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*Patent No. 3,115,237

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ELECTRONICS WORLD
THIS MONTH’S COVER shows an artist’s rendering (made from the 6 original diffusion masks) of the RCA linear integrated circuit being used as the intercarrier audio system in current RCA TV sets. The tiny circuit, 50 mils on each side, incorporates 12 transistors, 15 resistors, 9 diodes, and 3 diode capacitors. Over-all operation of this device was covered in our June, 1966 issue. Before the chips are separated from the master slice, each chip is automatically tested (as shown in the upper-right photo) by a test set having 12 fine-pointed test probes that contact certain terminals to measure basic circuit parameters. The IC at the lower left is a G-E linear IC showing typical mounting and lead configuration as used in the company’s new low-cost plastic flat pack. Photos courtesy of RCA and General Electric Company.
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COMING NEXT MONTH

SPECIAL FEATURE ARTICLES ON:

COLOR TV

Color-TV Broadcasting—NBC provides a behind-the-scenes look at color broadcasting from an electronics viewpoint. The article covers engineering problems, studio techniques, and technical solutions. Named are pickups, video tape recordings, outside pickups.


Color-TV Signal Generators—Here is a rundown on virtually all of the available color generators—with pertinent electrical and mechanical specifics for each model. This is presented in tabular form for easy comparison and reference.

PLUS....

Electronic Metal Locators—An in-depth survey covering models available to the sportsman and treasure hunter. Comparative characteristics and performance data are provided on beat-frequency, induction-balance, and transmitter-receiver types along with a directory of metal locator manufacturers.

CRYSTAL-SAVING FREQUENCY SYNTHESIZER

A novel method for generating many crystal-controlled frequencies at a great saving of crystals is described by F. P. Smith of Norco. Applications include FM receivers and CB transceivers as well as aircraft communications equipment.

CRYOGENIC LIQUID LEVEL CONTROLS

The increasingly widespread application of cryogens in industry has spawned a whole new family of controls for maintaining the level of cryogenic liquids in their reservoirs. W. W. Schopp of the Lawrence Radiation Lab describes some of them.

FIELD-EFFECT TRANSISTOR CIRCUITS

Six practical circuits are diagrammed and described in this article prepared especially for those interested in learning about FET's by working with them.

All these and many more interesting and informative articles will be yours in the December issue of ELECTRONICS WORLD... on sale November 17th.

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Tips on replacing electrolytic capacitors

Finding the right electrolytic capacitor for a replacement job often becomes a matter of juggling three factors: what the circuit originally called for, what you can get quickly from a distributor, and what you have on hand in your shop. Here are a few hints that may help to make your life easier.

The important parameters about an electrolytic are voltage rating, capacitance, temperature rating and size. You have a certain amount of leeway on all four of these... and knowing how far you can stretch safely may save you a lot of shoe leather looking for the exact replacement.

Let's take voltage first. You can always substitute a capacitor with higher voltage rating than that originally required, with absolutely no harmful effects (except maybe on your pocketbook, because you may pay for extra capability that you don't need). But you should never replace with a voltage rating lower than the original.

How about capacitance? Our advice—don't go too far from -10% +50% of the original value. You've probably heard that standard industry specs allow tolerances of 10% low and up to 150% high. Actual manufacturing practice at Mallory, is to make capacitors to considerably tighter tolerances... because most radio and TV manufacturers won't tolerate the wider variations. Too small capacitance is apt to raise hum levels. Too high capacitance may lead to surge damage to silicon rectifiers.

On the temperature score, you don't have to worry if you use a Mallory FP-WP, TC, TT, or MTA type, because they're all rated for 85°C (except for three odd-ball TC's), and that's plenty for home instruments or industrial electronics. Our wax-filled cardboard tubulars are rated 65°C. The few cents extra that you might spend for a Mallory capacitor, compared to the cheapest ones you could buy, will assure you of several times longer service life.

How about size? Don't be surprised when you find that in many instances the Mallory replacement is smaller than the original capacitor (naturally, it will still fit chassis cutouts). That's because of our new techniques for deep-etching aluminum to increase the effective area of the anode. So we can get about nine times more microfarad-volt rating inside a given container than with plain foil.

One final tip. Our new Capacitor Replacement Guide makes it a cinch to find the exact part number to specify, to replace just about any electrolytic you may encounter. Ask your Mallory Distributor for a copy, or write Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., P. O. Box 1558, Indianapolis, Indiana 46206.
LETTERS FROM OUR READERS

**INSULATED-GATE TRANSISTOR**

To the Editors:

As the author of some articles and papers on insulated-gate field-effect transistors, I was quite interested to read Donald Lancaster’s piece in your July, 1966 issue on the same subject. In general, I felt the topic was well handled. However, there are two items which Don and his readers might find interesting.

The first item is that the IEEE Symbols Coordinating Committee now has an IGFET symbol which gives positive identification of the source terminal by putting the gate connection at the source end of the gate. In addition, this new symbol shows whether an IGFET has a p-channel or an n-channel and also differentiates between enhancement-type and depletion-type IGFETs.

Incidentally, Don’s article may have left his readers with the impression that all IGFET’s are the enhancement type. As you probably know, there are several depletion-type IGFET’s available also. (Depletion types are characterized as “normally on” in contrast with the enhancement types which are “off” in the absence of gate voltage.)

Another point is that I think Don has confused “bipolar” with “bilateral.” All FET’s, whether insulated-gate (IGFET) or junction-gate (JUGFET), are unipolar devices because all source-to-drain conduction is carried out by charge carriers of one polarity. On the other hand, all FET’s are bilateral because their source and drain can be interchanged. (It should be noted that differences in the size or relative position of source and drain in some devices lead to the designation of a “preferred” source which gives best performance in certain applications.)

IGFET’s should open a whole new range of applications, so I’m looking forward to reading future articles.

David M. Griswold
New Providence, N. J.

**AUTO BURGLAR ALARM**

To the Editors:

After reading the article by Edwin R. DeLosch an an SCR auto burglar alarm (August issue), I thought some readers might be interested in the alarm I designed. It operates on the same principle but can be built for under $6.

With S1 in the “On” position, RL2 will be energized if the hood, trunk, or dome light switch is operated. With the contacts of RL2 closed, the horn will blow and RL2 will remain energized. The horn will continue to blow until the heater of RL1 opens the contact of this circuit, causing RL2 to drop out.

R1 is used to limit the heater current of RL1, if required. Almost any 12-volt relay will operate with the standard 15-candlepower dome light. Most cars have smaller bulbs in the trunk and under the hood, and these bulbs will have to be changed to 15 candlepower or greater.

Daryl R. Styblo
Waltham, Mass.

**SAW-TOOTH TESTING**

To the Editors:

The article “Saw-Tooth Testing of Audio Amplifiers” in your July issue presents some interesting and useful information, but the authors seem to have drawn some incorrect conclusions.

The symmetrical square wave and the saw-tooth wave each consist of a fundamental frequency and an infinite series of harmonics, the amplitude of the nth harmonic being 1/n times that of the fundamental. As pointed out in the article, the square wave consists only of odd-order harmonics, while the saw-tooth has both even and odd harmonics. Now, for the same degree of resolution of each waveform, the same number of harmonics is required, and since only odd-order harmonics are present in the square wave, it follows that the bandwidth for the square wave is twice that for the saw-tooth instead.

(Continued on page 12)
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(Continued from page 6)
of "not as wide" as claimed by the authors.

The discussion of the "obvious utility" of the saw-tooth is erroneous. Since a 1-kHz saw-tooth contains a 1-kHz fundamental and harmonics at 2, 3, 4, ..., n times the fundamental frequency, it cannot be used to check the response at 100 Hz as claimed.

LLOYD CLAYTON
Gulf Breeze, Fla.

The authors of the original article still believe in the usefulness of the saw-tooth wave for amplifier testing. They point out that since this waveform has no gaps in its frequency spectrum (that is, it covers all harmonics) while the square wave has such gaps (since it includes only odd harmonics), one is more likely to detect a deficiency in frequency response using the saw-tooth. This is especially true for amplifiers with quite sharp roll-offs.

On the matter of using a 1-kHz saw-tooth to check frequency down to 100 Hz, this can certainly be done. If an amplifier, for example, cuts off just below 1000 Hz, it is found to have some phase distortion at this and at lower frequencies. The amplifier must be flat to a substantially lower frequency in order to perform properly at the fundamental frequency of the saw-tooth. We have seen cases where a 100-kHz saw-tooth was put into an amplifier whose response was —6 dB at 100 Hz, and the result was definite curvature of the linear portion of the waveform.—Editors

* * *

TIME DOMAIN REFLECTOMETRY
To the Editors:

I would like to obtain two reprints of John Lenk's article "Time Domain Reflectometry" (September, 1966 issue). This is an excellent presentation of a valuable technique that is not treated adequately in our curriculum.

I would like to have these copies for a display case in our department.

JOHN B. PEATMAN
Asst. Prof. of Elec. Eng.
Georgia Institute of Technology
Atlanta, Ga.

* * *

BOONTON CAPACITANCE METER
To the Editors:

In your September, 1966 issue you published an excellent description in your "Test Equipment Product Report" of our Model 71A capacitance/inductance meter. Unfortunately, a typographical error crept in which could be misleading to some of your readers. The capacitance range of the Model 71A extends from 0 to 1000 pF, not 1000 pF as indicated in your article.

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November, 1966
Kenwood TK-60 Stereo Receiver

For copy of manufacturer's brochure, circle No. 27 on Reader Service Card.

THE Kenwood TK-60 is a solid-state stereo receiver with a number of unusual features for a unit in its price class. It is relatively large in size, measuring 17¾" x 5½" x 14" and weighing some 24 pounds. Virtually all of its circuits are constructed on several printed boards, with the output transistors mounted on large, finned heatsinks.

The front-end of the TK-60 has a double-tuned r.f. stage for good image rejection; a.f.c. is provided, with a switch to defeat it; and the i.f. section has five stages, followed by a wideband ratio detector. Unlike most moderately priced receivers, this receiver includes an AM tuner. This is rather simple in its design, with a self-oscillating mixer, two i.f. stages, and a diode detector. A ferrite-rod antenna is built into the receiver, with provision for an external antenna.

The multiplex demodulator uses a 38-kHz oscillator, synchronized by the 19-kHz pilot carrier. A four-diode balanced demodulator separates the two channels, which are then amplified in individual feedback-type amplifiers. The stereo/mono switching system is quite complex, using six transistors, five diodes, two lamps, and many other components for the logic and switching functions. This is much more elaborate than the switching methods used in most receivers, even those costing considerably more than the TK-60. The complexity is justified by the results, since this is one of the best performing automatic stereo selection systems we have seen.

