 94063. Ask too, about the many AVR-1 accessories including automatic tracking control, velocity compensator, electronic editor and the new auto-chroma. We can also tell you about the companion of the AVR-1. The automatic cassette recorder which includes all these automatic features. The Ampex ACR-25. You'll profit from the experience.

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plied within the modulator and appear at the output resistors as ±KExEy. Just as in the basic balanced modulator, these output signals are four quadrant, always possessing the correct sign for all input polarities. The scale factor "K" is set by the resistances Rx and Ry in relation to RL and the ratio of Y channel current to X channel current. Both signal inputs are differential and can handle DC as well

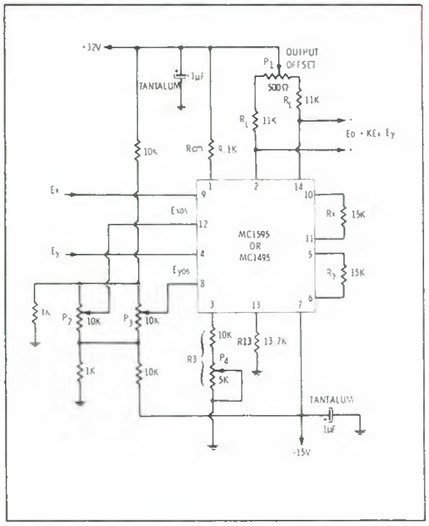

Fig. 4 Test circuit for the MC1595/1495.

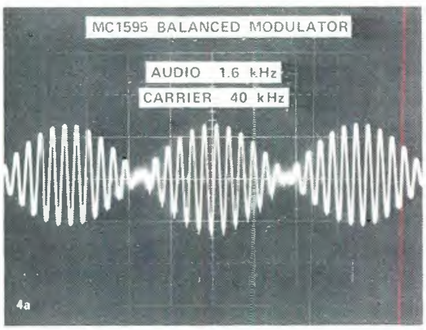

Fig. 4a Scope pattern for the MC1595 balanced modulator.

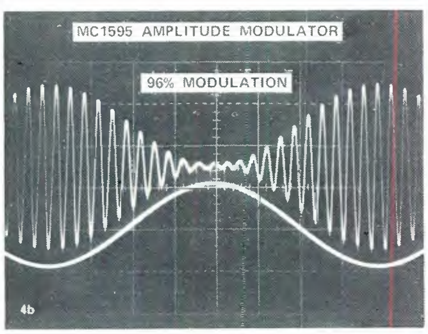

Fig. 4b Scope pattern for the MC1595 as a modulator.

as AC signals.

If we turn back to Figure 1 we see how this all goes together in a single chip as Motorola's MC1595/1495. This chip is in a 14 pin dual-inline package and contains all the circuitry shown in Figure 1 (with the exception of the Rx and Ry scaling resistors). As was true for the MC1596/1496, you will note there is little internal commitment of signal leads; rather, all pertinent points are brought out to the user for flexibility.

Biasing of the X and Y differential input channels is identical to that of the MC1596/1496: selection of a single external resistor sets the current in the differenital amp. The X and Y biasing taps are separate, however. This facilitates scaling of the relative bias ratios between the two channels. The bias connection for D1 and D2 (Vcm) is brought out for external connection.

Setting up the MC1595/1495 For Operation

Now that we have dissected the gadget and exposed its inner workings we'll want to put it to work in a few applications. We'll begin by talking of a few parameters important in applying the device and then progress into some useful circuits.

The first step in setting up an MC1595/1495 is the DC biasing required to properly operate the device within its linear range. Let's look at a typical operating condition and see what this means circuit wise. Figure 4 illustrates a typical multiplier circuit set up for an X and Y input range of ±10 Volts and an output swing of ±10 Volts. Under these conditions K is equal to 1/10. X and Y channel bias currents are set to 1 ma by R3 and R13, with R3 made variable (more on this in moment).

For good linearity, the dynamic current in Rx and Ry is not recommended to be more than ⅔ the bias current at pin 3 and 13. This makes Ix and Iy .67 ma max, and with Ex and Ey 10 Volts max, Rx and Ry then become 15 K.

The value of the load resistor RL is determined by the scale factor K, Rx, Ry, and I3 according to the relation

$$K = \frac{2RL}{13Rx\ Ry}.$$

Since all of these factors are known, we can easily solve for RL and it is found to be 11.25K. And since the scale factor is also dependent upon I3, trimming this current allows a precise value of K to be set. So we can use an 11K resistor for R1 and set K to exactly 1/10 by trimming R3 with the 5K pot.

The remaining resistor, Rcm, is selected to drop the difference between the supply voltage (here 32 Volts to allow a 10 Volt swing at each RL) and a voltage high enough to insure non-saturated operation of the Y channel input transistors. Since these transistors must swing +10V max, 3 Volts is added for safety. Then this plus the .7 Volts of D1-D2 places pin 1 at 13.7 Volts. Then

$$Rcm = \frac{32-13.7}{2\ ma} =$$

9.15K or, since this voltage is not critical, the nearest standard value of 9.1K is used.

These conditions set up the basic operational conditions of the circuit "ball park" so to speak. But for precise operation, the conditions will need to be trimmed more closely to optimize things. This is similar to the carrier balance technique used with the MC1596/1496, but in this case there are more adjustments. There is a definite procedure recommended, which goes as follows: **(1)** With Ex and Ey=0, adjust output offset (P1) to zero. **(2)** With Ex=5v, Ey=0 adjust Ey offset (P3) until output is zero. **(3)** With Ey=5v, Ex=0, adjust Ex offset (P2) until output is zero. **(4)** With Ex and Ey=0, adjust offset (P1) to zero. **(5)** With Ex=Ey=5v, adjust scale factor (P4) until output is 2.5v. **(6)** With Ex=Ey=-5v, insure that output is correct at 2.5v. If out of tolerance, repeat steps 1-5.

Having properly set the multiplier up for correct operation, it will now operate according to specification. The MC1595 has a maximum output linearity error (in percent of full scale) of 1 percent for the X input, a 2 percent for the Y input. The MC1495 has maximum allowable errors of twice these figures for the same conditions. These tests are at 25°C and using the circuit of Figure 4, which is in

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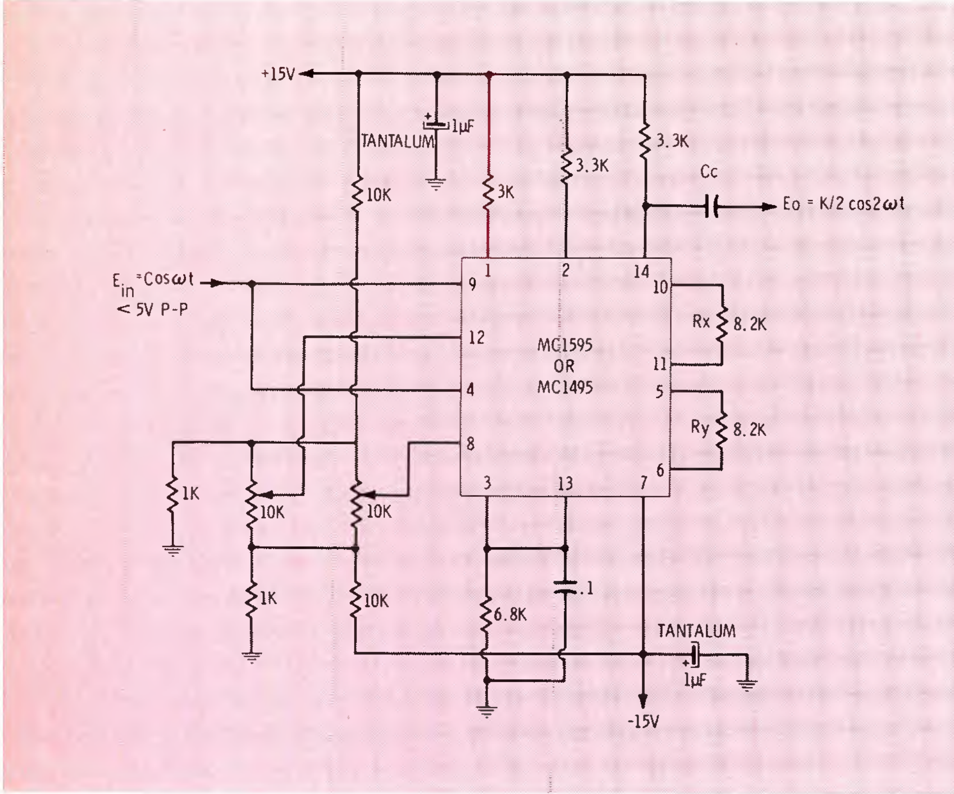

Fig. 5. Squaring circuit or frequency doubler.

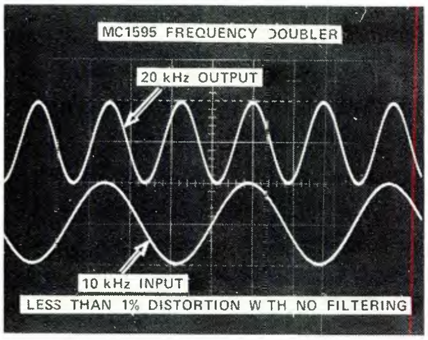

Fig. 6. MC1595 frequency doubler waveforms indicating less than 1% distortion with no filtering.

fact Motorola's test circuit for the device.

The circuit of Figure 4, although it is a test circuit, can be useful also as a working circuit. For use with AC signals, the output can be taken from pin 2 or 14 through a DC blocking capacitor (or capacitors). This circuit can be useful just as is for a linear balanced modulator (Figure 4A) or AM modulator (Figure 4B) (with appropriate carrier insertion offsetting the carrier balance). Frequency response is 3 dB down at 3 MHz typically with this circuit, making it useful well into the lower video region as well as at audio frequencies.

As in the MC1596/1496, this one also can be used for demodulation by multiplying a modulated carrier times a local synchronous carrier and low pass filtering the output to recover the modulation products. Hence the name "product detector".

Again, as was true with the MC-1596/1496, the MC1595/1495 will double an input frequency without tuned circuits and with minimum distortion. The MC1595/1495 also has the big advantage of a much wider dynamic range. Figure 5 is a squaring circuit (which doubles a single input frequency or squares a spectrum) optimized for this particular use. Note that offset adjustments are still used to insure accuracy. In this circuit the X and Y offset adjustments are made initially with the X and Y inputs separated (steps 2 and 3). There is no output offset adjustment for this circuit. Then connect X and Y and apply an AC input and you will get a waveform like Figure 6.

DC Applications

For DC applications the output of the multiplier must be directly coupled. A differential DC signal is available between pins 2 and 14 of Figure 4. However this signal rides on a 21 Volt DC quiescent level, and in many applications it may be desired that a DC output be centered around ground. Figure 7 is another general purpose multiplier, but in this case it can be completely DC coupled with an output which rides around ground quiescently. Note also that it operates from ±15 Volt supplies.

This circuit uses a multiplier block with a scale factor of 1/75 and an op-amp level converter with a gain of 7.5 to give a net scale factor of 1/10. The op-amp amplifies the differential signal from the multiplier and shifts the DC level down to zero at its output. The output offset control allows adjustment of the output DC level to null both the offset of the multiplier and the op-amp. Setup procedure for this circuit is the same as that described for Figure 4.

Viewed As A System

So far we've discussed a few circuits and how they work on two voltages. But a better appreciation of the device can be had if it is viewed on a **system** basis. To do this let's now visualize applying the circuit blocks we've discussed in some systems.

Figure 8 is a good example of what can be accomplished with the versatility of the MC1595/1495 multipliers. Here a pair of multipliers are connected as complementary gain controlled stages with a gain control voltage applied to the Y channels. The X channels are fed two signals which are to be controlled, A and B. The control voltage is a 0 to +10 DC signal. Operation is as follows.

The A channel multiplier operates as a voltage controlled amplifier. Its range of gain extends from zero with Vc=0VDC to maximum with Vc=+10VDC. The B channel multiplier operates as the exact complement of this; its range of gain extends from **maximum** with Vc=0VDC to minimum with Vc=+10VDC. With this arrangement the single control voltage controls the degree of gain of both channels from minimum to maximum or anything in between. The outputs of the two multipliers are combined in an op-amp summing circuit which also buffers it to a low source impedance.

Versatility Of A Voltage Controlled Stage

There are many things you can do with a voltage controlled stage such as this. If signals A and B are two audio inputs, a pot supplying the 0 to 10 Volts DC control will serve as a remote fader control. In fact if suitable attention is paid to optimizing the bandwidth of the multiplier circuit and the summing amplifier, this circuit can be useful at video frequencies as well as audio.

This provides a tremendous advantage to switcher/fader design as a **single** control voltage provides complementary control of two video channels, allowing smooth transitions from one to the other without clumsy attempts to make two different ganged fader pots track, a situation which although theoretically realizable is a near impossibility in practice.

By going a step further you can automate the control by using a ramp generator as shown. With individual control of ramp times you can make programmed fades from one channel to the other. Although the schematic shows push-button switches to initiate the fades, this could also be done by control logic and thus be completely automated. The fades you will get with a circuit like this will always be smooth, linear and perfect, and with the selection of ramp times, easily adjustable to create the desired effect.

You can carry the idea of the ramp control a step further and apply it to special effects video processing and come up with some very unique results. This is illustrated in Figure 9, which shows waveforms corresponding to the circuit of Figure 8. Here two video inputs A and B are switched by a trapezoidal control signal, shown here in approximately the middle third of a single TV line.

Note that as A is fading to zero, B is rising to maximum. On the trailing edge of the switching waveform the reverse is true. During the period of the switching transistion portions of **both** video waveforms will appear on the screen, giving a "soft" transistion between the two, a "movie-like" effect not hertofore possible with TV techniques. Control of the switch transistion times and the shape of its slope (linear, "S-shaped") will give creative control over the resultant image.

Another version of a voltage controlled attenuator with wide usefulness is an AGC system. By rectifying a portion of the AC output signal from a multiplier and applying it back as a voltage control, automatic level control can be implemented.

Summing Up

The listing of linear multiplier applications could go on and on indefinitely, for the potential applications of a device such as this go as far as there are requirements for solving for the product of two variables. Just as is true with the operational amplifier, imagination is the only real limitation to the use of the 4 quadrant multiplier.

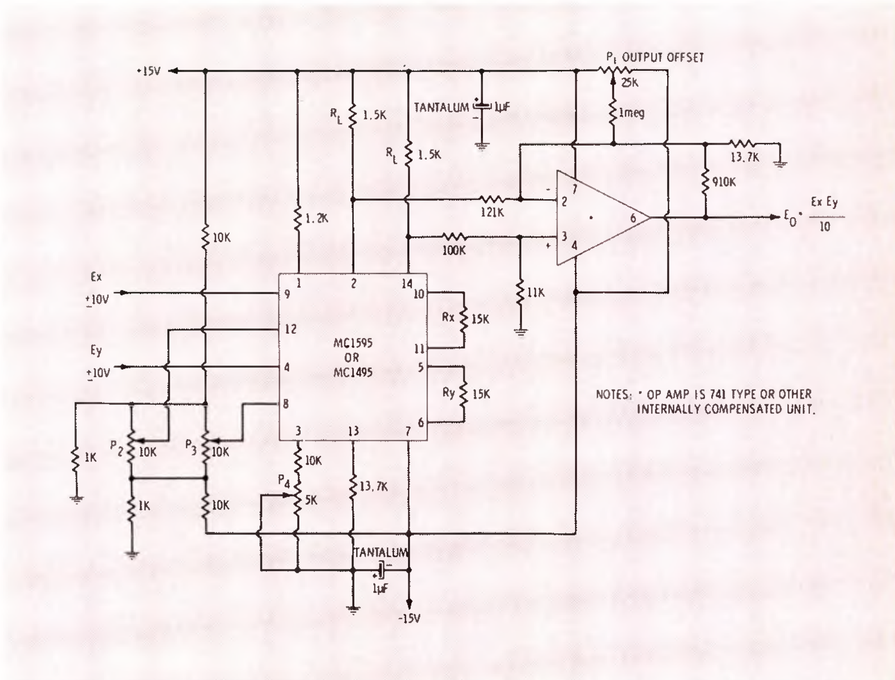

Fig. 7. Direct coupled general purpose multiplier with buffered output.

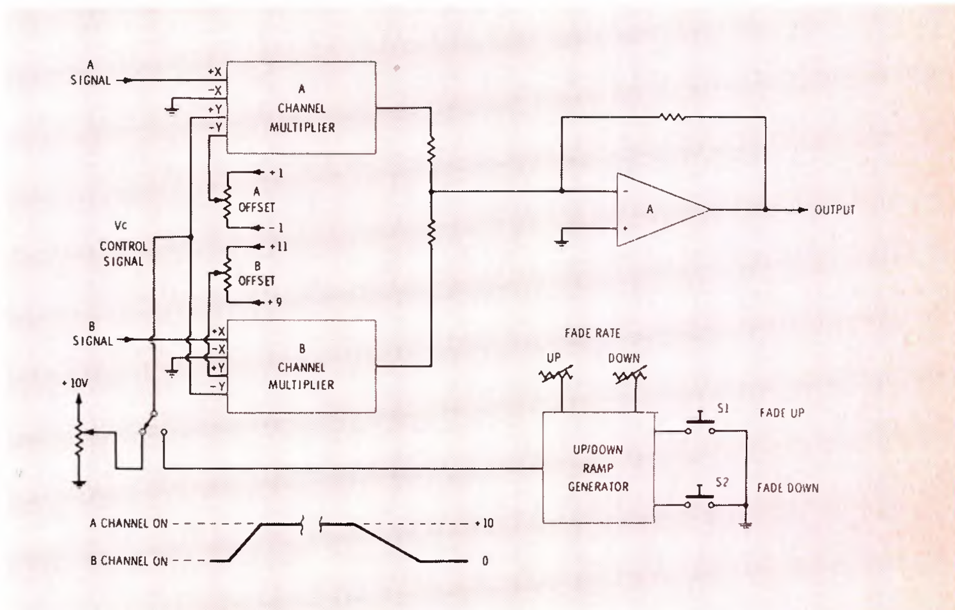

Fig. 8. Voltage controlled mixer.

In these two articles we've tried to lay down the groundwork of the circuit concepts behind the monolithic balanced modulator and the four quadrant multiplier. You may want to learn more of this fascinating class of devices, so we are including a list of application notes and data sheets which are concerned with the multiplier concept. You may write to Motorola on your company letterhead at the address listed to obtain further information. ▲

Application Notes—

AN531: MC1596 Balanced Modulator.

AN489: Analysis & Basic Operation of the MC1595.

AN490: Using the MC1595 Multiplier in Arithmetic Operations.

AN491: Gated Video Amplifier Applications The MC1545.

AN475: Using th e MC1545—A Monolithic Gated Video Amplifier.

AN432B: A Monolithic Integrated FM Stereo Decoder System.

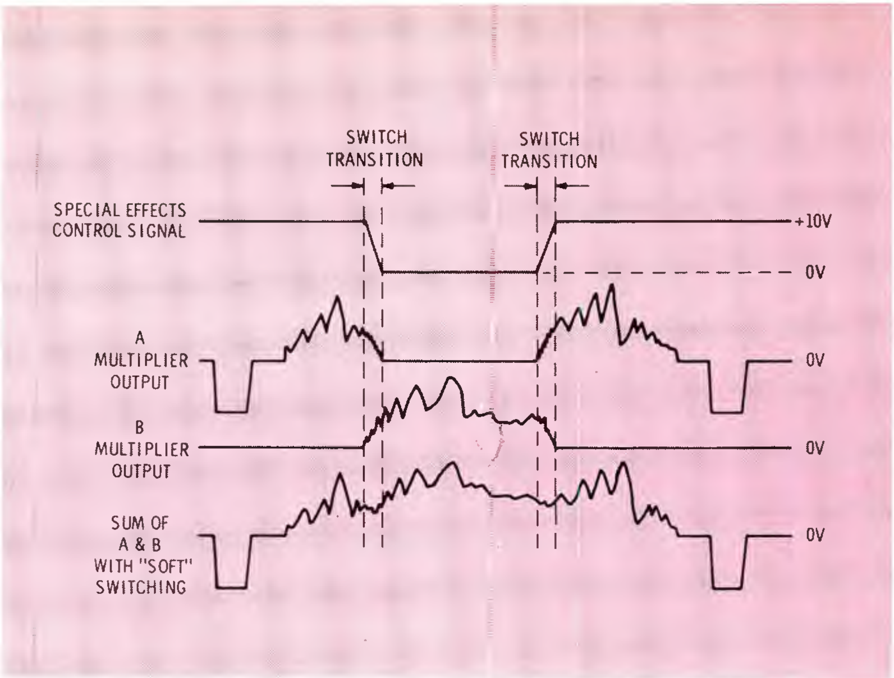

Fig. 9. Special effects "soft" switch.

Data Sheets—

MC1596 MC1496
MC1595 MC1495
MC1594 MC1494
MC1545 MC1445
MC1304, MC1305, MC1307
MC1326, MC1328, MC1330
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Solid State Rectifier Stacks

By Guffy P. Wilkinson

How much did one hour and 39 minutes of "Off Air" time cost your station last year?

How much money did your station spend for obsolete and expensive mercury vapor rectifier tubes?

How much did the money cost, which was tied up in spare rectifier tubes?

How much money was spent on uncomfortable engineering time to replace bad rectifier tubes at 6 a.m.

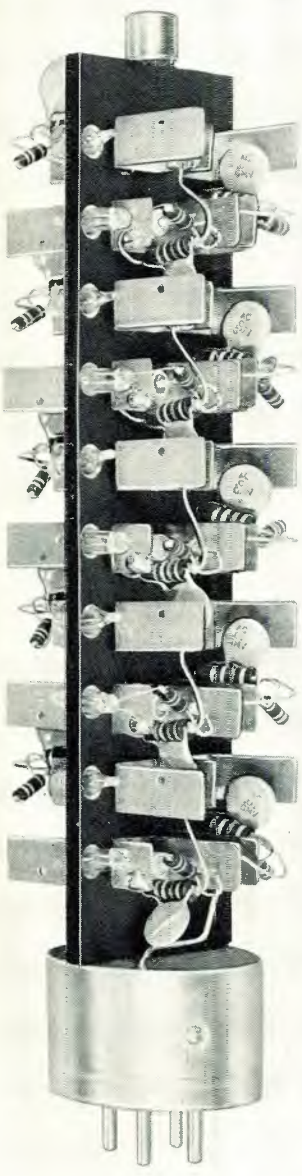

Fig. 1. This 20 kV, 6 Ampere stack replaces the 673.

How much money was wasted on power consumption for the rectifier filaments and for heaters and cooling devices for 6,370 hours?

Add up all this money and multiply it by the number of years of your transmitter life. That's a lot of money!

In the old days, mercury vapor and zenon gas filled diode rectifier tubes were the most efficient known for high power use. Mass-produced at relatively low cost, having little internal voltage drop and high current capability, they were the only answer for rectifiers in large power supplies for transmitters; nevertheless, they have many disadvantages.

The mercury vapor tube must be operated within a limited temperature range, and the condensed mercury within it must be maintained between 20° and 60° C. If the ambient temperature is too cold, arc starvation occurs and the tube will not fire, thus, some form of heating is required. If the ambient temperature is too hot, arc backs will occur and external cooling is necessary. Spare tubes must be preheated for 30 minutes and maintained in a vertical position on the shelf. Thirty seconds of warm-up time is required to bring the tube up to temperature and this time is lost if failure occurs.

Expensive filament transformers are necessary because of the high voltage insulation required. Filaments burn out and spent emission requires tube replacement and causes lost air time. Filament power consumption is costly and produces unneeded heat. Since no new equipment incorporates mercury vapor tubes, fewer units are being manufactured, and they are becoming more expensive and less reliable due to extended shelf life. In many localities, they are very scarce and additional spares must be bought in order to guarantee availability.

Today, the broadcast station still operating equipment using mercury tubes is practicing a false economy, for new solid state rectifiers will pay their own way in a very short time.

It is now easy and economical to directly replace mercury vapor tubes with highly reliable controlled avalanche silicon rectifier stacks. These units plug directly into the tube socket; no re-wiring is necessary and the conversion takes only minutes. Such devices now have a service history in excess of ten years in power supplies of every conceivable configuration.

Properly selected and protected, they will last virtually forever. They will operate in the temperature range of –65° to +100° C. They operate instantaneously and do not require warm-up time. Filament transformers are unnecessary and emission will not fade. They do not consume filament power and produce no heat.

How It Stacks Up

The modern silicon stack is composed of several individual controlled avalanche diodes stacked in series in order to obtain the peak reverse voltage characteristic desired. This reverse voltage is that which the stack must withstand when it is not conducting. A reasonable peak reverse voltage rating for a single junction diode is 1 kV. Thus, a stack rated at 18 kV PRV at 3 amperes will incorporate 18 1 kV diodes in series, each having an average current rating of 3 amperes.

Of prime importance in this series circuit is the requirement that reverse voltage be divided equally across all the junctions in the stack. For this reason, the best practice is to match all the diodes in the stack for reverse current leakage, and then shunt each diode with a voltage dividing resistor and a capacitor.