In the absence of a transmitted pilot carrier, a red light on the dial face glows, and the multiplex circuits are disabled. When a pilot carrier is received, the red lamp goes out and a blue lamp is turned on, indicating a stereo broadcast. The 38-kHz oscillator is simultaneously gated on and the receiver is in the stereo mode. The outstanding characteristic of this circuit is its freedom from accidental tripping by modulation peaks or interstation noise. Most such circuits give a flickering indication when tuning between stations. The Kenwood will not respond, even momentarily, to anything except a bona fide stereo transmission. The switchover is completely silent and indistinguishable except for the different spatial characteristics of stereo.

The audio section of the receiver is rated at 50 watts total music power, with 8-ohm loads. Speakers from 4 to 16 ohms impedance may be driven successfully. There are no transformers in the audio section. The only transformer in the receiver (other than i.f. coils) is the power transformer. The preamplifiers have equalization for RIAA phono and NAB tape head. A mixed (mono) output signal is available in the rear for driving a center-channel speaker through an external power amplifier.

We measured an IHF usable sensitivity of 3.1 µV on the FM tuner por-
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Marantz Model 7T Preamplifier

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The Marantz Model 7T transistor stereo preamplifier is difficult to criticize since it apparently has no faults. We have encountered other units which incorporate many of the features, but we have never found a unit which embodied all of the performance characteristics of the Model 7T. This sort of near-perfection does, of course, have its price.

Most of its frequency response curves can be drawn with a straightedge. The only distortions we were able to measure at any reasonable signal level were those inherent in our test equipment. Using the preamp in a music system for a prolonged test did not reveal a single flaw or basis for criticism.

(Continued on page 95)
A New Electronics Slide Rule
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Here’s a great new way to solve electronic problems accurately . . . easily. The Cleveland Institute Electronics Slide Rule* is the only rule designed specifically for the exacting requirements of electronics computation. It comes complete with an illustrated Instruction Course consisting of four AUTO-PROGRAMMED* lessons . . . each with a short quiz you can send in for grading and consultation by CIE’s expert instructors. With this personal guidance, you’ll soon be solving complex electronics problems in seconds while others still struggle along with pad and pencil.

Here’s what Mr. Joseph J. DeFrance, Head of the Electrical Technology Dept., New York City Community College, has to say about it:

“I was very intrigued by the ‘quickie’ electronics problem solutions. It is an ingenious technique. The special scales should be of decided value to any technician, engineer, or student. The CIE slide rule is a natural.”

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CIRCLE NO. 94 ON READER SERVICE CARD
Linear Integrated Circuits

By B.V. VONDERSCMITT and R.L. SANQUINI

RCA Electronic Components & Devices

The circuit engineer who is designing consumer products must now change his way of thinking in order to include the use of integrated circuits. Here are some practical ground rules to follow in the design of such equipment.

During the initial stages of integrated-circuit development, most of the effort was directed toward the design of digital circuits. Within the past three years, however, both equipment-design engineers and integrated-circuit applications engineers have been working diligently to design circuits for linear applications. One of the major difficulties has been the development of linear circuits which are economical in equipment use yet sufficiently flexible in application to permit their employment in many different types of equipment in which the actual functions may differ greatly. Because the development cost of a circuit from inception to successful production is substantial (primarily in engineering manpower), a sufficient production quantity to amortize development cost is required.

A rather wide variety of linear circuits are currently available as "off-the-shelf" items. Although many of these circuits were designed and developed for specific applications, there is also an impressive list of linear circuits with a broad base of application. (For further details, refer to the article "Linear Integrated Circuits: What's Available?" in this issue.—Editors)

The use of linear integrated circuits in equipment has lagged digital use by approximately three years. Fig. 1 shows a projection of linear-circuit applications from 1965 through 1970. To a large extent, the rate of growth will be a sharp function of the acceptance of linear integrated circuits in the consumer market because the design time from inception to full production is at least twice as long for militarized as for consumer equipment.

There has been much speculation about the future of the circuit or equipment-design engineer and his role in integrated-circuit evolution. In the digital field, there is little doubt that the circuit engineer's role will be changed rather dramatically over the next decade. He will almost certainly be working with "off-the-shelf" gates (flip-flops) which already exist as standard items in combinations of low power and low switching speed to higher power and ultra-high switching speeds. The low cost of these standard items will tend to force equipment manufacturers to use existing types rather than design their own and incur the expense of developing and "debugging" new circuits for which they cannot demand sufficient volume to provide low cost. Large-scale integrated arrays will further change the role of the digital-circuit engineer.

In the linear field, however, the future is not so clear. Because communications equipment (commercial or military) demands a wide variety of circuits, there tends to be a conflict between the most economical design, i.e., more functions within one package intended for a specific application, and the simpler single-function design which can be used in a large number of different applications.

To fulfill his new role in the integrated-circuit field, the circuit engineer must become familiar with the "ground rules" that are used to design circuits suitable for integration. Many of the ground rules are dictated by cost considerations. To design circuits, however, the engineer must be familiar with the list of basic components, their characteristics and the variation of these characteristics within the nor-
mal production processes, and the trade-offs of closer tolerances on characteristics and the reduction in yield that these tolerances will cause.

For the design of completely monolithic circuits with present processing capability, there are four components available to the linear-circuit designer: transistors, diodes, resistors, and capacitors. Figs. 2 through 6 show the equivalent circuits of these four components in monolithic form and their characteristics. The wide range in basic parameters and in parasitic components results from the fact that transistor geometries can be varied and processes can be changed to effect large differences in transistor characteristics in the same circuit. In an operational amplifier, for example, the input transistors may be required to have high beta at collector currents as low as 100 microamperes, while the output transistor may be required to deliver 100 milliampere. When the circuit and equipment engineers understand the characteristics of the basic devices, application of integrated circuits in equipment functions effectively reduces to the same problems encountered in the use of discrete components.

Cost and Reliability
The factors that contribute to the cost of electronic equipment can be categorized as follows:
1. Original component cost.
2. Inspection of components at the equipment manufacturer's plant to guarantee conformance with the purchase specifications.
3. Labor associated with assembly of components into final equipment.
4. Troubleshooting of equipment at the manufacturer's plant as a result of defects in the original component or defects caused by the equipment manufacturing process.
5. Maintenance of the equipment over its useful life.

The relative importance of these five factors is largely a function of the type of end equipment—military, industrial, or consumer. For the military market, item 1 can be more significant than the other four. For consumer applications, items 1, 2, and 3 are the most significant, with item 1 most important of all.

There are other significant factors in the use of integrated circuits in consumer-type equipment which are difficult to cost-analyze, e.g., the availability of replacement parts in case of an integrated-circuit failure. Unless some standardization can be achieved by a manufacturer on successive models, availability of replacement parts may be an added factor in servicing problems.

Experience to date indicates that integrated circuits improve equipment reliability by a factor which is almost directly related to the number and complexity of components within one package. Failures tend to occur as a result of servicing of other parts of the equipment, rather than through any fundamental failure of the integrated circuit itself. Various integrated-circuit manufacturers have demonstrated failure rates from 0.03% to 0.001% per 1000 hours with acceleration factors normalized to 55°C operation. If an MTBF (mean time between failures) of ten million hours is considered as typical, a complexity of 100 circuits results in a theoretical equipment MTBF of more than ten years. This value is already nearly at the limit of equipment obsolescence.

Manufacturers of consumer equipment will not use integrated circuits unless the initial cost is no more than that of an equivalent complement of discrete components. A small percentage of the initial cost may be added because of the elimination of the additional handling required for discrete-component circuits. Reliability improvement, although very real, is of significance primarily to military-equipment manufacturers. There are exceptions in the industrial field, however; users of test equipment (counters, oscilloscopes, digital voltmeters, and the like) are sensitive to the cost of maintenance and the cost of down-time of test equipment both in engineering and production use.

Another important factor is that special circuits designed for a specific application may be used only when a sufficient volume is needed to justify the engineering costs required to design, develop, and "debug" the circuit, to introduce it into production, and to refine it in production until the circuit can be manufactured with an acceptable yield. The cost of such development (which is primarily engineering manpower cost rather than the cost of the masks associated with the circuit) is between $10,000 and $50,000, depending upon the complexity of the unit. It becomes obvious, therefore, that selection of standard "off-the-shelf" units is preferred wherever possible.

The most important factor affecting the cost of integrated circuits as compared with that of discrete components is inherent in the manufacturing process. This basic consideration is that every discrete component must have an individual package and must receive individual handling.
after dicing (breaking into individual pellets) through the final test. Practical methods of handling the pellet dictate a minimum pellet dimension of 0.015 to 0.020 inch. However, only a very small percentage of this silicon area is utilized. Improved methods of attaching the pellet to the package (e.g., the flip-chip method which eliminates mounting and bonding) plus the use of either epoxy or silicone encapsulation for the package all tend to reduce the cost per die to a uniform figure. As a result, the increased number of functions per package possible with monolithic integrated circuits and the utilization of a higher percentage of the silicon are fundamental considerations which assure that integrated circuits offer distinct cost advantages. This advantage will become sharper as processing technology (line resolution) improves to permit further reduction of the silicon area.

**Packages**

The following items must be considered in the selection of the package to be used for integrated circuits: (1) cost, (2) difficulty of assembly on printed-circuit boards, (3) ability to isolate between input and output in a high-gain circuit, and (4) shielding to prevent radiation, particularly in high-frequency applications.

The lowest cost package available at the present time is the TO-5, 8-lead package shown in Fig. 7. This package has the advantages of low cost, shielding, assured hermeticity, and sufficient spacing between leads to permit assembly on printed boards by means of wave-soldering techniques.

When an integrated circuit requires more than eight leads, 10- or 12-lead TO-5 packages can be used. The leads of these packages can be reformed to provide wider spacing.

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**Fig. 8** shows a 14-lead flat package that offers the advantages of greater compactness and improved flexibility in circuit connections. The disadvantages of this type of package are that it is in most cases more expensive than the TO-5 case and in all instances requires lead reforming if soldering techniques are to be used.

Several manufacturers are introducing dual in-line packages which permit large separation between the input and output leads. Fig. 9 shows a typical dual in-line package. Some of these packages are hermetically sealed and some are surface-passivated and mechanically protected by means of transfer molding with either an epoxy or silicone. These packages, particularly those of the transfer-molded types, promise to be quite low in cost.

**Monolithic Circuits vs Other Types**

Development work on microcircuits has covered not only the monolithic circuits which now appear to be receiving universal acceptance but also thin-film, thick-film, and "hybrid" or "chip" circuits. The following definitions may be used to differentiate among these various types of microcircuits.

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**Fig. 7.** The type TO-5, 8-lead package and its dimensions.
In monolithic circuits, the active and passive components are fabricated simultaneously by selective diffusion. Isolation between circuit elements is obtained by a single diffusion step which forms back-to-back diodes, conductively isolating these elements.

In thin-film circuits, the passive elements are generated by masking and successive evaporation of various materials to permit optimization of the characteristics of these materials. The objective of all thin-film processes is to fabricate active as well as passive devices by evaporation. To date, the evaporation of well-performing active devices has seriously delayed acceptance of this approach. In thick-film circuits, passive components are deposited in the form of thicker films through a masking technique.

"Hybrid" circuits cover the use of thin-film passive devices, thick-film passive devices and interconnections, monolithic chips, and single special-characteristic active devices which are electrically isolated by a low-dielectric-constant material and which are interconnected by internal bonding techniques, either thermal-compression or ultrasonic.

The advantages and disadvantages of the three types of circuits are summarized in Table 1. From the standpoint of techniques, either thermal-compression or ultrasonic, which are electrically isolated by monolithic chips, and single special-characteristic active devices, thick-film passive devices and interconnections, the close proximity of components and the simultaneous fabrication of these components.

Advantages and disadvantages of the three types of IC's.

Advantages

Monolithic Low cost, improved reliability, multi-sources.

Thin Film Passive components can be optimized.

Hybrid Both active and passive devices can be optimized.

Disadvantages

Monolithic High cost, poor reliability.

Thin Film High cost, active devices must be attached separately. Multi-source manufacturers difficult to obtain.

Hybrid High cost, poor reliability.

Criteria for Selection

In designing with integrated circuits, an equipment-design engineer should, if possible, select standard circuits and use outboarded components for his specific applications. The partial list of available standard circuits will grow substantially over the next three years so that most signal-processing functions can be accomplished by the use of standard circuits plus a limited number of discrete components. Because of the advantages of multiple sources, such standard circuits will be selected in most instances.

For minimum cost, which can normally be provided by multi-function circuits, it may prove economical to design special circuits if the manufacturer's volume is sufficient to justify the expense. The following steps are necessary to develop new designs:

1. Define the input, output, and transfer characteristics of the circuit to be developed.

2. Estimate the cost of the discrete components that the new circuit will replace. After the circuit is designed, the production cost can be estimated rather accurately from a determination of the silicon area required, provided the specifications and design are consistent with normal processing variations.

3. In development of the circuit, keep in mind the following fundamental ground rules:

(a) Select the components based on minimum wafer area; cost and yield are related to the pellet size.

(b) Design the circuit to tolerate a large variation in absolute resistor values. Variations in absolute values of ±25% provide lowest cost. Yields for absolute values of ±10% would be low, and hence cost would be high. Ratios between two resistors can be held to ±2%. Permissible variations designed to allow larger tolerances are desirable.

(c) Minimize the use of large capacitor values. Values in excess of 50 picofarads are considered undesirable.

(d) Design circuits to tolerate a large range of transistor beta.

(e) Take advantage of the matching of transistors for beta and $V_{bb}$; these matching characteristics are fundamental in the production of integrated circuits as a result of the close proximity of components and the simultaneous fabrication of these components.

(j) Wherever possible, (Continued on page 79)
Line-Operated Transistor TV Sets: Magnavox

By WALTER H. BUCHSBAUM

A light-dependent resistor that compensates for ambient room lighting, a novel horizontal oscillator circuit, and capability of driving up to 27-inch CRT’s are featured in these receivers.

The Magnavox Co. is the first TV manufacturer to offer a completely transistorized (except for the CRT and high-voltage rectifier) 27-inch TV receiver. The same basic chassis is used in the Magnavox “Astrosonic” line, which includes 19-inch portables and 23- to 27-inch console models. Shown in Fig. 1 is the 24-inch model with the rear cover removed. It is startling, at first, to see a large picture tube and two substantial speakers mounted in a console with a relatively small chassis and no visible vacuum tubes. The main advantages such a receiver has over its vacuum-tube cousin are the use of considerably less power and less heat, and greater reliability.

These transistor sets operate from the 120-volt line. The high-voltage winding of the power transformer and its rectifiers provide +68 to +140 volts, while the low-voltage section provides +14 volts unregulated and +12 volts regulated by a single zener diode.

The receiver uses a total of 22 transistors, four of which are used in the v.h.f. and u.h.f. tuner, and 23 diodes. The single vacuum tube, in addition to the picture tube, is a 1K3 high-voltage rectifier for powering the CRT ultor anode.

Generally speaking, the transistor circuits are very much like those described for previous transistor TV receivers. Both v.h.f. and u.h.f. tuners, the three-stage i.f. section, and the two-stage video amplifier are relatively conventional. The first video amplifier is an emitter-follower which drives the output stage. To get sufficient video-signal amplitude, this stage is connected to the +140-volt supply. Like most transistor receivers, a two-stage a.g.c. section controls the gain of the v.h.f. tuner r.f. stage separately. The i.f. gain is controlled by applying the a.g.c. voltage to the base of the second i.f. stage, and from the emitter of this transistor to the base of the first i.f. amplifier. This is the generally accepted forward-a.g.c. method.

The intercarrier audio circuit uses a single sound i.f. stage, a dual-diode ratio detector, and two direct-coupled stages of audio amplification. The audio output stage receives its collector voltage from +110 volts. Since some of the console models include transistorized hi-fi equipment, the audio output circuits will vary (Continued on page 98)

Fig. 1. The Magnavox 1908 chassis can drive a 24-inch CRT.

Fig. 2. A light-dependent resistor senses the ambient room lighting and makes corrections in both contrast and brightness.
RECENT DEVELOPMENTS IN ELECTRONICS

First Inorganic Liquid Laser. (Top left) A high-energy liquid laser, the first to use an inorganic fluid, has been developed. An experimental model, operated at room temperature, has produced an infrared beam of energy comparable to that of solid-state lasers of similar size. Making the laser is an uncomplicated ten-minute procedure. A bluish powder of the rare earth neodymium oxide is dissolved in a solution of selenium oxychloride, an inorganic substance. The liquid is then transferred to a glass tube, such as the one held by a GT&E lab technician shown. This liquid is the active medium which serves the same purpose as the ruby rod in a solid-state laser. The new inorganic liquid laser emits light at a wavelength of 1.06 microns (slightly more than one-thousandth of a millimeter), which is in the infrared region of the electromagnetic spectrum.

Hospital Closed-Circuit Television. (Center) Mothers of babies delivered at Sacred Heart General Hospital in Eugene, Oregon may learn to bathe and feed their infants by watching CCTV programs transmitted from the hospital nursery. The infant-care programs may be seen on 227 television receivers installed in patients' rooms throughout the hospital. The sets also receive entertainment and news from the regular commercial channels as well. CCTV equipment has also been installed in two operating rooms, outside the emergency entrance, and in the hospital chapel, auditorium, and kitchen. The hospital's medical staff uses the system to watch surgery from the auditorium and lounges throughout the building. Also religious services are transmitted from the chapel and the patients can see their meals being prepared in the hospital's kitchen. The closed-circuit TV system was designed and manufactured by Sylvania.

Machine-Tool Control Uses IC's. (Bottom left) Many integrated-circuit elements like the one in the foreground beside the dime are used in a new numerical contouring control system. This single, tiny, integrated circuit is the equivalent of the circuit board in the background which was used in an earlier system. In numerical contouring, material such as metal or wood, is automatically cut and shaped by a machine tool that is programmed by means of a punched tape. Output signals from the tape go into the control unit which subsequently positions the cutter on the tool which can take any position that is determined by three axes of motion. The new system, used by The Cincinnati Milling Machine Co., weighs so little and occupies so little space that an entire three-axis system could be mounted on a machine column or operator's platform, reducing the need for cumbersome cable links between control, console, and machine. The entire control is housed in an air-conditioned cabinet not much larger than previous operator's console.
Electronic Medical System. (Right) A complete system for simultaneously measuring and displaying functional changes that can occur in a patient was demonstrated recently. The system, made by Honeywell, is a combination of several instruments for recording, storing, and displaying medical information. A graphic display of a patient's heart, pulse, or breathing activities is traced on a multi-channel oscilloscope that shows simultaneously up to eight kinds of physiological data on a long-persistence, 17-inch CRT screen. A direct-recording oscillograph can also be used for a permanent display. In addition, an FM magnetic tape recorder is used to record up to eight channels of data, plus voice channel, on half-inch magnetic tape.

Integrated-Circuit Radar Calculator. (Center) Mounted directly above the radar indicator scope is a new radar intercept system, which will enable a radar operator to determine optimum time and course, and to direct interceptors against as many as five targets simultaneously. The small size of the device—it occupies only ¾ cu ft—is due to the use of integrated circuits. The Motorola-built unit is designed as an accessory to any general-purpose radar indicator. It determines target position and course automatically and computes speed and projected target position. This is done directly from the radar video data and antenna azimuth information, thus providing a speed and accuracy beyond the capabilities of an operator alone.

Lunar Orbiter Memory. (Below left) This tiny memory, not much larger than five packs of cigarettes, carries all the information needed to shift the Lunar Orbiter into its orbits around the moon, position it for photography, and start the cameras taking photographs of the lunar surface. The unit, built by Electronic Memories, also acts as a speedometer during acceleration of the spacecraft, and provides continuous information on its attitude during rotation. It also issues commands to deploy the spacecraft's four solar panels and two antennas. Drive-current selection and routing are performed by magnetic techniques rather than by the usual semiconductors. Use of the latter would require more components and would be less reliable.

Portable Battlefield Radar. (Below right) A new second-generation man-portable radar for battlefield use is shown here. The unit provides aural surveillance that distinguishes between a walking man and a small moving vehicle out to about 3 miles. A remote indicator is also provided that can be operated from a concealed position as much as 50 feet away from the antenna. This indicator has two ranges (from 0 to about 3 miles and from 3 to about 6 miles) and it provides the usual B-scan and PPI-scan along with a moving-target indication out to the maximum range. The rechargeable battery used will power the radar for 9 hours. The portable battlefield radars will be built for the Dept. of the Army by Airborne Instruments Lab.
The Tape Cartridge Comes of Age

By LEONARD COPLEN & ROBERT JOHNS

The emergence of the magnetic tape cartridge may be the most important innovation in musical entertainment for the car and the home since the LP record. Dozens of equipment makers are now offering their wares, and many record companies are duplicating their libraries in cartridge form.