Nearly all individual diode failures result in a junction short, which reduces the PRV rating of the stack by the voltage rating of the diode. Because of this, a well-designed stack will continue to operate until its PRV rating is lowered below the PRV present, at which time all the rest of the diodes will fail. To avoid this occurrence, silicon stacks should not be encapsulated so that individual diodes

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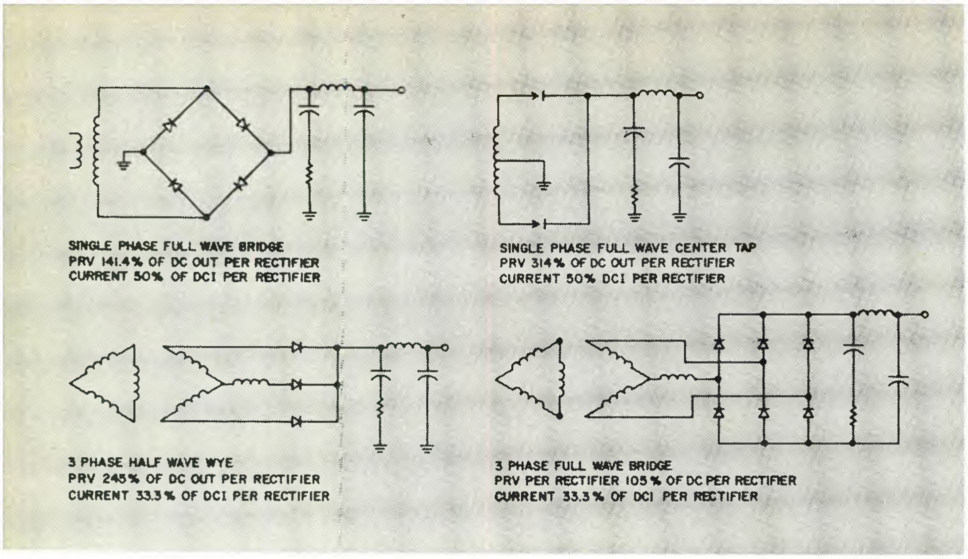


can be tested periodically and replaced if necessary.

This testing can be eliminated by the installation of a neon lamp across each individual diode. The reverse voltage on the diode lights the lamp and indicates that the diode is normal. If the diode shorts, or its reverse leakage exceeds the norm, insufficient reverse voltage is developed and the neon lamp is extinguished, automatically indicating a failure.

A voltage dropping resistor must be placed in series with the lamp not only to achieve the proper voltage for it, but to determine the amount of permissible reverse leakage possible before the lamp is extinguished. This self-testing feature saves many hours of maintenance time and because of their light, serve as an added reminder that high voltage is present.

When excessive reverse voltage is applied to a silicon junction, reverse current will start to avalanche through the junction at the most vulnerable point on the junction surface. If the point passing the reverse current cannot dissipate the power generated, the junction will be punctured, thereby destroying the diode. A controlled avalanche device, however, controls the reverse current flow equally through the whole surface of the junction; therefore, more power can be dissipated before the junction is destroyed. This provides added protection for the diode and is a very necessary feature in a silicon stack to combat high voltage transients.

The only disadvantage that a silicon stack exhibits in comparison to the mercury vapor or zenon gas filled tube is its destruction due to excessive voltages caused by transients or lightning. However, if adequate safety factors and good engineering practices are observed, this condition will rarely occur.

Most overvoltage is caused by high voltage transients or lightning on AC power lines. Line Surge Protectors, however, are now available to control lightning and such high voltage transients. For lightning protection, these devices are placed on the load side of the input breaker between the AC line and ground. This is done since lightning generally strikes all phases at the same time, and, therefore, the voltage differential is developed between line to ground rather than from phase to phase. When transients occur from other sources that are developed between phases, then it is practical to install an additional Line Surge Protector across each phase.

The most practical Line Surge Protectors incorporate thyrite varistors which are voltage sensitive variable resistors. The varistor has a given resistance at its rated voltage; and at its rated voltage, very little power is dissipated. The unique characteristic of the varistor is that when voltage increases, the resistance of the varistor decreases at a much greater rate than that of the voltage increase. Thus, the varistor acts as an instant load to any overvoltage and is an automatic, instantaneous regulator for such overvoltage.

High voltage transients are also produced by the collapsing field of the filter reactor in a power supply. The filter reactor produces a magnetic field around itself having a force equivalent to the power being generated at any given instant. When the equipment is turned off, the field collapses, generating a voltage transient many times that of the normal peak reverse voltage. When mercury vapor tubes are used, this voltage causes an arc back in the tube which is not seen because the tube is not operating, but such a transient would destroy a silicon rectifier. It is very simple to filter out this spike with the installation of an RC filter network from the rectifier side of the filter reactor to ground. The formula for determining the value of the resistor and capacitor is:

$$R = \frac{EDC}{1\ DC}$$

$$C = \frac{L1^2\ dc \times 10^5}{4\ E^2\ dc}$$

Where resistance is ohms, C is in microfarads, Idc is the total DC current drawn, and L is the total inductance in the circuit. The voltage rating of the capacitor should be DC voltage divided by .7 (approx.) and a 50 Watt resistor is normally sufficient.

A well-designed silicon stack should have a reverse voltage rating of at least 200 percent of that to which it is normally subjected. The current rating should be at least 300 percent of average current. This will assure an adequate safety margin under nearly all circumstances.

Proper Stack Selection

To select the proper silicon stack replacement for a given tube, the circuit should be analyzed to provide the proper safety margin.

Figure 1 shows the four most commonly used rectifier circuits, the percentage of peak reverse voltage present for each stack within that type of circuit, as well as percentage of total current that each stack will supply. For example, in a single phase full wave center tap circuit, the peak inverse voltage is 314 percent of the rated DC voltage; and each stack will supply 50 percent of the current. Therefore, if two mercury vapor tubes were used in a 2800V, 1 ampere supply, each stack would be subjected to a normal peak reverse voltage of 8,792V, and each stack would supply 500 mills. In this instance, the

Turnover Would Create Chaos

Evans Outlines Renewal Tasks

Mark Evans, chairman of the National Association of Broadcasters' Task Force on License Renewals, warned broadcast executives that they must band together and fight unjust attempts to deprive them of their licenses or face the possibility of losing them to those who "promise to produce programs more satisfactory to the Commission's taste."

He said the effort of the NAB Task Force never will succeed unless each broadcaster maximizes "every ounce of power and influence this industry possesses to achieve a fair and reasonable license renewal policy."

Evans, vice president and director of public affairs, Metromedia, Washington, emphasized at NAB's Chicago Fall Conference that broadcasters are not attempting to escape their responsibilities, nor "seeking to avoid our commitment to operate in the public interest by one iota," but are seeking "a balanced recognition of everybody's rights and not the myopic pursuit of one group's rights."

He noted that NAB's Board of Directors feels the final solution to the license renewal matter will be a federal law spelling out a permanent national policy binding on the Federal Communications Commission and the courts.

Broadcasters, Evans said, are up against a "Coordinated inter-locking national movement to displace current licenses." This movement, he stated, is financed by a war chest of over a half-million dollars.

He said that while broadcasters are united against the unjustified harassment by radical groups seeking their licenses, they also must be united behind whatever bill is drawn up for Congressional action.

The fight can be won, Evans said, because "right is on our side. The wholesale turnover of radio and television licenses to challengers would create chaos and public resentment that would make it very uncomfortable for those who support it."

To combat the campaign by radical groups, Evans urged broadcasters to:

– Master the facts and be articulate on the arguments.
– Sell their position to everybody: employees, family, clients, advertising agencies, service clubs and public service organizations.
– Establish "eyeball contact" with their Congressmen. "Letter writing is not enough."
– Fight the label "racist." He said "the only thing racist about our efforts is the people who are making it so in their criticism."
– Avoid the wheel-spinning of futile legislative efforts.
– Stand by for an all-out battle on the issue.

Voice Identification Still Applies To Land Mobile

In response to requests by the Associated Public-Safety Communications Officers, Inc. (APCO), and RYDAX, Inc., for reconsideration of rules governing operation of non-voice radio systems on voice channels in the land mobile services below 950 MHz (Docket 19086), the Commission has retained a requirement for identification of land mobile radio stations by voice, but has deleted a requirement for automatic sensing of channel occupancy.

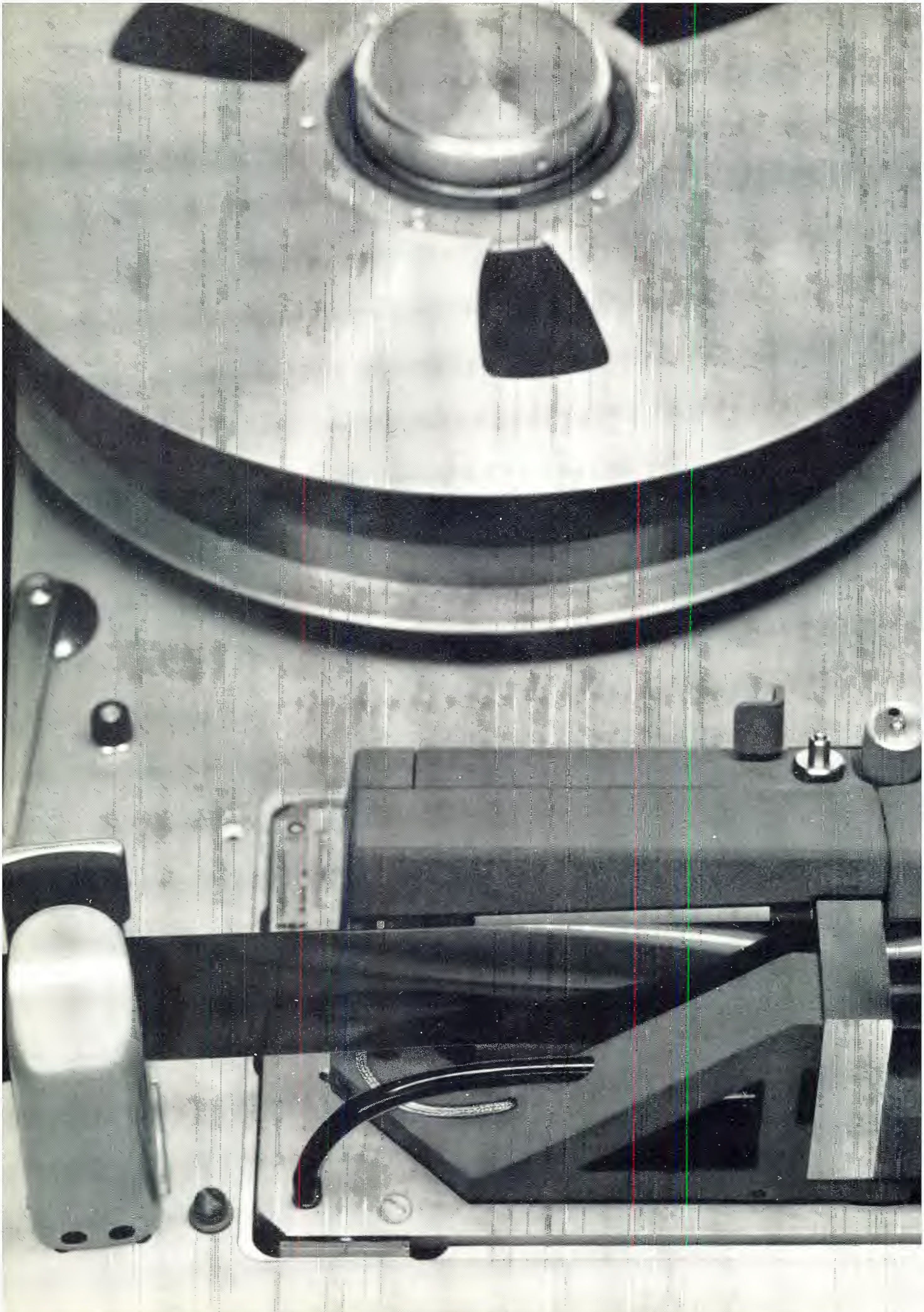
In an order adopted August 18, 1971, the Commission amended Parts 89, 91 and 93 of the rules to permit regular and expanded operation of non-voice operation in the land mobile services.

APCO had asked for an exception to the requirement for station identification by voice to allow station identification by Morse Code and RYDAX had asked for deletion of the requirement that non-voice systems employ automatic sensing or monitoring equipment that can prevent transmission on an occupied channel.

The Commission said, in denying the APCO request, that use of Morse Code would not afford significant advantages and noted that the additional transmitting time required could increase potential interference.

In granting the RYDAX request, the Commission stated that it had originally required automatic sensing of channel occupancy to protect voice communications from interference by non-voice transmissions and to assure that non-voice operations would be secondary to voice operations.

The FCC observed, however, that RYDAX, as well as General Electric Company and RCA Corporation, had raised "significant questions" as to the effectiveness and adaptability of automatic sensing devices and said that while it would permit use of these devices, it would not impose a mandatory requirement for their utilization at this time.



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stack should be rated at 18 kV, 1.5 amperes.

It is very important that silicon stacks essentially developed to replace a given tube should be rated well in excess of the tube in order to avoid failure. Several 1 kW AM transmitters use two 8008 or 872 tubes in a full wave center tap circuit providing 2800 Volts DC at 1 amp. These tubes are rated for a maximum PRV of 10 kV when operating between 20° and 40° C and in this instance, very little margin of safety exists. If a silicon stack with a PRV of only 10 kV is used, then it would be destroyed immediately by a 10 percent line voltage variation or a no-load condition which increases the high voltage.

When silicon stacks having 300 percent safety factor are used, little or no heat is generated. If heaters of blowers were used to keep the tubes at the correct temperature, they may be removed.

Some broadcast equipment has been designed incorporating parallel rectifiers for greater current capability. Such parallel operation with silicon rectifiers must be avoided and is unnecessary since a single silicon stack can be provided with any current capability desired.

The voltage drop across a silicon stack is approximately the same as that of the mercury vapor tube; therefore, the rectified voltage will be the same. This is not the case where high vacuum rectifiers are replaced. When replacing 5U4's and 5R4's, the silicon unit will produce up to 15 percent more voltage and this should be taken into consideration.

Several station engineers have attempted to build medium current silicon stacks in an effort to reduce the cost of conversion to solid state rectification. It is very rare that reduced cost was achieved and in many instances, complete failure resulted. Failure most often occurred because low cost, poor quality diodes were purchased.

Unless adequate means were available to properly test these devices, the engineer had no way of knowing actually what he purchased or why they failed. Experience with several sample purchases of so called 1 kV, 6 ampere devices from several processing jobbers proved that less than 20 percent of the diodes could withstand a DC voltage of 1 kV, and the reverse leakage of these varied from 10 MA to 500 MA. Placed in a stack, every one of them failed.

Acceptable diodes such as the IR 6F100A on the Syntron D-140-AS, 1 kV, 6 ampere unmatched devices are priced at around $11 each in quantities of 1 to 99. The reverse leakage on these units can vary up to 10 MA but should be selected not to exceed 5 microamperes at rated PRV. A stack of 20 of these rectifiers would certainly cost the station trying to build it far more than $200, for in addition to the diodes, heat sinks, resistors and capacitors must be acquired and a mechanical means of support must be obtained.

The Diode As A Transient Suppressor See Engineers Exchange

Digital logic basics

part 3 of a four-part series

By E. S. Busby, Jr.*

Ordinary two-state logic concerns itself with one wire at a time and is fine for yielding the answers to yes/no, true/false, on/off, whether or not, etc. An array of wires can be used to define "how many" and "how much". Two wires, each of which has two possible states, have 2 X 2, or 4 possible arrangements. Add one more wire and there are twice again as many possibilities. If there are N wires there are 2N different arrangements of ons and offs among them.

If the wires and their states are named in a way everyone understands then the states of a number of wires can define "how many".

Imagine a wire that can have ten different states (ten voltages, perhaps). Each state has a name, called a numeral, running from zero through nine. Each wire has a name, called its "weight", there are units (10^0), tens (10^1), hundreds (10^2), thousands (10^3), and so on. Thus, as we are all taught, when 8092 is written we know that there are:

2 many units=2 X 1
9 many tens=9 X 10
no hundreds=0 X 100
and 8 many thousands=8 X 1000

This scheme (the decimal system) for counting things is used by people with 10 fingers, gears with 10 teeth, and stepping relays with 10 contacts. They all work slowly. Wires with 10 states are more trouble than they are worth. Wires with **two** states we have. So, to make use of two state wires, there came to be a "binary" numbering system. At the risk of creating some confusion, two well-known numerals were borrowed to name the two states. They are zero (0) and one (1). To add to the confusion the names of the wires (the weights) were **also** borrowed from the decimal system. These names are units, twos, fours, eights, sixteens, etc., the mutiples of two.

*Engineer, Ampex corporation, Redwood City, Calif.

One And One Are 10

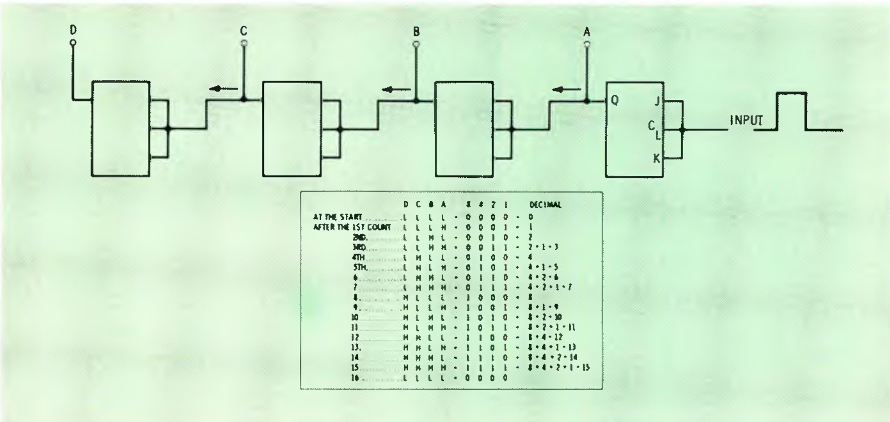
The binary system (as well as some others) are taught to the kids in school these days. To them 111101 means:

A unit	=	1
no two	=	0
A four	=	4
An eight	=	8
A sixteen	=	16
A thirty-two	=	32
TOTAL	=	61

You **think** in decimals. Much of today's equipment **operates** in binary. To do the translation between systems in your head, it is advisable to commit to memory the first 12 multiples of two:

$1 = 2^0$	$128 = 2^7$
$2 = 2^1$	$256 = 2^8$
$4 = 2^2$	$512 = 2^9$
$8 = 2^3$	$1024 = 2^{10}$
$16 = 2^4$	$2048 = 2^{11}$
$32 = 2^5$	$4096 = 2^{12}$
$64 = 2^6$	

To convert from binary to decimal, for example 100111, first examine the right-most "place" or "bit". If it is a 1, then there is a ONE involved, so add it in. If the next to the left is a 1, then a TWO



	D	C	B	A		8	4	2	1		DECIMAL
AT THE START	L	L	L	L	=	0	0	0	0	=	0
AFTER THE 1ST COUNT	L	L	L	H	=	0	0	0	1	=	1
2ND.	L	L	H	L	=	0	0	1	0	=	2
3RD.	L	L	H	H	=	0	0	1	1	=	2+1=3
4TH	L	H	L	L	=	0	1	0	0	=	4
5TH.	L	H	L	H	=	0	1	0	1	=	4+1=5
6	L	H	H	L	=	0	1	1	0	=	4+2=6
7	L	H	H	H	=	0	1	1	1	=	4+2+1=7
8.	H	L	L	L	=	1	0	0	0	=	8
9.	H	L	L	H	=	1	0	0	1	=	8+1=9
10	H	L	H	L	=	1	0	1	0	=	8+2=10
11	H	L	H	H	=	1	0	1	1	=	8+2+1=11
12	H	H	L	L	=	1	1	0	0	=	8+4=12
13.	H	H	L	H	=	1	1	0	1	=	8+4+1=13
14	H	H	H	L	=	1	1	1	0	=	8+4+2=14
15	H	H	H	H	=	1	1	1	1	=	8+4+2+1=15
16	L	L	L	L	=	0	0	0	0		

Fig. 1 Four-bit binary counter.

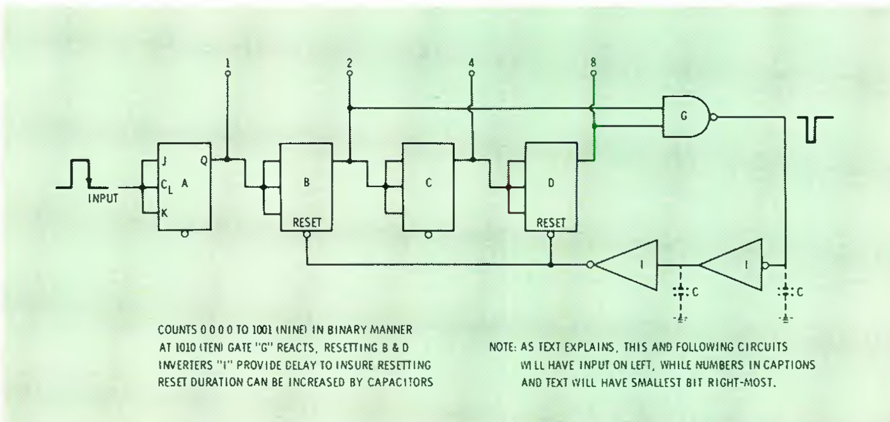


Fig. 2 Example of partial decoding, including reset.

is involved, so add it in. If the next to the left is a 1, add in a FOUR, etc. In the example shown there is a ONE, a TWO, a FOUR, and a THIRTY-TWO represented, for a total of 39.

To convert from decimal to binary, for example 525, ask yourself: "Which is the largest multiple of two which **isn't** larger than 525?" 512 fits, so write a "1" in the 512 column. 525 minus 512 leaves 13 unaccounted for. The largest multiple not larger than 13 is 8, so a "1" goes in the 8 column. This leaves 5 unaccounted for, so a "1" goes into the 4 column, leaving a "1" in the 1 column. Write zeroes in all other columns. Result:

512	256	128	64	32	16	8	4	2	1	
1	0	0	0	0	0	1	1	0	1	= 525

Figure 1 shows how the outputs of cascaded flip-flops directly reveal the (binary) number of input edges received. In the example shown, the sixteenth input edge returned the counter to its starting position. The counter exceeded its capacity or "overflowed" at sixteen. Counters which overflow at an exact multiple of two are known as "pure binary". Counters can be arranged by feedback from later stages to earlier ones so that they count in a binary fashion, but return to zero prematurely.

One popular compromise between the decimal world with its 10-fingered people and the binary devices with their two states is the binary counter which returns to zero on the 10th count. Six of the possible 16 states are not used. A 4-bit binary "word" which never exceeds the range 0000 through 1001 (0 through 9) is called BCD, or "Binary Coded Decimal".

This scheme for representing decimal numerals is used a great deal where people enter numbers into a system (with a keyboard for example) or where decimal numerals must be displayed or printed. It is not so much used in computation. There are BCD counters, BCD decoders and BCD/binary and binary/BCD converters. Most demimal numeric displays use a BCD input. Besides the popular 8-4-2-1 binary weighting there is a large number of other weighting schemes using 4 bits to describe the set of 10 decimal numerals. (More about these next month.)

Look at Figure 1 again. The schematic is odd in that the input is at the right instead of the left, as is usual. This was done to avoid a popular source of confusion. In counters, the units output is the one nearest the input, and in left-to-right circuit diagrams the units or "least significant" output is the left-most. When writing numbers, it is customary to place the least significant bit **right**-most. You should learn to visualize binary numbers arranged either right-to-left or left-to-right. To force you to do this, in this and the next article, circuit diagrams will be arranged with inputs on the left, and numbers will be arranged with the units column right-most.

Pick A Number

To know when a counter contains some particular number, it is necessary to "examine" all the stages of the counter to see if that number's unique arrangement of highs and lows exists. Convert the desired number into binary form. Keeping in mind that the unit column is the one nearest the counting input, figure which stages should have high (1) outputs and which should have low (0) outputs. Connect an input of an "AND" gate to the regular output of each stage which should be "ONE" and

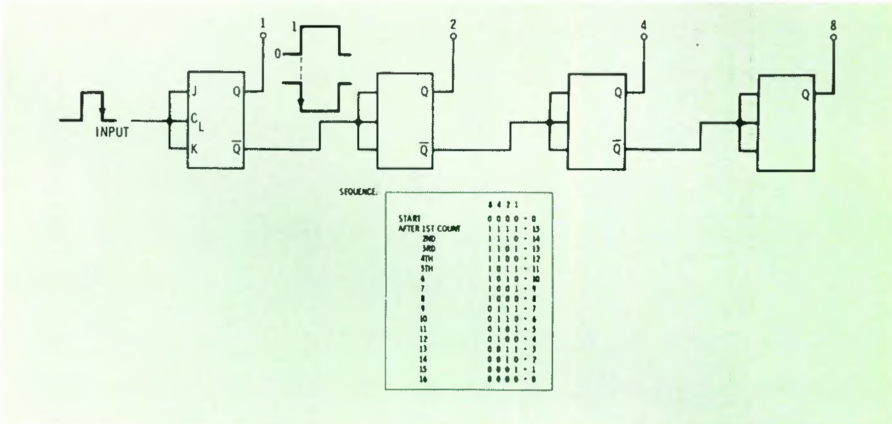


Fig. 3 Down-counter (binary).

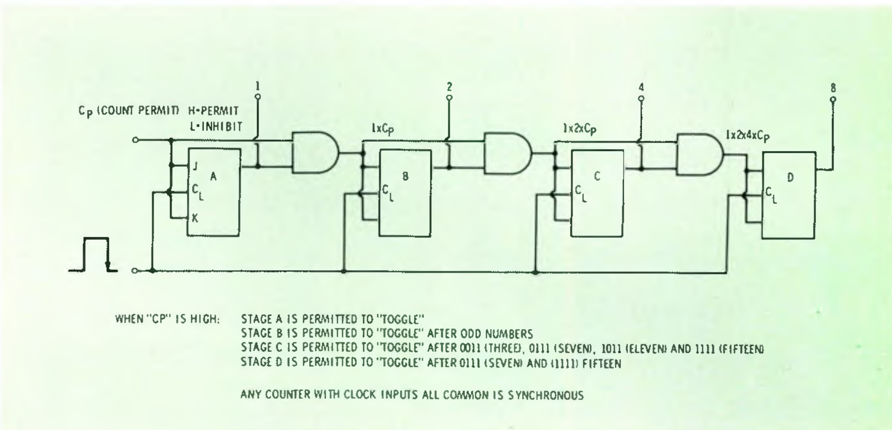


Fig. 4 Synchronous binary counter.