Traditionally, entertainment media like the phonograph, radio, and television, have started in the home and then spread to other locations. Radio, for example, first became popular as home entertainment and then moved out to the family car. The tape cartridge, on the other hand, although introduced in home machines a few years ago, was given real impetus by the availability of cartridge players for the car.

The heart of the system is the cartridge itself, a plastic case that holds a single reel of ⅛" tape joined in a continuous loop or two reels of ⅜" tape in a conventional reel-to-reel arrangement. The cartridge and the machine designed to play it make up a cartridge system.

There are two leading systems on the market. Both use ⅛" tape, operating at 3⅞ ips, recorded in conventional two-track stereo. In order to put more music into a cartridge, however, both systems record more than one set of tracks per cartridge. One system, usually identified as the Fidelipac system, uses four tracks while the other (known as the Lear system) employs eight tracks. In other words, the Fidelipac 4-track cartridge contains two sets of tracks, while the Lear carries four. The average music content in both 4- and 8-track systems has been running about 40 to 50 minutes, or the equivalent of a record album (although the Lear cartridge is capable of holding 80 minutes of music). In addition, there is a mono 4-track library which contains four bands of music per cartridge.

Editor's Note: As we go to press, it appears that the Lear cartridge system described below has a good chance of becoming number 1 in the auto tape-cartridge market. And with the fast-increasing library of 8-track cartridges for this system, home use would seem to be assured. At least this was the feeling of many observers at a recent all-industry tape-cartridge conference held in Chicago. Some of the reasons given are that Ford has decided to stick with the Lear system, and Chevrolet and Plymouth are expected to announce it for next year. Also, the major recording companies are all expected to join the 8-track fold. Don't count out the Philips (Norelco) system, however, which is expected to make a strong bid for this market. If they can't make it in the auto field, they should do well in the portable and home markets.

The question arises as to whether one system will supplant the others, whether all will continue to coexist, whether another system will replace them. In order to understand the situation more clearly, it might be well worth the time to describe the background of the various systems, their strengths, and their weaknesses.

Early Developments

The emergence of the tape cartridge for musical entertainment was preceded by a long period of preparation in radio broadcasting. In the early 1960's, radio stations began using cartridges to program their growing load of music. A pair of Fidelipac 300-ft cartridges are shown here prior to being loaded with 4-track tape and before label is applied.

A pair of Fidelipac 300-ft cartridges are shown here prior to being loaded with 4-track tape and before label is applied.
The first man to make an impact in the car market was Earl Muntz. In fact, he might be called the father of the industry since he opened the first market for 4-track auto cartridges in California as early as 1962. Using the Fidelipac system, Muntz provided a complete package, both the players and library, which he duplicated through licensing agreements with about 40 record companies, including MGM, ABC-Paramount, Verve, and Dot. He currently maintains a 4-track library of about 3000 titles, which he updates every month. Regarding the 4-track equipment now on the road, he estimates that there are about 700,000 units operating on the road. He currently maintains a 4-track library of about 3000 titles, which he updates every month. Regarding the 4-track equipment now on the road, he estimates that there are about 700,000 units operating on the road, he estimates that there are about 700,000 Fidelipac-type players in use, half of them made by Earl Muntz.

Muntz's use of three different sizes of Fidelipac cartridge pretty much set the pattern for the entire 4-track industry. The smallest (a 300-foot tape load) carries 40 minutes of music, the equivalent of one record album; the next size (600 feet) holds 80 minutes of music, the equivalent of two albums; while the largest (1200 feet) contains the equivalent of four albums, or two hours of music. (Fig. 1)

Another name that figures in the history of auto cartridges is TelePro Industries, which purchased Fidelipac. By the summer of 1963, the company was producing 10,000 cartridges; by 1965 production had risen to 300,000 a month as a direct result of the rapid growth of the car cartridge market. Up to that time, the company did not produce tape players but supplied cartridges to about 12 manufacturers (including Muntz) who marketed their own machines. All of these companies produced 4-track cartridge players that retailed for over $100.00.

Feeling that too many car owners were being excluded because of high prices, TelePro began manufacturing low-cost cartridge players in 1965. The company is responsible for the development of hang-on units, which can be attached quickly and cheaply under the dashboard. These units operate through the car radio, eliminating the expense of extra amplifiers and speakers. Since the introduction of the low-budget players, the cost of 4-track equipment has dropped to the point where it is now possible to get a home cartridge player for as little as $30.00.

All of these manufacturers of 4-track equipment serviced what is called the "after market," which means that the consumer buys his accessories after his car has left Detroit. This is in contrast to accessories which are installed and delivered by the auto maker—called the "new-car" market. The 700,000 4-track units that are now operating on the road were purchased in the after market.

Lear Enters the Field

In 1965 a new name appeared in the cartridge field when Lear Jet presented its 8-track concept to The Ford Motor Co. The Lear system brought two innovations to the auto cartridge field: it was the first system to break into the new-car market; and it introduced the 8-track cartridge to an industry that had been exclusively 4-track.

The reason for introducing 8-track was classically simple, twice as much music in a cartridge. (A Lear cartridge containing 300 feet of tape can carry 80 minutes of music.) RCA Victor agreed to duplicate its recordings in 8-track cartridges, and the promise of a major library was enough to commit Ford to the 8-track system. In the fall of 1965, Ford offered 8-track stereo as optional equipment in its new cars. Over 70,000 units have been sold. Lear 8-track and Fidelipac 4-track cartridges are incompatible. The major difference involves a pinch roller which engages the cartridge with the drive mechanism and causes the tape to rotate. In the Fidelipac system the pinch roller is located in the tape player, while in the Lear system it is seated in the cartridge itself. Owners of Fidelipac cartridges cannot play them on Lear machines and vice versa.

Proponents of the Fidelipac system point out that (1)
4-track technology was already perfected and in wide use; 
(2) a set of standards for Fidelipac equipment was estab-
lished by the National Association of Broadcasters (NAB) 
and these were carried over to the 4-track car market; (3) 
by using only four tracks, it was possible to record better 
sound, and; (4) the tolerances in 4-track were less critical 
and there was less chance of the equipment falling out of 
alignment.

However, the Lear system prevailed at Ford, perhaps be-
cause of the inherent advantage of being able to double the 
musical content in a Lear cartridge and the subsequent sav-
ing of storage space in the automobile.

The debate seemed to have been resolved when Capitol 
Records announced that it would release its library in 8-
track and Chrysler joined the 8-track fold. If the major rec-
cord and automotive companies have sided with 8-track, 
what could the future hold for the 4-track system?

The Competition Continues

The answer was forecast in 1965 when TelePro opened 
up the low-budget market with its hang-on deck. Muntz has 
followed suit with a hang-on unit retailing for $59.95. Com-
pare this with a new car installation cost of from $125.00 
to about $180.00 (or a Lear hang-on unit for around 
$125.00). Furthermore, since most of the low-cost units are 
designed for external mounting (as opposed to permanent 
installations in the dashboard), the owner can easily move 
his cartridge player to his new car at trade-in time and 
save himself the expense of a new cartridge player.

As a natural outgrowth of the activity in the auto market, 
many manufacturers are now offering cartridge equipment 
for the home, where the same controversy continues.

Now let us consider the current 4-track library. There are 
roughly 40 to 50 labels using the 4-track system. Elimi-
nating those titles which have been dropped over the course 
of years, there are about 20,000 cartridge titles available. 
The bulk of this library can be categorized as popular, in-
cluding collections by well-known pop artists (The Beatles, 
Tijuana Brass, Sinatra, etc.), show albums, motion picture 
sound tracks, collections of favorite pop tunes, and mood 
music. About 5% of the library consists of classics, mainly 
the better known symphonies, overtures, operas, and popu-
lar concert artists.

Because of its later start, the 8-track library is small and 
relatively few releases have taken advantage of the 80-min-
ute potential program content. RCA Victor has about 300 
titles on the market. Some record companies have released 
both 4- and 8-track recordings, while Columbia and Capitol 
are both releasing 8-track. The total number of 8-track 
titles now available is about 1000.

Both 4-track and 8-track cartridges retail for about $1 
more than an equivalent phono record album.

Meanwhile, both TelePro and Muntz are making their 
bid for the teenage market with a miniature 4-track car-
tridge similar to the 45 rpm single record. These cartriges 
contain one or two selections and retail for $1.19. Both com-
panies are marketing low-cost "mini" players to accommo-
date these short-play cartridges.

If the consumer wants to spend less money for his equip-
ment, he must buy 4-track; if he wants to avail himself of 
the releases from the major record labels, he may buy 
the more expensive 8-track. Or, if he wants to have the 
capability to play both, a number of manufacturers have in-
roduced compatible players that will accept both Fidelipac 
4-track and Lear 8-track. Here, the prices range from 
$99.95 for auto units (speakers extra) to about $160 for 
integrated home players with speakers.

Orrtronics & Norelco Systems

It is important to note that two other systems are com-
peting for the cartridge market. The Orrtronics system 
(Caradino) which was mentioned earlier is now available as 
an 8-track system. It is incompatible with either Lear or 
Fidelipac. Since none of the major record companies (and 
few of the other companies) are releasing cartridges for 
this system, it is difficult to see how Orrtronics can achieve 
the popularity of Fidelipac or Lear. However, the Electronic 
Industries Association has issued standards of compatibility 
covering all three systems, and this may help Orrtronics in 
its bid for a share of the cartridge market.

Phillips (Norelco), on the other hand, has presented a 
system which differs completely from the single-reel sys-
tems. Phillips has a reel-to-reel cartridge (cassette) which 
runs at 1% ips, using a tape 3/4" wide and carrying four 
tracks of recorded material. The cassette is one-fourth the 
size of a Lear cartridge and the miniaturization of this sys-
tem is a marvel to behold. The cassettes provide a normal 
playing time of 60 minutes, although they must be flipped 
over at the end of 30 minutes. Recently, the company has 
come out with a cassette with thinner tape that plays for 90 
minutes. The tape players, which are available as both por-
tables and consoles, are most versatile in that some of the 
decks can be transported from home to car, where they can 
be plugged into the dash. (Continued on page 96)
Power Inductors

By ROBERT E. COY/Engineer, Triad Distributor Div.

How to select the proper iron-core choke for power-supply filtering, as a charging choke for pulse networks, and for interference reduction.

Inductors used in electronic power circuits are characterized by high induction levels, relatively large air gaps in the core, and larger size than other inductor types. Applications for power inductors include: (1) filter reactors for rectifier circuits, both input and smoothing types, (2) charging inductors for pulse networks, (3) interference reduction filters as found in "A+" lines of mobile equipment, and (4) saturable reactors used in some types of control circuits.

Power-supply filters make up a large percentage of power inductor applications, and the considerations necessary for these circuits are much the same as for the other types mentioned.