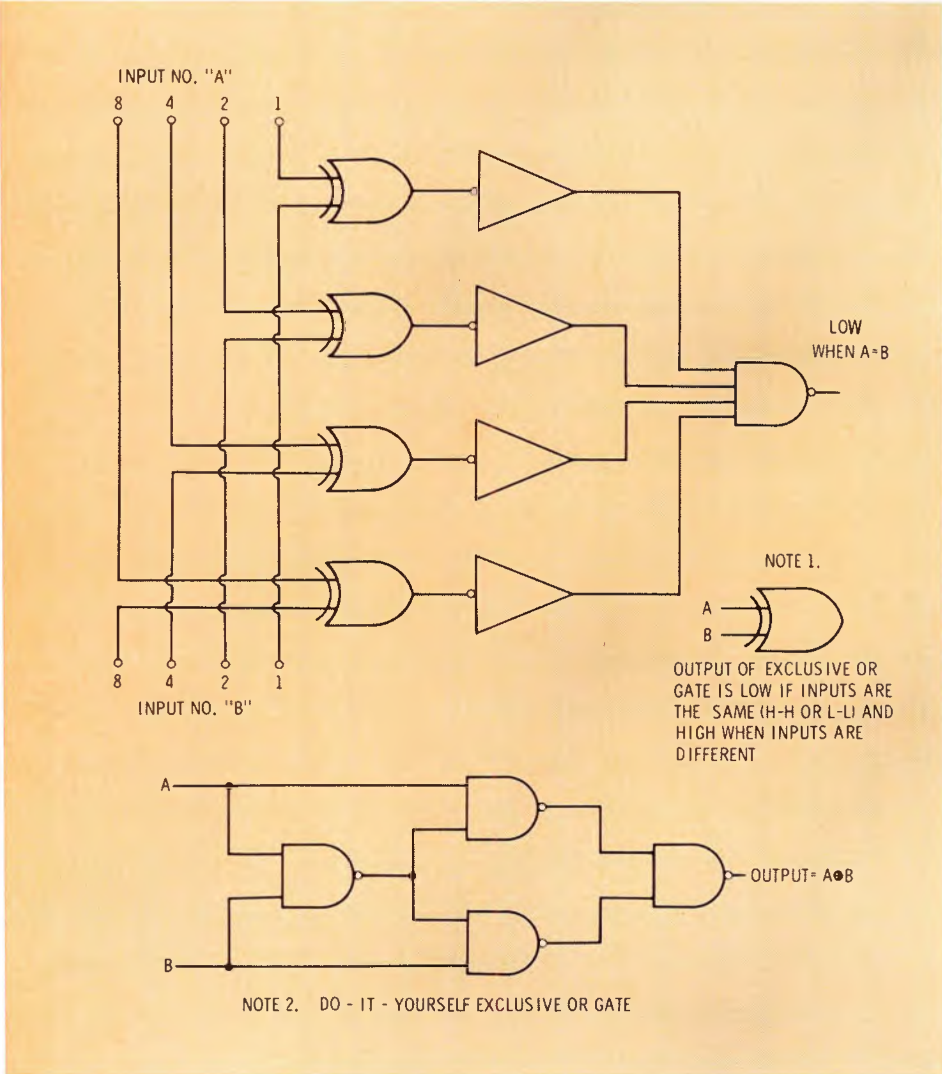


Fig. 5 Simple four-bit comparator.

to the inverted output of each stage which should be "ZERO." This way all the inputs to the AND gate will be high when the desired number has been counted. **No other count** can produce this result. This process is called "decoding" a count. As many decoding gates may be attached as there are different numbers to be decoded.

Partial Decoding

Often a counter is reset to zero as soon as some desired count is reached. In this case it is permissable to examine only the stages which should be active (1) at the desired count. To decode 525, for example, requires only the four-input gate attached to the 512, 8, 4, and 1 stages. If the counter were permitted to count beyond 525, false outputs would appear at 541, 557, 573, etc., but if resetting occurs right after 525 there is no problem.

Sometimes It Pays To Wait

Using the output of a decoding gate directly to reset a counter can cause what is called a "race" condition. This effect is often encountered in logic circuits where the detection of something is used to undo the very thing that was detected. In a counter the danger is that one stage will reset faster than another and thereby negate the resetting signal before **all** stages get reset.

Adding delay between the gate and the resetting terminals, as in Figure 2, will usually assure resetting. Adding capacitors will further lengthen the reset period, maybe even to the point that it's long enough to see on a scope.

Figure 2 happens to be a BCD counter. It counts from 0000 (zero) through 1001 (nine) in a binary manner. On the tenth count (1010), the partial decoding gate reacts and quickly resets the second and fourth stages to zero.

Cape Kennedy Connection

Most counters "increment" (get one bigger) for each input count. Figure 3 shows how a counter can be arranged to "count down" or decrement one for each input edge. The difference is that a counting edge is passed to the next stage when the output changes from 0 to 1 instead of the other way around.

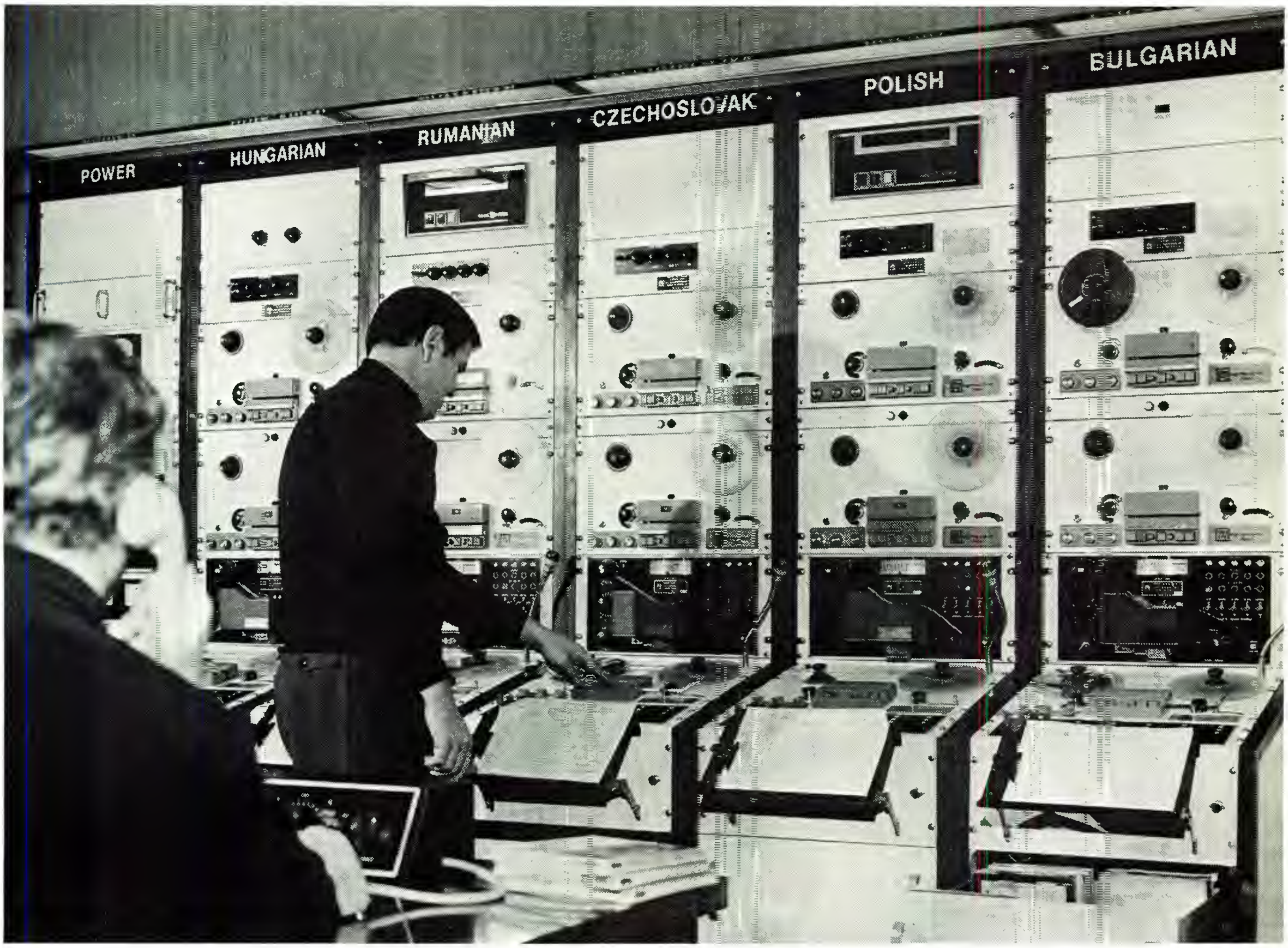
In the counters discussed so far, the stages were connected in cascade. Such counters are called "ripple counters" and suffer from two limitations. The fastest speed at which recognizable counting can occur is limited by the **total** delay time through **all** the stages. Try to go any faster, and the first stage is reacting to an input before the previous count has rippled all the way to the output.

Even when counting slowly, ripple counters are prone to producing "decoding spikes" at decoding gate outputs. You might think that the reception of the eighth count might look like this: FROM: 0111
TO. 1000

It doesn't. It looks like this: 0111
THEN: 0110
THEN: 0100
THEN: 0000
THEN: 1000

with the "rippling" going from right to left in the example. A decoding gate set for zero, four or six would produce a short, but troublesome output during the transition.

Figure 4 illustrates a synchronous counter. The counting inputs of all flip-flops are fed from a common source. The steering inputs, which determine whether or not the flip-flop will flip at clock edge time, are connected, using gates, to the previous stages. Outputs can only change at clock edge time, and when several stages are changing at once, they all do it together.



POWER
HUNGARIAN
RUMANIAN
CZECHOSLOVAK
POLISH
BULGARIAN

Speed is limited by the delay of **one** flip-flop and the gate delays. Decoding spikes are drastically reduced if not eliminated.

When not counting at high frequencies and when using partial decoding and resetting, a ripple counter is as good as any. Otherwise, synchronous counters are preferable.

Following, stated somewhat tersely, are some approaches using counters to answer questions and solve problems:

1. HOW MANY?

Start the counter at zero. Make edges out of the events to be counted. When you get curious, examine the counter outputs. Convert these output states from binary (or perhaps BCD) to decimal and there's the answer.

2. HOW FAST?

Start the counter at zero and count input events. Allow the counter to proceed for exactly some known length of time, like one second. (This may take yet another counter.) The number in the counter is then events per second.

3. HOW LONG?

Start the counter at zero. Make edges at some known frequency, like 1 megacycle. Start the counter when one input event is received, and stop it when the next arrives. The number of counts is the **period** of or "time between" the events.

4. IS "A" EQUAL TO "B"?

See Figure 5, which shows the simplest of comparators. It is essentially an adjustable decoding gate.

Figure 6 shows a more complex comparator. It has three outputs, one of which is always active. It reveals whether the counter number is less than, equal to, or greater than the comparator's other input.

5. IS "A" FASTER THAN "B"?

If an "A" arrives, count **up** one. If a "B" arrives, count **down** one. If both arrive at once, do nothing. If the counter reaches its maximum value, stop counting "A"s. If it reaches its minimum value (zero) stop counting "B"s.

If the counter hangs up at the maximum value, A is faster than B. If it hangs up at zero, B is faster than A.

This up/down counter approach is often used as a frequency/phase comparator. When used to phase-lock a local oscillator to some reference input, the filtered output of the counter's most significant stage is used to control the local oscillator's frequency. Phase-lock is indicated by the most significant stage turning on about half the time. An exact 50 percent duty cycle indicates that the two inputs are exactly 90° apart.

Words Of Warning

When measuring time and frequency you cannot usually predict whether you started and stopped the counter just before a count or just after one, leaving an inherent uncertainty of $\pm$ 1 count.

When measuring that which lies **between** events, like the length of tape between N frame pulses, or the length of wire between N telephone poles, don't forget that the first

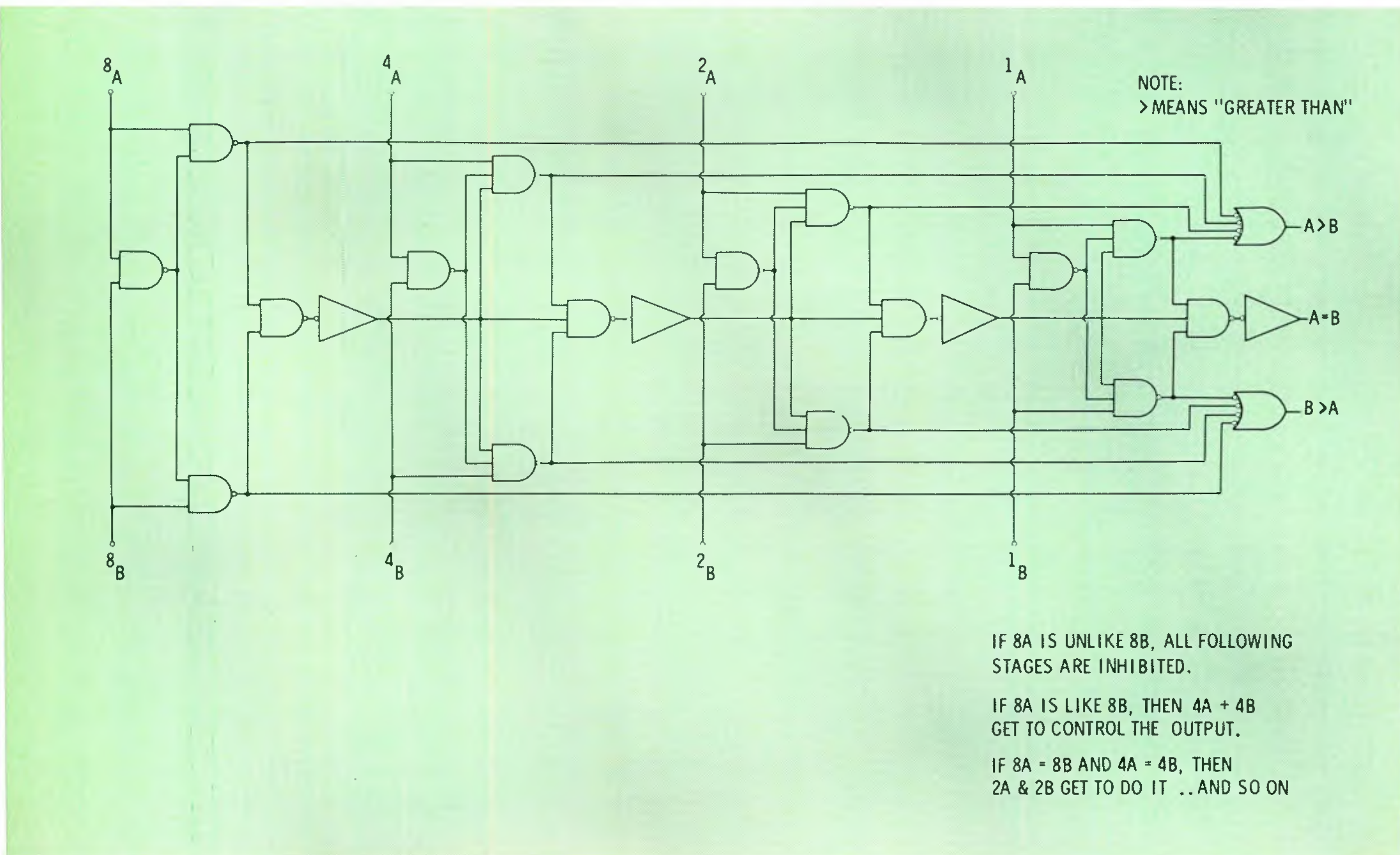


Fig. 6 Full comparator.

phone pole counts one before any wire goes by. For these and similar problems, **remember to subtract one** from the total count.

Put it this way: If you walk four blocks, you touch five corners. The counter counts corners.

When starting and stopping counters, it is best to avoid gating the input signal on and off. Instead, manipulate the first stage's steering inputs. If the input happened to be active when you shut off the input gate, an extra count would result at shut-off. If you must gate the input, it is best to make narrow pulses out of the events to be counted.

Counters and the circuits which are often hung onto them were among the first to undergo medium-scale integration (MSI). MSI devices generally cost about the same, maybe a little less, use a little less power and occupy much less real estate than the equivalent made out of separate flip-flops and gates. There are MSI synchronous and ripple counters in BCD, decimal, and 12 count. Some count up and down. Almost all have four stages.

MSI decoders typically have one output for each possible input pattern, with only one output active at a time. Some can withstand the ignition voltage of gas-discharge numeric display tubes. Others can energize more than one output at a time and can switch the currents used by the incandescent lamps of seven-segment numeric displays. Several 5-bit comparators are available. These have three outputs available: A greater than B, B greater than A, and A equals B. Four-bit binary adders and subtractors are available (more about this next month). Most MSI devices are TTL.

New MSI devices appear on the market at a frightening pace. Read the ads and don't rely on out-of-date catalogs.

How Much?

Some of the variables of life are already "quantitized". Your pay check, when and if it changes, must change by at least one cent, the smallest increment, or some whole number times one cent. Money is expressed as a number anyway, so HOW **MUCH** MONEY really means HOW **MANY** CENTS.

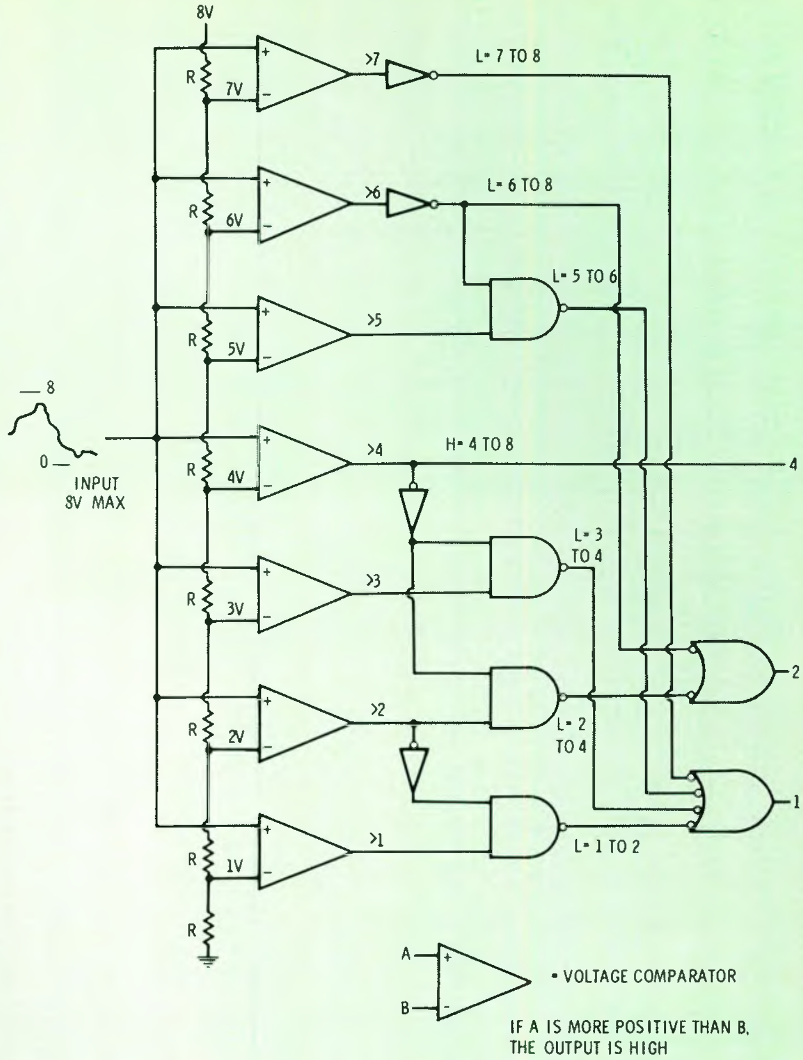


Fig. 7a A three-bit (8 level) A/D converter. No counting is involved.

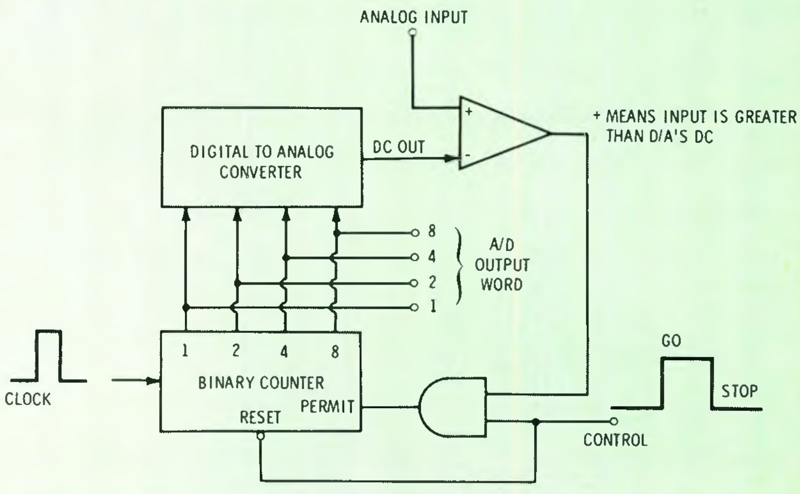


Fig. 7b Counter-type A/D conversion.

The words in the dictionary differ by at least one whole letter. There is no such thing as half-way between "card" and "care". Most goods have some minimum quantity, a division of which does not exist or is not important. So there is a stick of gum, a jigger of whiskey, a page, a word, a grain of sand, and "one each" soldier. The quantity of these usually consists in finding how **MANY.**

Other variables, such as temperature, pressure, brightness, weight, etc. may be measured in terms of some standardized unit like seconds, degrees, grams, centimeters, etc. HOW MUCH TIME then becomes HOW **MANY** SECONDS (or milli-seconds, or microseconds.) It is up to you to decide what is the smallest increment of interest. Even if you are fussy, there is no point in being interested in an increment smaller than the accuracy of the measuring device, nor in an increment so small it is obscured by noise.

Whereas sticks of gum are counted, temperature and pressure are measured. It is often handy to convert one of these continuously variable quantities into a voltage. For this there are numerous transducers like microphones, photoelectric cells, strain gauges, etc. It is sometimes even handier to convert or quantitize the variable voltage into an electrical number. In this form, the variable may be displayed (as a number instead of a meter deflection) or massaged by a computer.

Converting a variable voltage into a numeric quantity is the job of an Analog-to-Digital (A/D) converter. The size of the number that must be used depends on the smallest increment of interest and the maximum range of the variable. The unit "bit" must represent a quantity not larger than the smallest increment, and the number of "bit" must be enough to allow for the maximum variable value.

Thus, to qauntitize the outdoor temperature from –40°C to +60° C to the nearest tenth degree, you must accommodate 1000 different temperatures. 10 binary "bits" have 1024 combinations, so a 10-bit binary number is adequate.

There are more methods of A/D conversion than there is room to describe, but generally they take two forms:

1. Using a massive resistive voltage divider "ladder", with a voltage comparator at each rung of the ladder, find out which rung's voltage is equalled or just exceeded by the input variable voltage. Convert this "rank" into a binary number. This method has the advantage of speed in that the output number is determined in one go. It requires lots of hardware, however.

2. The outputs of a counter are connected to a D/A (Digital-to-Analog) converter, whose output is then compared (in a single comparator) to the input variable

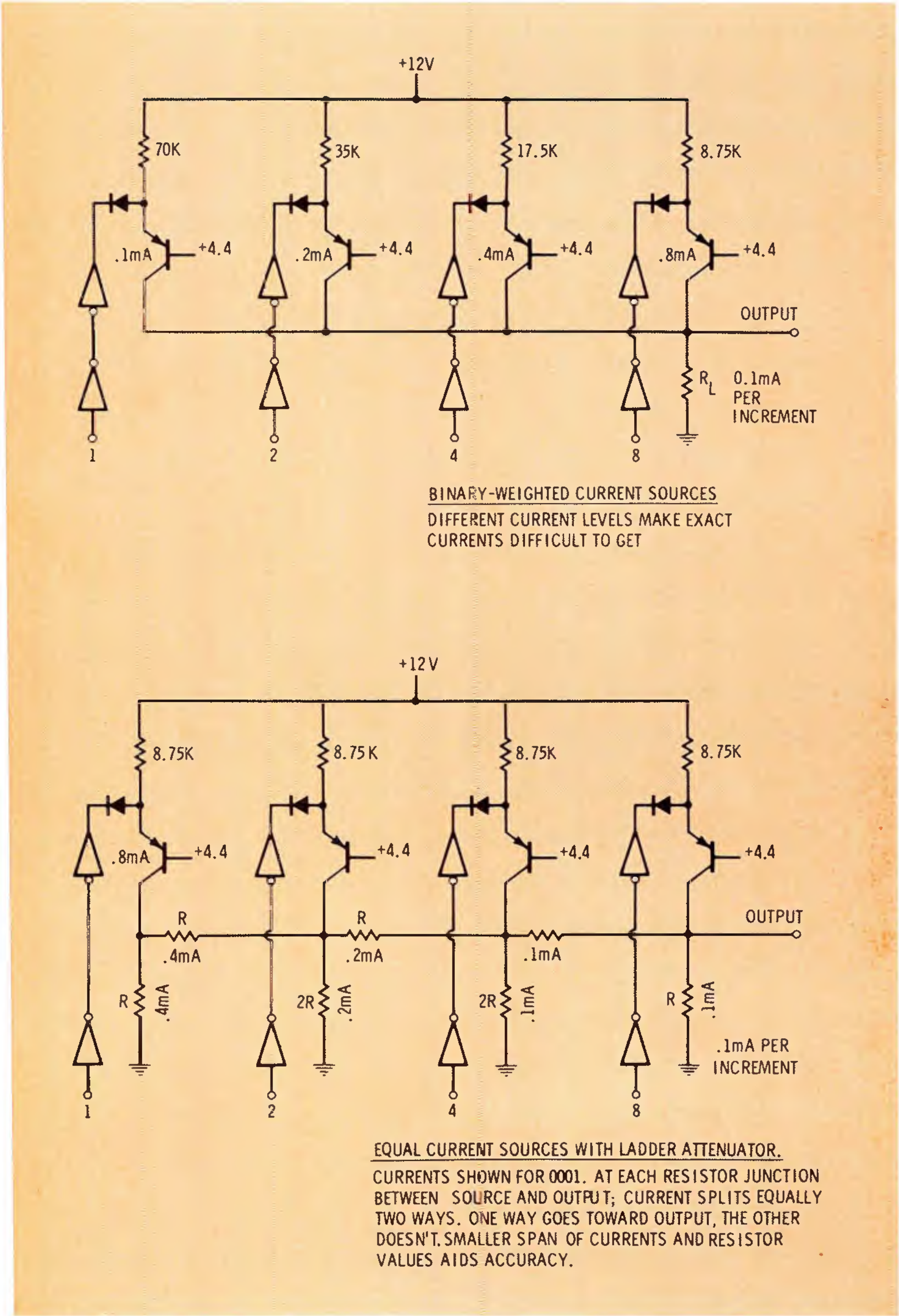


Fig. 8 D/A converters. In the examples shown, current is taken from the emitter via the diode when the bit is inactive (low).

voltage. Any time an A/D conversion is desired, start the counter from zero and let it count until the D/A output just exceeds the input variable, then stop. The number in the counter is the desired conversion.