The important considerations for inductors used in power-supply filter circuits are fewer and more straightforward than for many other inductor applications. An exception, perhaps, is the effects of superimposed direct current in the coil. One of the reasons for this relative simplicity of specification is that power chokes are normally used at a single frequency, that is, the available a.c. power-line frequency, or twice that in the case of full-wave rectification. These frequencies range from 25 Hz in a few countries to the 400 Hz encountered in military aircraft and some shipboard equipment. Thus, it can generally be assumed that the entire frequency range is below 1000 Hz, which virtually eliminates the need for considering such high-frequency parameters as the effects of distributed capacitance and self-resonance.

Rectifier filter circuits may be divided into two groups, depending upon whether a choke or capacitor is used as the first component following the rectifier. Choke-input filters are preferred in cases where good regulation and low surge currents through the rectifiers are important to the power-supply design. The d.c. voltage from a given a.c. source is lower than can be obtained with a capacitor-input filter; however, more current is available from the same source by using the choke input because of the lower current peaks and r.m.s. heating factor.

It is important to use a choke with sufficient inductance to maintain current flow through one leg of the rectifier circuit at all times. There are many formulas for determining the minimum or critical inductance, which usually results in a value (in henrys) approximately one-thousandth of the effective load resistance (in ohms) at minimum load.

Many power supplies are designed for use at a single d.c. output current level. In such cases, finding the value of critical inductance is fairly simple. Typical inductance values range from 2 to 25 henrys. In other supplies, the load current may vary over a wide range of values. Swinging chokes are often used in such applications, especially in transmitter power supplies where the output current varies from bleeder current to fairly large values only when the transmitter is keyed. The inductance of these chokes drops off rapidly with an increase in direct current through the coil. A typical swinging choke may have an inductance rating of 5:1 for an increase in current of 10:1. For example, the choke may have an inductance of 25 henrys at 20 milliamperes and drop to 5 henrys at 200 milliamperes. In this way, the choke "adjusts" itself to at least the minimum inductance for all current values.

A second choke, called a smoothing choke, is often incorporated in an additional filter section to reduce ripple further than can be economically accomplished with a single input filter. The value of inductance for this choke depends upon the input ripple and the desired amount of ripple reduction for the filter stage.

Charging inductors are used in the charging circuits of pulse-forming networks of radar equipment. They are similar in design and specifications to filter chokes. The inductance value is selected so that the circuit will resonate at one-half the pulse repetition rate. Charging inductors differ from filters in that much higher a.c. flux densities are encountered in charging inductors. Design considerations must sometimes take this into account.

Electrical Characteristics

Most power inductors have a direct current in the winding as well as the a.c. voltage across the terminals. The formula for inductance of an iron-core inductor with superimposed direct current may be stated as follows:

\[ L = \frac{3.2 N^2 A_x \times 10^{-8}}{l_p + (l_a/\mu_s)} \]

where \( L \) is the effective inductance in henrys, \( N \) is the number of turns, \( A_x \) is the net cross-sectional area of the core in square inches, \( l_p \) is the total length of the air gap in inches, \( l_a \) is the mean magnetic path length of the core in inches, and \( \mu_s \) is the incremental permeability of the core material.

The factors in the numerator are straightforward and can be easily understood. The denominator of this equation represents the effective magnetic path length. This effective length is the total length of the air gap and core path lengths divided by their respective permeabilities. (The permeability of the gap may be regarded as unity; therefore, the effective length is that of the gap.) In many cases, the design of a reactor is determined to a great extent by the correct proportioning of these two lengths. Incremental or effective permeability (permeability when an alternating magnetizing force is superimposed on a direct magnetizing force) depends upon the characteristics of the core material,
the d.c. magnetizing force set up in the core, and the amount of a.c. flux in the core. Data on permeability is not readily available and is best obtained from the core manufacturers' charts which plot effective permeability against d.c. magnetizing force and a.c. flux density. (See Fig. 1.)

Effective permeability decreases with an increase in d.c. magnetizing force in the core and reduces the effective inductance of the choke. Air gaps may be placed in the magnetic path to absorb some of the d.c. flux, thus reducing the effects of the direct current in the winding. A graph illustrating the effects of d.c. in a typical filter reactor is shown in Fig. 2.

Inductors carrying direct current may be classified as one of two types, linear or non-linear. Linear reactors are designed with an air gap greater than the effective length of the core \( \left( \frac{L}{\mu_s} \right) \). As the permeability of air and the length of the gap are constant, the inductance of the choke will be fairly linear across the range of direct current in the coil.

Non-linear inductors, commonly called swinging chokes, are often used when the direct current from a power supply must vary over a wide range of values. They are designed so that a change in direct current will have a definite effect on the inductance. This is done by using little or no air gap so that \( l_i \) is small compared with \( \left( \frac{L}{\mu_s} \right) \). Thus, the inductance of the reactor is determined largely by the incremental permeability of the core which decreases with an increase in direct current.

Under normal conditions, the d.c. flux in a filter reactor is much greater than the a.c. flux. For example, filter chokes are usually tested at an a.c. level of 5 to 10 volts and the rated direct current. This typically results in an a.c. flux density of 300 to 1000 gauss and a d.c. flux density of 12,000 to 14,000 gauss. If the a.c. flux were to be substantially increased on an inductor of this type, the total flux could reach the saturation level of the core material, resulting in low inductance, non-linearity, and poor filtering in power-supply circuits. For this reason, the a.c. voltage must be specified in inductor performance requirements. In 60-Hz single-phase full-wave rectifiers, the effective a.c. voltage at the choke input is approximately 50% of the d.c. voltage.

If a choke is selected for use in a circuit where high a.c. voltages are present across the coil as well as direct current in the winding, it may be checked on an inductance bridge to determine whether it is suitable for the application. With the specified a.c. voltage across the terminals, direct current through the coil is increased from zero to the rated value, observing the inductance. If the inductance remains relatively linear until the rated value of direct current is reached, the choke should be suitable for the application. If inductance drops off before the rated value of d.c. is reached, core saturation is indicated, and the inductor would not be recommended for use in the application.

In order to maintain good regulation and low losses in a filter section, it is important to keep the d.c. resistance of the inductor at the lowest possible value. The largest wire size consistent with the number of turns required and the winding space available is used to accomplish this. The d.c. resistance can be a determining factor in the size of an inductor, as it may be necessary to increase the core size in order to use a large enough wire to maintain the minimum value. Fig. 3 shows the range of inductance and resistance values generally available from standard lamination sizes having a stack height \( (L) \) equal to the length of the center leg.

Insulation ratings are often misunderstood because the rated dielectric strength does not directly indicate the maximum voltage which may be continuously applied. To ensure normal life expectancy, the insulation should be rated for at least twice the r.m.s. working voltage plus 1000 volts for commercial applications. Table 1 shows military ratings set forth in MIL-T-27B. The r.m.s. working voltage is defined by EIA Standard RS-197 as "0.707 times the sum of the maximum d.c. voltage and the peak a.c. voltage which may appear between winding and ground under normal conditions of continuous operation." This method may be used to determine the suitability of an inductor for a specific application by working back from the original formula. Subtract 1000 volts from the specified rating and divide the remainder by two. This gives the maximum r.m.s. working voltage which may be continuously applied.

Heating in power inductors is caused by losses in the core and in the coil. Since most power inductors (with the exception of charging reactors) operate at relatively low a.c. flux levels, core loss makes up a small part of the total. The losses due to the resistance of the winding make up most of the total heating. But since the largest wire size possible is normally used to keep d.c. resistance low, the coil or copper losses are seldom large enough to cause excessive heating.

Inductance values are not significantly affected by temperature variations. However, if a choke is to be used at high ambient temperatures, consideration must be given to the effect of the inductance materials used in construction of the unit. Furthermore, copper losses and d.c. resistances will increase with an increase in temperature so that it may be necessary to use a larger wire size to offset these additional losses.

**Construction**

General construction of power inductors varies from open-style, varnish-impregnated units for commercial equipment with few environmental requirements to hermetically sealed types built to withstand the most severe temperature and climatic conditions. Basic coil and core construction is similar for all types.

Power inductors characteristically operate at high inductance levels. Silicon steel having 3% to 4% silicon content...
is widely used for core material because it has a high saturation point and moderate permeabilities. Twenty-four gauge (0.025 inch thick) EI shaped laminate is most common in filter reactors for 60-Hz power supplies, along with 0.019- and 0.014-inch thicknesses. These are normally stacked with a butt stack to provide air gaps. Size and weight can be reduced by using grain-oriented silicon steel stacked with a butt stack to provide air gaps. Size and weight can be reduced by using grain-oriented silicon steel stacked with a butt stack to provide air gaps.

Cost is somewhat higher than standard lamination, but the material because of the higher induction levels possible. Weight can be reduced by using grain-oriented silicon steel stacked with a butt stack to provide air gaps. Size and weight can be reduced by using grain-oriented silicon steel stacked with a butt stack to provide air gaps. Weight can be reduced by using grain-oriented silicon steel stacked with a butt stack to provide air gaps.

"C" cores are also popular, especially for inductors used in 400-Hz aircraft supplies. Thinner materials are used in these cores, which reduces core losses encountered at these higher frequencies. They are wound with a continuous strip of material, commonly grain-oriented silicon steel, then cut into two C-shaped halves for assembly with the coil. Gaps may be placed between the core halves if desired.

Coils are generally wound in paper-layer construction, with insulating paper between each layer of wire. Bobbin types may be used in some applications, but the paper-layer coil offers better dielectric qualities and is more economical to produce.

As previously mentioned, the largest wire size consistent with winding space available and required number of turns is used in coil construction. In some cases where the wire size requirement exceeds the practical limits of standard wire, copper foil or strips may be used to wind the coil. This is practical only where the inductance value is small, as only one turn per layer is possible.

Insulating materials must be selected to provide the required dielectric strength at maximum operating temperature over the normal life expectancy of the inductor. Besides these characteristics, the material must have sufficient mechanical strength to maintain its insulating properties even after suffering the stresses that are encountered in winding.

Insulating materials are categorized by maximum operating temperature affording normal life expectancy. Both military and commercial specifications list these classes of insulating materials. Although designations for these classes differ for military and commercial classifications, they are similar in temperature characteristics. A listing of both classes is shown in Table 2. Unless otherwise specified, commercial units are normally constructed using class A insulating materials capable of continuous operation at 105°C maximum for normal life expectancy. This corresponds to military class R. The operating temperature includes the ambient temperature surrounding the unit and the allowable temperature rise of the unit.