It takes time to do the counting, and this is a disadvantage of this approach. It tends to use less hardware, however, and besides the D/A part can often be used to advantage elsewhere in the system.

Figure 7 shows, in very simple form, two D/A approaches. Figure 8 shows two popular D/A approches. Remember that a D/A output is not truly an analog output. It cannot vary continuously, but only in steps. It is therefore a "dedigitized" voltage.

Both D/A and A/D converters should have an accuracy of at least ½ a basic increment. Thus when a digital number makes that one-step change from 011111111 to 100000000, the output voltage really does go **up** by at least ½ a notch, and no more than 1½ notches.

Once a quantity is made into an electrical number, whether by counting, keyboard entry, thumbwheel switches, or A/D conversion, there **are** some digital techniques that make the whole process worth the effort. That's the subject for next month's article. ▲

Recommended Reading

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6. ANALOG AND DIGITAL COMPUTERS — ORGANIZATION, PROGRAMMING AND MAINTENANCE. Chapter 6. Pub. by H. W. Sams (Cat. #20132)

7. SOLID STATE COMPUTER CIRCUITRY. Chapt. 8. Pub. by H. W. Sams (Cat. #20133)

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   - APP-164 "Applications of the μA722 10-bit Current Source", M. Rudin, G. Erdi, R. Walker and R. Ricks.
   - APP-169 "CCSL 9306 Up-Down BCD Counter", R. Clive Ghest.
   - APP-170 "Applications of the 9311 One-out-of-Sixteen Decoder".

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   - "Self-Correcting Ring Counters", Tom McCarthy
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   - "Up-Down Binary Counters", Joe Eccher.
   - "TV Sync Generators", Joe Eccher.
   - "Television Pattern Generator", R. Seymour.
   - "High Voltage Decoders with Conventional Elements", Dale Mrazek.

ENGINEER'S EXCHANGE

Transient Suppression

A recent contributor to "Letters to the Editor", taking issue with an article on "Automatic Assistance Circuits" in a previous issue of *Broadcast Engineering,* raised a question that may remain unsettled in the minds of many readers. Perhaps we can settle it here.

The original article touched upon transient suppression in DC control circuits. It suggested a reverse-connected diode across a relay coil, as shown in Figure 1, to shunt out the inductive "kickback", or transient, that occurs when switch S is opened.

Arguing with this line of reasoning, the "Letters" contributor countered with, "Actually, the transient voltage is of the same polarity as the applied DC and it is the Zener breakdown characteristic of the diode that limits the voltage of the transient." *Is this true?*

My off-the-top-of-my-head reaction was one of consternation. I had just wired a 24-volt relay switching control center for a large industrial sound installation. For transient suppression on its 20-odd relays, I had used inexpensive diodes with a PIV rating of 1000 volts. Clearly, their Zener action would not come into play at reasonable voltages! Transients spiking at 1000 volts are guaranteed to be heard in adjacent audio circuits. Had I been laboring under a false premise?

With doubts thus raised, I went back to review a few fundamentals. If you, too, are so far removed from your exposure to the basics as to be a little uncertain about inductive "kickback", maybe you can profit from my research.

First, it is important to agree that we *are* dealing with an inductive phenomenon. The many turns of wire in a relay coil, surrounding an iron core, possess appreciable *self*-inductance. The distributed capacitance of these turns is relatively small, being inconsequential when working with DC and low frequency AC. Resistance of the wire may be appreciable but—being by definition nonreactive—it cannot contribute to the generation of transient voltages and currents. Thus the principal factor at work is the coil's inductance.

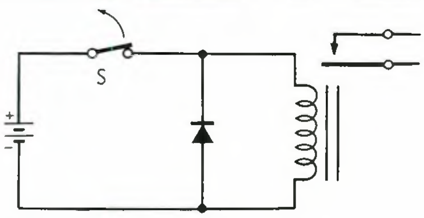


Figure 1

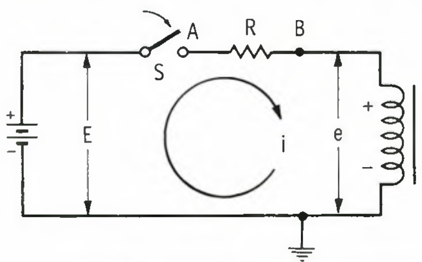


Figure 2

When the excitation voltage is removed from a relay coil, the resulting collapse of the magnetic field in its core induces a voltage, or counter-electromotive force (cemf) that tries to maintain the *current* in the coil. This follows from the fundamental characteristic of an inductance: *self-inductance is that property of an electric circuit that opposes any change in the* current *in that circuit.*

Expressed mathematically for an inductance,

$$\text{cemf} = -L\frac{di}{dt},$$

where cemf = instantaneous voltage generated by the coil,

i = instantaneous current in the coil,

(Continued on page 58)

Cartridge Tape Splice Finder

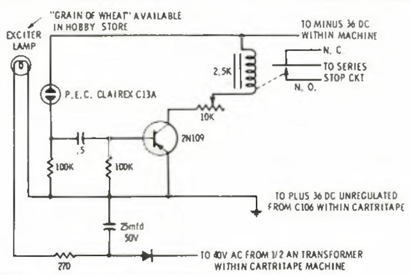
At WIOD we built a simple, inexpensive and easily built splice finder. It uses a photo electric cell and is installed on an elderly Cartritape 2 playback machine, used primarily for cueing cartridges just beyond the splice. It can be built aboard your regular recorder, but there's more flexibility in having it on another machine because you can splice cue cartridges while doing production work on your regular makeup machine.

Loads are so slight that it can be readily powered from within the unit it is installed on. Of course some component values would have to be changed if the unit is other than a Cartritape 2.

The electronics (not including the PE cell and exciter lamp) are aboard a small angle plate attached to the tape deck with two self tappers that could be black boxed completely external to the machine.

The PE cell, with the lamp taped one half to three quarters of an inch behind the eye, will probably scan the passing tape from a distance of ⅛ to ¼ inch. Its small mounting bracket could be fixed to the deck with contact cement if drilling is undesirable.

It's possible to adjust the sensitivity of the PE cell to see the actual splice, but a bright foil is a much better idea for it is more positive and allows exact adjustment of sensitivity. Put a half inch slug of bright foil atop the splice for the PE cell to see. 3M #51 pressure sensitive 7/32 sensing tape is one type that works well. This is a conductive foil but its conductivity is not the requisite—brightness is the only requirement.



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Miami, Fla.

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AKG-17

Engineer's Exchange

(Continued from page 56)

$t =$ time

$\frac{di}{dt} =$ instantaneous rate of current *change*

and $L =$ value of inductance: a constant for a particular coil.

This means that the polarity of voltage that appears across the terminals of a relay coil is determined by the direction of the current through it. This voltage may undergo any change necessary to maintain the current. To examine this relationship a practical step at a time, first consider Figure 2. With switch S initially open, instantaneous voltage *e* across the coil is zero, as is the circuit's instantaneous current *i*. Since there is no current, there is no drop across resistor R and the voltage at A (referred to ground) = the voltage at B = zero.

Now we close S. At this very instant, *i remains* at zero (an inductance opposes any *change* in current). This means that the voltage at A still equals the voltage at B, because there is no *i*R drop across R. However, A now clearly stands at voltage E above ground, which means that point B must also. In other words, the coil's cemf *e* is of magnitude E and of the *same* polarity, as indicated in Figure 2.

Having thus established that the induced voltage is of the same polarity as the applied voltage at turn-on, we'll pursue its nature at turn-off. For this, refer to Figure 3.

Assume that switch S_2 has been closed for some time, so that a steady current I is flowing. (If L were theoretically perfect, with zero resistance, the steady-state current with S_2 closed would be limited only by the battery's resistance. R_b is included here to permit a finite current.) Suppose

$R_b = 1$ ohm, and
$E = 10$ volts. Then
$I = 10$ amperes.

The nature of inductance dictates that, at the instant S_2 is opened, I must momentarily remain at 10 amperes. This is true regardless of the value of R. Then if R is 100 ohms, there must be an instantaneous voltage developed across it of

$IR = 1000$ volts.

Since the *direction* of current remains unchanged (the inductance generates a voltage that opposes current *change*), this IR drop must be positive at A with respect to B. But A is 9 volts positive with respect to ground ($E - IR_b$), so the coil's cemf *e* is 991 volts *negative* with respect to ground. This is the polarity indicated in Figure 3.

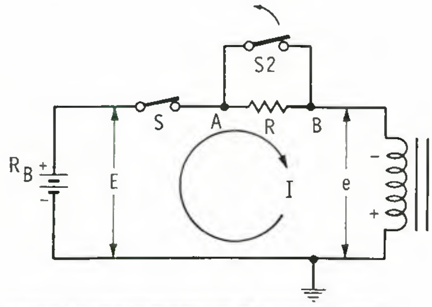

Figure 3

This shows that a diode connected across the coil as in Figure 1 will indeed conduct in its *forward* direction when the relay is de-energized, limiting turn-off transient voltages to very low values. The Zener breakdown voltage is not a consideration in its operation.

A possible source of confusion in dealing with polarities lies in the source of voltage. When the coil's current is supplied by an external battery and a steady state is reached, current flows through the coil from positive to negative just as it would in a resistor. However, when the external circuit is opened, the coil becomes a *generator*, and the *internal* current in any generator supplying energy to a circuit flows from negative to positive (note the direction of I through the battery in Figure 3).

Diode suppression is a convenient way to obtain noise-free relay operation in DC control circuits. However, there is a trade-off to keep in mind: The result of limiting transient voltage rise is a prolonging of the decay of current in the relay coil. This effectively delays the opening of the relay by a substantial interval. Fortunately, in most control circuits it isn't important whether a relay opens in three milliseconds or in 75. On the other hand, such delayed release is intentionally incorporated into some telephone switch-gear circuits to time the sequence of relay operation.

And to conclude with a parenthetical observation, the diode-suppressed relay control circuit that I built has since proven to be free of audio transients.

R. H. Coddington
Richmond, Va.

Substituting The 6B4

The nearly extinct 6B4 (V11) tube in the fine old 1181-A frequency monitor can easily be replaced with the relatively modern 6W6GT. Simply leave the present leads connected to V11 socket and jumper from pin 2 to 8, also from pin 3 to 4. After this modification either a 6B4 or a 6W6GT tube may be used in V11 socket. No other changes are necessary, just check B+ regulated bus and readjust R68 if need be. One other point, **never** substitute anything else for the F5 fusible link in the oven; not even fine copper, lead or wire solder. F5 is a heat sensitive fuse, not an electrical fuse. It is the main oven protection from burnout.

Eidson Electronic Co.
Temple, Texas

TECHNICAL DATA

For further information, circle data identification number on reader service card.

100. ANACONDA WIRE AND CABLE CO.—Voice frequency subscriber loop design principles are described in detail in a new engineering bulletin. The 68-page bulletin entitled, "Principles of Voice Frequency Subscriber Loop Design", is used in conjunction with two subscriber line calculators showing the most economical combination of gauges, for a given

(Continued on page 60)

(Continued from page 59)

distance, that meets all current transmission, pulsing and ringing requirements. One calculator, for the H-88 loading system, shows combinations of 22 and 24 gauge cables, and 24 and 26 gauge cables, for buried or aerial plant applications with central office limits of 1500, 2200 and 3000 ohms. The other calculator, for D-66 loop design, shows combinations of 22 and 24 gauge cables for buried plant use with 1700, 2000, 3000, 3500, 3800 and 4300 ohm central office limits. In addition to providing complete instructions for calculator use, the bulletin also describes design considerations of loaded and repeatered loaded loops, expected performance of repeatered loops, one-man tests for loaded loops, other loading systems, E-6 and other repeaters suitable for loop applications, and tabulated attenuation, resistance and miscellaneous loss data.

101. ANIXTER-PRUZAN—Two new catalogs prepared by Anixter-Pruzan show a full-line of the most up-to-date developments in both drop materials and grounding materials. Items in the 6-page "Drop Material Catalog" include a variety of house drop cables, drop attachment hardware, house attachment hardware and passive devices. The four-page "Grounding Materials" brochure lists ground rods and clamps, pipe grounding clamps and straps, ground wire, and ground wire moulding and staples.

102. COHU ELECTRONICS, INC.—Two low light level TV cameras present a usable picture with only 0.003 footcandles of illumination on the faceplate of the vidicon, and they can be aimed directly at the sun without damage. Details on these self-contained cameras are described in technical data sheet 6-579. One camera is enclosed for outdoor use, the indoor camera has rear panel controls.

ADVERTISERS' INDEX

FM And Land Mobile
FCC Proposals

Amendment of Section 73.261(a) of the rules to provide for licensing all FM Broadcast stations for unlimited time operation and to require them to maintain a minimum operating schedule of at least eight hours between 6 a.m. and 6 p.m., local time, and at least four hours between 6 p.m. and midnight, local time, each day of the week except Sunday, has been proposed in a rulemaking notice by the FCC.

At present FM stations are required to provide a minimum of 36 hours per week during the hours 6 a.m. to midnight, consisting of not less than five hours in any one day, except Sunday.

In proposing the change, the Commission pointed out that even though FM has become "economically more viable" a number of stations are operating at or near the minimum level permitted under the rule. The Commission said that when there are needs for more aural service in many places, "this appears hardly consistent with the public interest." To the extent that FM and unlimited AM are alike, the Commission said, "it would appear that the same standard should apply in both instances."

In response to requests by the Associated Public-Safety Communications Officers, Inc. (APCO), and RYDAX, Inc., for reconsideration of rules governing operation of non-voice radio systems on voice channels in the land mobile services below 950 MHz (Docket 19086), the Commission has retained a requirement for identification of land mobile radio stations by voice, but has deleted a requirement for automatic sensing of channel occupancy.

In an order adopted August 18, 1971, the Commission amended Parts 89, 91 and 93 of the rules to permit regular and expanded operation of non-voice operation in the land mobile services.

APCO had asked for an exception to the requirement for station identification by voice to allow station identification by Morse Code and RYDAX had asked for deletion of the requirement that non-voice systems employ automatic sensing or monitoring equipment that can prevent transmission on an occupied channel.

The Commission said, in denying the APCO request, that use of Morse Code would not afford significant advantages and noted that the additional transmitting time required could increase potential interference.

In granting the RYDAX request, the Commission stated that it had originally required automatic sensing of channel occupancy to protect voice communications from interference by non-voice transmissions and to assure that non-voice operations would be secondary to voice operations.

The FCC observed, however, that RYDAX, as well as General Electric Company and RCA Corporation, had raised "significant questions" as to the effectiveness and adaptability of automatic sensing devices and said that while it would permit use of these devices, it would not impose a mandatory requirement for their utilization at this time.

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USED EQUIPMENT—Pay Cash for FM/AM transmitters, antennas, consoles, etc. Contact: Electrónica Fernández, Box 415, Hato Rey, Puerto Rico 00919, Tel.: 767-3500. 11-71-4t

Sale—50% off on all factory new RS Coils, Contactors, Chokes, Switches, Sampling Transformers, Loops, etc. Stock items. Quick delivery. Geleco Electronics, Ltd., 2 Thorncliffe Park Drive, Unit 28, Toronto 17, Ontario. Phone (416) 421-5631. 11-71-2t

CIRCA 1947 Western Electric 506-B-2 ten kilowatt transmitter plus spare parts inventory; just retired from daily use. Best offer over \$500. Can be bought complete with RCA BTE-10-B stereo exciter (not available separately) at best offer over \$1,1250. (Blind box reply). Dept. 257 Broadcast Engineering, 1014 Wyandotte, K. C., Mo. 64105. 12-71-1t

The University of California offers for sale to the highest bidder 2 only Ampex VR 1100 Videotape Recorders. With Mark Ten heads, one playback only. Accessories: Electronic Editor, Vertical LOC Boards, Processing Amplifier, Mincom Dropout Compensator, Smith Tape Splicer. Minimum acceptable bid for lot \$20,000. Sealed bids must be submitted to University of California, Purchasing Department, Santa Barbara, Calif. 93106 no later than 2:30 P.M., December 17, 1971. For bid forms, please contact above address or call A/C 805 961-2588. 12-71-1t

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VSI-2200 Film Multiplexer and Spindler & Sauppe Model 332 Slide Projector with Lens and Base for Sale. \$2,250.00. SMU TV System. (214) 363-5611 ext. 811. 12-71-1t

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Radio Station For Sale

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TV STATION FOR SALE—Complete television station available for package price of \$12,000 f.o.b. KETC-TV transmitter room at Boatmen's Bank Building, St. Louis, Mo. Equipment in package includes: 320-foot Blo-Knox self-supporting tower, 320 feet of 3⅛ inch transmission line, RCA TT5 transmitter driver with GE 20 kw TF-4 amplifier, two Ampex VR-1000 videotape machines (one complete with Allen mod, demod & switcher) with Amtec, one Eastman 275 film projector, one GE 4-TV-86-C-1 multiplexer, one Spindler 35mm slide projector, and one GE 4-PC-13-A-1 vidicon film camera with GE 4-TC-58-A-1 controls. This equipment is now in daily use but will be retired from service with opening of new KETC-TV Broadcast Center November 1. This is first and last time this equipment is being offered and it won't last long at this package price. Station prefers to sell as a package, but would accept offers on individual items. For more information write: Director of Engineering, KETC-TV, 6996 Millbrook Blvd., St. Louis, Mo. 63130 (or phone 863-0998). 12-71-1t

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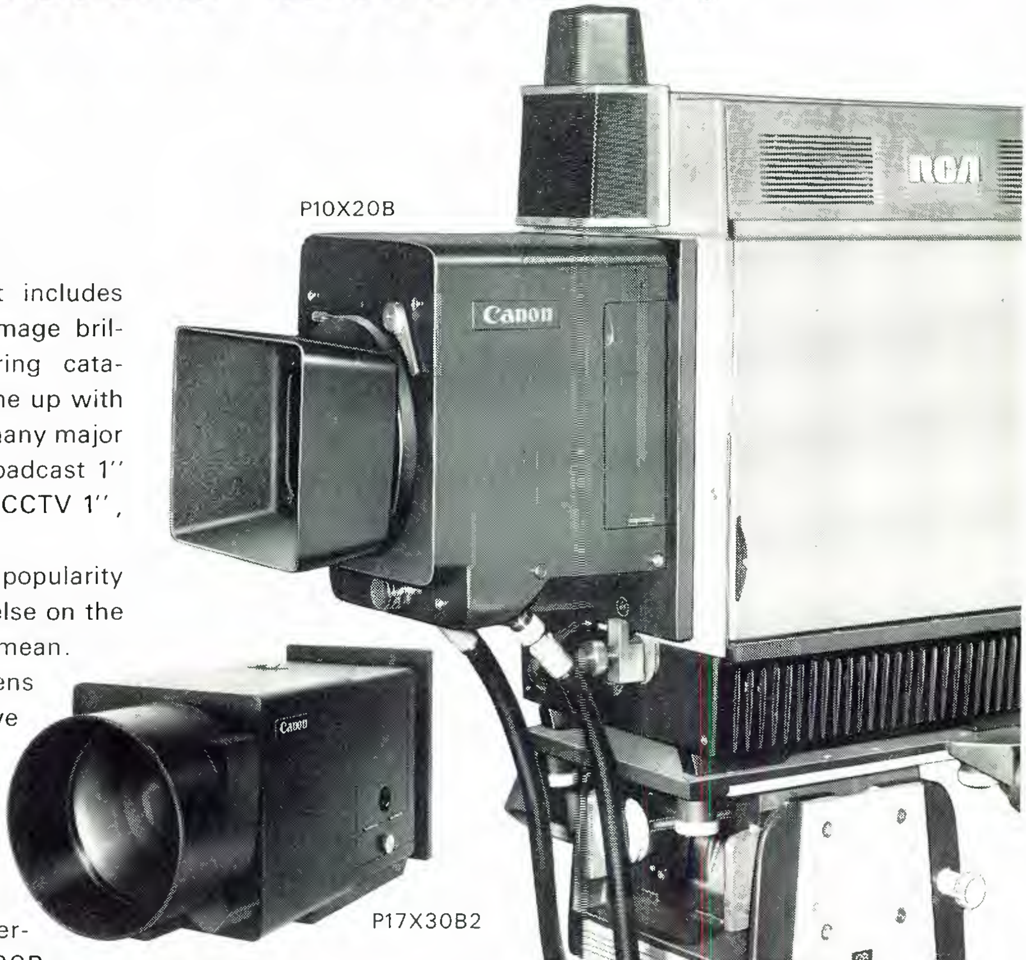

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	V6 x 16	16.9— 95mm	1 : 6	F 2.0
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	V4 x 25	25—100mm	1 : 4	F 1.8
⅔" Vidicon	J10 x 13	13—130mm	1 : 10	F 2.8
	J 6 x 13	13— 76mm	1 : 6	F 1.9
	J 5 x 15	15— 75mm	1 : 5	F 2.1
	J 4 x 12	12.5— 50mm	1 : 4	F 1.8
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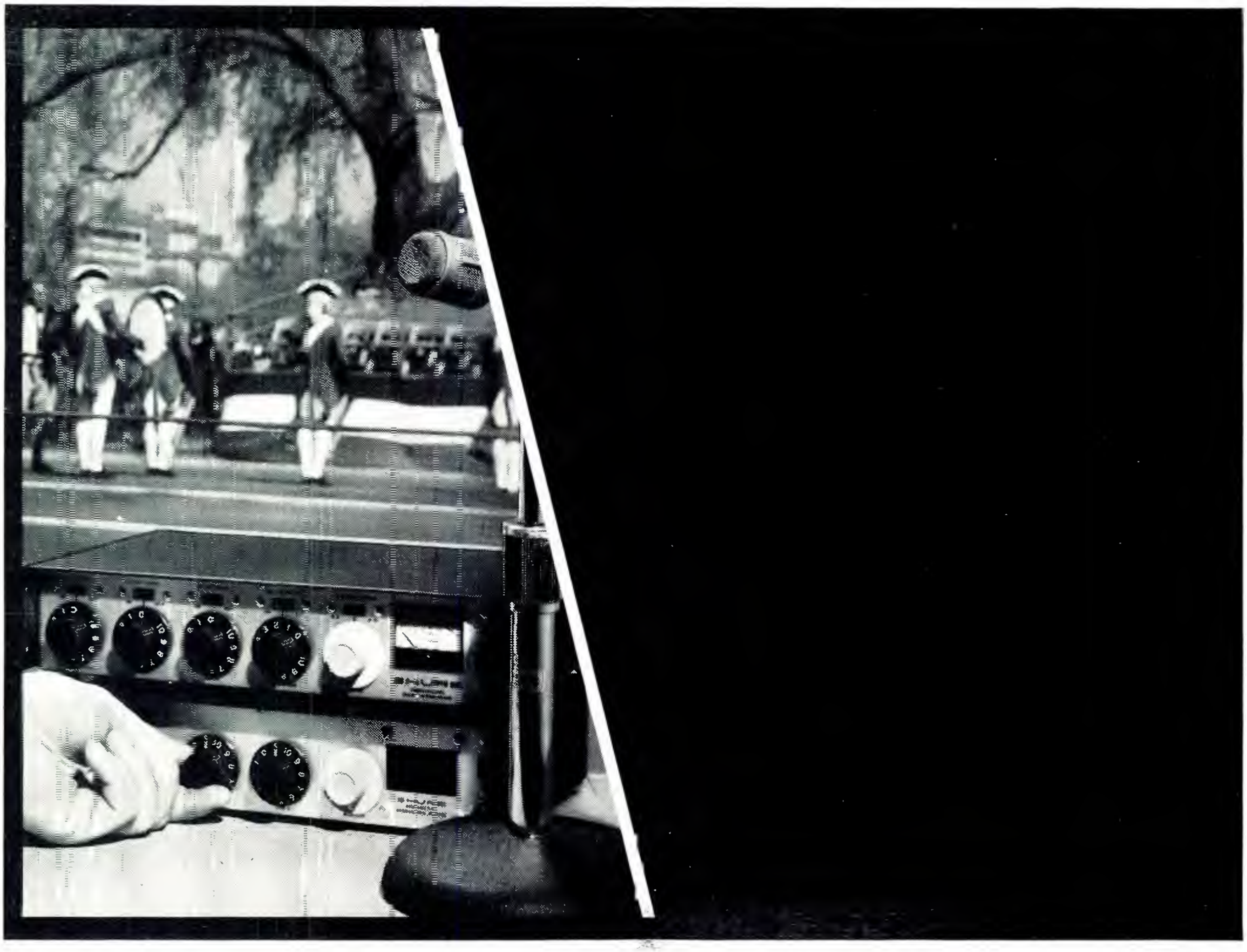

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