External packaging is determined to a large extent by the amount of protection required. In military applications, hermetically sealed types are generally preferred, although the encapsulated and molded types are increasing in popularity. In commercial applications, where equipment will be operated under normal room temperatures, open-frame construction is often quite adequate.

Other factors that determine packaging are space available in the equipment, heat dissipation, and, of course, the cost of the item. Open construction offers better heat dissipation and lower cost but is not capable of withstanding severe climatic conditions. The (Continued on page 78)

Table 1. Military dielectric strength requirements (MIL-T-278).

<table>
<thead>
<tr>
<th>Working dielectric strength requirements</th>
<th>R.M.S. Test Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Voltage</td>
<td>Voltage</td>
</tr>
<tr>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>&gt;25 to 50, incl.</td>
<td>100</td>
</tr>
<tr>
<td>&gt;50 to 100, incl.</td>
<td>300</td>
</tr>
<tr>
<td>&gt;100 to 175, incl.</td>
<td>500</td>
</tr>
<tr>
<td>&gt;175 to 700, incl.</td>
<td>2.8 x working voltage</td>
</tr>
<tr>
<td>&gt;700</td>
<td>1.4 x working voltage + 1000</td>
</tr>
</tbody>
</table>

"Working voltage is defined by MIL-T-278 as "the maximum instantaneous voltage stress that may appear under normal rated operation across the insulation to be considered." Ref. MIL-T-278, Table XVI.
### DIRECTORY OF MOST POPULAR, LOW-PRICED VIDEO TAPE RECORDERS

<table>
<thead>
<tr>
<th>PHOTO</th>
<th>Model</th>
<th>Number of Heads</th>
<th>Tape Size Used (in)</th>
<th>Tape Speed (ips)</th>
<th>Record-Playback Time (min)</th>
<th>Input Level (V) and Impedance (Ω)</th>
<th>Output Level (V) and Impedance (Ω)</th>
<th>Response (MHz)</th>
<th>Horizontal Resolution (lines)</th>
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<tr>
<td>A</td>
<td>VR-6000</td>
<td>1</td>
<td>9 1/4</td>
<td>9.6</td>
<td>60</td>
<td>1</td>
<td>75</td>
<td>R.F. 30mV</td>
<td>250</td>
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<tr>
<td>B</td>
<td>VR-7000</td>
<td>1</td>
<td>9 1/4</td>
<td>9.6</td>
<td>60</td>
<td>1</td>
<td>75</td>
<td>R.F. 30mV</td>
<td>300</td>
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<td>C</td>
<td>VTR-600</td>
<td>2</td>
<td>1</td>
<td>12</td>
<td>60</td>
<td>1</td>
<td>75</td>
<td>1</td>
<td>250</td>
</tr>
<tr>
<td>D</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>TVR-301</td>
<td>2</td>
<td>7 1/2</td>
<td>9.6</td>
<td>66</td>
<td>.7</td>
<td>.7</td>
<td>75</td>
<td>2.7</td>
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<td>F</td>
<td>TVR-311</td>
<td>2</td>
<td>7</td>
<td>12</td>
<td>45</td>
<td>.7</td>
<td>.7</td>
<td>75</td>
<td>3.5</td>
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<tr>
<td>G</td>
<td>IVC-500</td>
<td>1</td>
<td>8</td>
<td>6.5</td>
<td>60</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>Panasonic Tape-A-Vision</td>
<td>1 1/2</td>
<td>7</td>
<td>12</td>
<td>40</td>
<td>.4</td>
<td>.4</td>
<td>75</td>
<td>2.5</td>
</tr>
<tr>
<td>I</td>
<td>EL-3400</td>
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<td>9</td>
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<td>1</td>
<td>75</td>
<td>75</td>
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<tr>
<td>K</td>
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<td>1</td>
<td>3</td>
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<td>CV-2000 D Color VTR</td>
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<td>7</td>
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<td>1</td>
<td>75</td>
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<td>3</td>
<td>300</td>
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<td>7 1/2</td>
<td>60</td>
<td>.5</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- a-camera; b-monitor; c-camera tripod; d-microphone; e-recorder, camera, and monitor as a package $1609.95; f-t.f. modulator; g-price depends on packaging and whether black-and-white or color; h-v.h.f. channels 2, 3, and 4; i-console version VTR-155C includes recorder, receiver, camera, tripod, headset, microphone $2995.00; j-VR-7100 Videotastrainer including VR-7000 deck, camera, monitor, and microphone

---

AMPEX CORP., 401 Broadway, Redwood City, California 94063

CONCORD ELECTRONICS CORP., 1935 Armacost Ave., Los Angeles, California 90025

GENERAL ELECTRIC CO., Audio Products Dept., Decatur, Illinois

IKEGAMI ELECTRONICS IND., INC., OF NEW YORK, 501 5th Avenue, N.Y., N.Y. 10017

INTERNATIONAL VIDEO CORP., 330 Village Lane, Los Gatos, California 95030

MATSUMITA ELECTRIC CORP. OF AMERICA, 200 Park Ave., N.Y., N.Y. 10017

NORTH AMERICAN PHILIPS CO. INC, 100 E. 42nd St., N.Y., N.Y. 10017

REVERE-MINCOM DIV., 3-M CO., 2501 Hudson Road, St. Paul, Minnesota 55119

SONY CORP. OF AMERICA, 580 5th Ave., N.Y., N.Y. 10036

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ELECTRONICS WORLD
Besides the models covered in this table, several more companies have a VTR under development. These include the Japanese manufacturers Oki, Akai, Sanyo, Toshiba, and Victor; and the American companies Fairchild Industrial Products, Defense Electronics, Paco, Par Ltd., and the ITT Research Institute (Illinois Institute of Technology).

<table>
<thead>
<tr>
<th>Micro (dB and Ω)</th>
<th>Line (dB and Ω)</th>
<th>Output</th>
<th>Response (Hz)</th>
<th>Dimensions (in)</th>
<th>Weight (lbs)</th>
<th>Price ($)</th>
<th>Special Video</th>
<th>Accessories (See footnotes)</th>
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<tbody>
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<td>0</td>
<td>1 V</td>
<td>600Ω</td>
<td>50–10,000</td>
<td>19</td>
<td>38</td>
<td>color</td>
<td>a, b</td>
</tr>
<tr>
<td>-60</td>
<td>0</td>
<td>1 Meg.</td>
<td>600Ω</td>
<td>50–10,000</td>
<td>19</td>
<td>38</td>
<td>color</td>
<td>a, b</td>
</tr>
<tr>
<td>1 mV</td>
<td>20K</td>
<td>1 V</td>
<td>1 Meg.</td>
<td>50–10,000</td>
<td>19</td>
<td>38</td>
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<td>a, b</td>
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<td>600</td>
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<td>50K</td>
<td>10–20,000</td>
<td>15</td>
<td>29</td>
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<td>-70</td>
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<td>10</td>
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<td>15</td>
<td>29</td>
<td>color</td>
<td>a, b</td>
</tr>
<tr>
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<td>1K</td>
<td>200mV</td>
<td>500K</td>
<td>120–12,000</td>
<td>24</td>
<td>15</td>
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<td>a, b</td>
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<tr>
<td>2 V</td>
<td>10K</td>
<td>.5 V</td>
<td>10K</td>
<td>50–10,000</td>
<td>20</td>
<td>14</td>
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<td>a, b</td>
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<tr>
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<td>-10</td>
<td>-10 dBm 10K</td>
<td>50–10,000</td>
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<td>9½</td>
<td>8½</td>
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<tr>
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<td>-10 dBm 10K</td>
<td>50–10,000</td>
<td>15½</td>
<td>9½</td>
<td>8½</td>
<td>color</td>
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<tr>
<td>600</td>
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<td>9½</td>
<td>color</td>
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Linear Integrated Circuits: What's Available?

A survey of what the various manufacturers are now offering, arranged by circuit application. The article discusses where IC's can be used, their specs, what they cost, and how they are designed into circuits.

The big breakthrough has arrived. Linear integrated circuits are finally distributor stock items, and they are available today in a wide variety of sizes, performance levels, and circuits from at least a half-dozen major manufacturers. Many linear IC's are now quite low in cost, with many devices in the $2 to $12 each price range.

For instance, a complete TO-5 can sized i.f. strip for a television set or FM receiver can be purchased for $2.65. A hearing-aid-sized audio amplifier can be obtained for $10.50. One r.f. amplifier costs $4.40, a second $4.50, and a third $4.80. Other linear integrated circuits are still very high-priced, but these frequently offer performance advantages unavailable in any other form of circuitry.

Let's take a closer look at some of the more noteworthy linear integrateds. Everything to be described is now distributor stock and available for immediate use. Prices in parentheses are approximate single-quantity cost at the time of publication. Sources of data sheets and distributor lists are indicated in Table 1.

Audio Amplifiers

The Texas Instruments SN1220 ($16.20) is a linear IC designed specifically for hearing aids but also useful for a wide variety of very-low-level, high-gain audio applications. The frequency response has been optimized for voice applications. Maximum output power is three milliwatts at a 3% distortion level, and total voltage gain is 16,000 (84 dB) when the device is powered by a single 1.5-volt, 4-milliampere cell. The ten-lead flat pack used has provision for an external gain control. Either an output transformer or a center-tapped earphone is normally required. The single-cell operation is a most important advantage for subminiature hearing aids as well as orbital satellite applications.

More audio power is offered by the Westinghouse WC183 ($10.50), the circuit of which is shown in Fig. 1. Available either in a ten-lead flat pack or a twelve-pin TO-5 style can, this linear IC is able to produce as much as 100 milliwatts of audio output with a voltage gain of over 30,000 (90 dB). Frequency response is flat from 50 Hz to beyond 20 kHz, and reasonable audio quality may be obtained at low output levels. Although 6 volts is required for maximum gain and output, the WC183 will also operate with a single 1.5-volt cell. In this mode, a voltage gain of 4000 (72 dB) is combined with a three-milliwatt output.
The WC183 is particularly suited to experimental uses, some of which are suggested in Fig. 2. Sufficient audio power is available for low-level recorder monitors, intercoms for low-noise areas, and similar applications.

Higher Power Audio ICs

The RCA CA3007 ($6.00) is an audio driver that may be combined with an output stage and transformer to produce 300 milliwatts or more of audio power. This twelve-pin TO-5 style package provides a power gain of 160 (22 dB) and is supplied with push-pull input and output. It serves nicely as a transformerless phase splitter and driver for class-B audio-output stages. Feedback is easily provided to automatically hold the output stage bias levels at optimum values.

Higher power audio ICs are still scarce and expensive, owing to the heat problems associated with substantial signal levels. Motorola's MC1524 is one 10-pin TO-5 style linear IC that can supply one watt of audio-output power. It is oriented towards a military transceiver market and, as such, has a military reliability and a military price tag ($70). A hybrid construction technique is used in which the lower level circuitry is fully integrated, while the output stage consists of discrete transistors. A photo of the unit is shown on page 41.

Incidentally, for those with a military budget, this amplifier is strictly hi-fi. It has a voltage gain of 1000 (60 dB) and can provide 900 milliwatts of audio output with less than 0.6% harmonic distortion. Frequency response is flat from 20 Hz to over 300 kHz. Dual 6-volt supplies are required.

Low-cost, high-power audio integrateds are still well around the corner and will stay there until a better means of heatsinking ICs becomes practical or else until the switching-mode audio-amplifier schemes become more fully developed. NASA has recently demonstrated a one-watt switching-mode (class-D) audio amplifier that may readily be integrated. This is an important step towards solution of the high-power audio-IC problem.

R.F. and I.F. Amplifiers

R.F. and i.f. amplifiers form the application area where the majority of low-cost linear integrateds have recently been introduced. Fairchild's µA703 ($4.50) is an interesting entry. This 8-pin TO-5 style package functions as a self-limiting i.f. amplifier with up to 41 decibels (112:1) of voltage gain and may be operated either single-ended or push-pull.

Table 1. Sources of linear IC's covered in the text.

<table>
<thead>
<tr>
<th>FAIRCHILD SEMICONDUCTOR</th>
<th>313 Fairchild Drive</th>
<th>Mountain View, California</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENERAL INSTRUMENT SEMICONDUCTOR</td>
<td>600 West John Street</td>
<td>Hicksville, New York</td>
</tr>
<tr>
<td>GENERAL MICROELECTRONICS INC.</td>
<td>2920 San Ysidro Way</td>
<td>Santa Clara, California</td>
</tr>
<tr>
<td>MOTOROLA SEMICONDUCTOR</td>
<td>Box 955</td>
<td>Phoenix, Arizona 85001</td>
</tr>
<tr>
<td>RADIO CORPORATION OF AMERICA</td>
<td>Electronic Components and Devices</td>
<td>Harrison, New Jersey</td>
</tr>
<tr>
<td>TEXAS INSTRUMENTS</td>
<td>P.O. Box 5012</td>
<td>Dallas, Texas</td>
</tr>
<tr>
<td>WESTINGHOUSE MOLECULAR ELECTRONICS</td>
<td>Box 7737</td>
<td>Elkridge, Maryland 21227</td>
</tr>
</tbody>
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November, 1966
push-pull. The limiting action is symmetric and non-saturating, making the μA703 excellent for high-quality FM i.f. strips. (See the article "An Integrated Circuit for Consumer Products" in our October issue.—Editors) For non-i.f. applications, this IC also serves as a wide-band amplifier, a voltage-controlled oscillator, or an FM mixer useful above 100 MHz.

RCA's i.f. amplifier, the CA3002 ($4.40), is similar in purpose but has the added feature of a 10,000:1 (80 dB) electronic gain control (a.g.c.) range. A push-pull input is combined with a single-ended output, and an internal coupling capacitor is provided for direct interstage coupling in the 1- to 10-MHz range. Additional capacitance or transformer coupling may be used at lower frequencies. Voltage gain is typically 10:1 (20 dB). This same IC is also useful as a product detector, a Schmitt trigger, or a wide-band amplifier.

Westinghouse's candidate is the WC1146 ($10.50), a universal direct-coupled, two-stage negative-feedback amplifier that may be used for virtually any r.f. or i.f. application below 100 MHz. For instance, Fig. 3 shows a high-quality Citizens Band receiver which uses nothing but the WC1146's throughout. One serves as an r.f. stage, followed by an oscillator-mixer, an i.f. stage, and finally a detector and audio-output stage. An input antenna transformer, a ceramic filter, a crystal, and several capacitors complete the circuit. Each IC is capable of a high-frequency gain of 6:1 (16 dB), and automatic gain control is available.

Excellent high-frequency performance is obtainable in the Motorola MC1110 ($25), an emitter-coupled amplifier good to 300 MHz. The five-lead TO-5 style can IC offers a power gain of 400 (26 dB) at 100 MHz, with a typical noise figure of only 4 dB. The MC1110 operates over a -55 to +125°C range and is well suited for front-end, r.f., and i.f. applications in high-quality communications gear. Typical is the radar 60-MHz i.f. strip shown in Fig. 4 which offers a power gain of 80 dB with a 6-MHz bandwidth and a 6-dB noise figure. Four IC's are needed.

RCA's CA3004, CA3005, and CA3006 ($4.40, $4.80, and $6.80) round out the r.f. and i.f. linear-IC picture. These consist of a differential input stage and an internal controlled-current source. The amplifiers may be operated either in a differential or a cascode manner. No collector resistors are provided, as these IC's are normally used in transformer-coupled applications where interstage transformers determine the over-all frequency response. The three IC's differ in input offsets, gain, and linearity. All are potentially useful from d.c. to 100 MHz and have a very good a.g.c. capability. Important applications include use as detectors, mixers, limiters, modulators, and as cascode r.f. amplifiers.

**Differential Amplifiers**

It is sometimes desirable to compare two input signals against each other and produce an output proportional to the difference between the two. This is often done in d.c. amplifying systems, servo loops, error detectors, and regulated power supplies.

A differential amplifier is normally called on in these applications. Formerly, this meant expensive matched transistors, critical heatsinking, and perhaps external stabilization circuits to obtain good d.c. performance. Linear integrateds eliminate all of this. The transistors in an IC are practically identical in size and material. Due to their proximity, they must be at the same temperature, so the transistors track beautifully over wide temperature ranges.

Several companies manufacture linear-IC differential amplifiers. The Westinghouse WS115T ($10.50) offers some interesting performance features. It consists of four Darlington-connected differential emitter-followers combined with an internal controllable current source. Input impedance is typically half a megalohm and the frequency response...
is good from d.c. to 150 kHz. Drift is typically 10 microvolts per degree C, which means that over a 100° C operating range, an “extra” millivolt may appear at one input with respect to the other. For wide temperature operation, input signals as small as 10 millivolts may be processed with little error. Limited temperature range circuits will allow the d.c. processing of 100-microvolt input signals. The WC115T offers a voltage gain of 50 and comes in an eight-lead TO-5 style can.

Motorola has a whole family of integrated differential amplifiers. The most versatile is perhaps the MC1519 ($50), as n-p-n input transistors are combined with complementary matched p-n-p output transistors. This n-p-n/p-n-p configuration allows a variety of interconnections, all of which readily track over a wide temperature range. A gain of 4500 is combined with a 1-MHz bandwidth in the ten-lead TO-5 type package.

The Motorola MC1525 through MC1528 devices make up a family of medium-priced differential amplifiers, available either as all p-n-p or all n-p-n, with or without Darlington inputs. An n-p-n and p-n-p IC may be cascaded for extremely high gain and excellent temperature tracking.

One of Texas Instruments’ differential amplifier IC’s is the SN723 ($27.60). Housed in a 14-lead flat pack, this particular IC offers a voltage gain of 1800 (65 dB), a 150-kHz bandwidth, and a 250-ohm output impedance. The SN723 normally uses dual 12-volt power supplies.

**Operational Amplifiers**

An operational amplifier is any high-gain d.c.-coupled bipolar amplifier with low offset. Its unique performance feature is that the gain may be precisely controlled by external resistors and capacitors. Operational amplifiers have long been used in analog computers, but because low-cost linear IC operational amplifiers are now available, this basic amplifier is beginning to find very wide use. Once again, linear IC’s eliminate many of the temperature and tracking problems that formerly plagued the discrete tube and transistor circuits. External stabilization is now only very rarely required, thanks to the performance capabilities of today’s linear IC’s.

Important operational-amplifier applications are in precision waveform generation, controllable gain and bandwidth amplifiers, d.c.-coupled amplifiers, and active network synthesis. The latter is a new way of using resistors, capacitors, and operational amplifiers to simulate inductance and LC filters without using coils or transformers.

RCA’s CA3010 ($12) is one of the lowest priced operational amplifiers available today. It offers a voltage gain of 1000 (60 dB), a 300-kHz bandwidth, and a peak-to-peak output swing of seven volts. The CA3010 is housed in a 12-lead TO-5 style case. A second IC, the CA3008, is the identical circuit in a flat package at a slightly higher cost.

Motorola offers four operational amplifiers, the MC1430, MC1431, MC1530, and MC1531 ($18 to $30), which differ mostly in input impedance and operating temperature ranges. Darlington inputs are supplied on the MC1431 and MC1531.

Texas Instruments produces one low-cost operational amplifier, the SN724 ($16.20), and several premium units which are primarily intended for military usage. All are in the ten-lead flat package.

The Westinghouse line consists of half a dozen IC’s ranging in price from $20 to $70. One dual unit offers two independent operational amplifiers in a single TO-5 style package. Since operational amplifiers are often used in groups, such a configuration results in reduced space requirements and simplified wiring.

Fairchild supplies four distributor stock operational amplifier IC’s, the µA702 and the µA709. Each has a commercial “C” version and a military “A” version as identified by a suffix ($14 to $22).

There are many other operational amplifiers on the market, but most of the ones we have not mentioned are premium units of limited availability. The choice of which operational-amplifier IC should be employed is highly dependent upon the specific application, and a careful study of the data sheets of likely candidates is in order before a particular device is selected.

**Other Amplifiers**

The CA3000 ($6.80) is an RCA ten-pin TO-5 style linear IC intended for d.c. amplifier use but also quite applicable to feedback amplifiers, crystal oscillators, modulators, and mixers. It consists of four transistors in a differential Darlington configuration and a controllable transistor and two-diode current source. A 200-ohm input impedance is combined with a voltage gain of 50 and a d.c. to 30-MHz frequency response.

A second RCA linear IC, the CA3001 ($6.40), is intended for video amplifiers and other wide-band amplifier applications. Circuitry is somewhat similar to the CA3000 except that emitter followers are added for low output impedance and internal coupling capacitors are provided. This IC has a push-pull input and output, a 9:1 voltage gain, and a 16-MHz frequency response. The circuit finds use in video amplifiers and other wide-band amplifiers.
Comparators

Comparators are used to answer the question, "Which one is bigger?" when two inputs are applied. One input is often a reference voltage. In this mode, a comparator serves as a limit detector, an alarm, an analog-to-digital converter, or a sense amplifier for a computer's core memory. By using the output of a comparator as its own reference, a Schmitt trigger with controllable threshold voltage and hysteresis, both of which may be made zero, positive, or negative, is obtained. This configuration is of value in level detectors, alarms, tachometers, and anywhere else a snap-action output is required the instant a slowly changing inputs, or negative, is obtained. This configuration is of value in magnetic-core sense amplifiers, but this IC will find use anywhere several comparators would normally be employed in related circuits. As with other Fairchild units, both premium military versions and limited-temperature commercial versions are available.

MOS Analog Gates

We can conclude our survey with some remarkable IC's using MOS (metal oxide semiconductor) technology. Called commutators, analog gates, or multiplexers, these IC's are both linear and digital at the same time.

The units serve as high-speed selector switches of the single-pole, multiple-throw variety. The MOS technology offers several unique advantages. Analog or varying input signals up to ten volts in amplitude of either polarity are switched in a d.c.-coupled manner with zero offset, a feat that no ordinary transistor, IC, or vacuum tube can ever hope to perform. Further, there is only insignificant coupling between the signal voltages and the input switching waveforms. Practically no input switching power is required, as the input impedance on the switching inputs is typically several thousand megohms.

Being brand-new devices, they are still expensive, but the analog gates are already finding wide use in industrial telemetry and sampling circuitry as well as in radar-image-processing circuitry.

The Fairchild µM3700 ($62.50) is a representative sample of the dozen or so MOS analog gates now available. It may be used as a single-pole, five-position switch or as a single-pole, four-position switch with an all-channel blanking option. Any position can handle ±10 volts of analog signal. "On" resistance is around 150 ohms with

(Continued on page 76)
High-Quality Square-Wave Generator

This generator uses a novel design to produce perfect symmetry fast rise and fall time square waves covering the range from 20 to 20,000 Hz, using only a single-turn frequency control.

Most simple square-wave generators have several drawbacks: their frequency range is limited, transition times may be sluggish, and the output waveform may not be symmetrical. The first objection can be overcome by using a wide-range relaxation oscillator with a fixed C and variable resistor. Such an oscillator can easily be adjusted through a 1000:1 range with a single control, and the audio band can be covered without using a range switch. The last two points can be resolved by employing a circuit—a triggered flip-flop. This circuit has perfect inherent symmetry and fast rise and fall times. In the test set to be described, the generator output can be varied from 20 Hz to 20 kHz because the oscillator runs between 40 Hz and 40 kHz and pulses from it trigger the flip-flop, causing it to divide the oscillator frequency in half while creating ideal square waves.

The components associated with Q1 and Q2 (see Fig. 1) form a relaxation oscillator and pulse generator. The series combination of R1 and R2 charges C1 to the firing voltage of Q1. Transistor Q1 draws current through R5, which turns on Q2. Regenerative action causes Q2 to hold Q1 on until C1 is completely discharged; then the cycle starts over again. The combination of L1 and R4 limits peak discharge currents to protect Q1.

The upper frequency limit is set by the time constant R1C1 and the lower limit by (R1 + R2) (C1). Since the ratio of R2 to R1 is 1000:1, that is the frequency range of the oscillator. The value of C1 places the oscillator frequency in the desired part of the spectrum. The flip-flop circuit of Q3 and Q4 is conventional except for the use of emitter bias rather than fixed bias.

To trigger the Q3Q4 circuit, the conducting transistor must be driven to cut-off for an instant, and then regenerative action will cause the circuit to change state. The trigger network consists of coupling capacitor C3, d.c. restoring diode D2, and trigger diodes D1 and D3. Triggering is aided by the virtual ground placed on the emitters by C6. The circuit works at a reduced power-supply voltage due to the drop across R12. If reliable triggering cannot be obtained, an increase in the value of R12 is called for, as this will make the circuit more sensitive to triggering.

The output terminal is isolated from the flip-flop by a complementary emitter follower formed by Q5 and Q6. This circuit is fairly novel in that the output is d.c.-coupled yet referenced to ground, that is, the square-wave output will always rise from ground to some positive level. This level is set by R17, which places a clamp voltage on the collector of Q5. Using this scheme, the generator displays a constant output impedance of less than 200 ohms, besides the d.c-coupling and zero-reference features. Maximum output is about 5 volts peak-to-peak.

Any convenient construction techniques can be used. If transformer power is employed, the supply should be zener-stabilized to hold the frequency stability. Leads associated with the flip-flop should be kept short and direct to eliminate the possibility that external noise will trigger this circuit to produce unwanted outputs.

Adjustment

The first step is to check the pulse generator. At point B in the circuit, narrow negative-going pulses should occur. If frequency control R2 is set at minimum resistance, these pulses will be at the highest frequency and thus will be more easily observed. Once they are acquired, rotate R2 to its maximum resistance to make sure the frequency is variable. If no pulses are apparent, then adjust bias level control R7 to obtain an output pulse. As soon as pulses are available, a square wave should show up at the output. If not, increase the value of R12.

Until square waves are obtained, do not probe any points inside the flip-flop, as some scope probes can load the circuit down and prevent operation.

As a last resort, the Q3Q4 circuit can be checked with a v.t.v.m. and a clip lead as follows. With Q1 unplugged, measure the collector voltages of Q3 and Q4 and connect the v.t.v.m. to the one that gives the lowest reading. This is the conducting side. Then short (Continued on page 82)
World’s First Single-Chip Integrated-Circuit Radio

By J.A. CACCIOLA and E.Q. CARR
Radio Receiver Dept., General Electric Co.

Technical details on first mass-produced AM radio using a single IC to replace all active components in circuit. All 125 dB of r.f. and a.f. gain required is packed into 35- by 40-mil silicon chip. High reliability permits 3-year warranty.

The new G-E P1740 micro-sized receiver (Fig. 1) is the world’s first mass-production AM radio in which a single integrated circuit replaces all the discrete transistors used in conventional portable radios. This is technically significant because all 125 dB of r.f. and audio power gain is packed into a 0.035 by 0.040-inch silicon chip (Fig. 2) about the size of one audio amplifier transistor. Consumers benefit from IC component reliability as demonstrated by the 3-year warranty on the radio. The portable set is powered by a rechargeable nickel-cadmium battery which is also covered by this same warranty.

Virtually everyone is expecting something different from these incredible little chips. Stylists are anxious to take advantage of small size; engineers want to explore new design concepts; production men think they may answer some production-line problems; and manufacturers generally expect high quality while improving cost control. R.C. Wilson, General Manager of G-E’s Consumer Electronics Div. states "... it seems clear that microcircuits will have a major impact in shaping our industry."

Low cost, the pivotal factor in moving linear IC monolithics into consumer applications from high-reliability military, space, and industrial computers, results from three major steps:

1. Applying the same highly mechanized assembly methods responsible for the low-cost plastic encapsulated transistors already in many products.
2. Production control of island diffusion and epitaxial techniques, the more sophisticated semiconductor processes not used in many digital circuits but necessary for linear r.f. and audio bipolar circuits in the same chip.
3. Development of an inexpensive package capable of handling one watt or more of internal power dissipation.

Confident of the effectiveness of this particular attack on the cost problem, G.B. Farnsworth, Manager of Marketing, G-E Semiconductor Products Dept., has announced that 80-cent plastic-packaged circuits would be generally available in quantity during 1967 and that the prices could go below 50 cents each in production quantities.

Inside the IC Black Box

AM radios are a definite challenge to microcircuit de-
Fig. 3. Schematic of the IC radio. Outboard transformers and coils are used along with the outboard detector circuit. When the radio is plugged into its recharger, the battery is connected to the charging supply and an auxiliary speaker is hooked in.

Fig. 4. A flat plastic package with 7 leads on each side and an extra heat-sink lead is used to house the IC. The highly mechanized production line that turns out these packages is an outgrowth of work on plastic-packaged silicon transistors shown.

Fig. 5. Partly assembled chassis for IC radio. Outboard components are all standard types. The integrated circuit itself may be seen near bottom left, designated by "IC 161".

Integrated-Circuit Radio Design

Schematically, the P1740 radio is not much different from many ordinary transistor radios, except for the fact that a good many of the components are located in the IC and that a battery charger is used. See Fig. 3. From a technician's standpoint, this is especially fortunate since voltage test points, current ratings, etc., are similar. There are, however, some subtle differences. Notice, for example, that the first i.f. amplifier has only two active terminals and a third terminal which is not available as a separate test point. Of the external resistors, R, a current-source bias resistor for the audio driver, is the only component which may be of different value from production lot to lot.

The IC package is a high-pressure transfer-molded plastic encapsulation (Fig. 4). All 14 connections, seven on each side, are used in the radio in addition to the 15th lead from the end of the package which serves as a com-
The tight thermal coupling of a monolithic IC cannot be matched using discrete transistors even by mounting them on a common heat sink. In addition, discrete devices do not permit a simple geometric scale for bias in a transistor voltage stabilizer which is easily contained in the monolithic IC and also thermally coupled to the output transistors.

An audio amplifier design of superior characteristics is, therefore, a natural result of IC use. What is more, it is possible to optimize the transistor emitter-base periphery for necessary beta linearity at high currents. With discrete transistors, despite the many thousands of different devices that are available, finding the optimum audio output transistor is not an easy job.

### The Future of IC Radios

A complete radio, without external components, could probably be built on a single piece of silicon, but the performance would probably leave much to be desired. There are intriguing problems to solve in signal sensitivity, signal-to-noise ratio, power supply, tuning and volume controls, antenna, and speaker. The closest realization of such a radio would have six terminals (Fig. 6), but right now the practical compromises which would be necessary in tuning, selectivity, and signal-to-noise ratio, would place the performance below that of an ordinary low-cost transistor receiver. With present limitations on integrated-circuit production techniques, it is possible to get greater cost/value performance using simple bobbin-wound cup-core inductors in LC tuned stages. Thus, the final design chosen uses a single silicon chip with external LC tuned circuits.

Certainly there are other functional approaches to tuned circuits and even to the basic receiver operation. More than 40 years of modern receiver design have, however, hinged on the use of LC tuned circuits in single- or double-conversion superheterodyne designs. Integrated circuits may alter designs in the future, but this is by no means a certainty.

Present engineering work on precision frequency band-pass control with IC techniques is concerned with the use of RC frequency-selective feedback, negative-impedance converters, and "Q" multiplication. Specific solutions to these designs have encountered problems of supply voltage sensitivity, temperature sensitivity, limited signal range, difficulty in adjusting to frequency tolerances, and instability of elements with time, humidity, and other aging effects.

While none of these problems is insurmountable, the solutions for consumer receivers appear to be too complicated or difficult to be economically feasible.

Getting the L and the C out of radios has been achieved with mechanically resonant structures; usually a beam or plate of small dimensions driven into a resonant condition electrostatically, thermally, or magnetically. One successful solution, sometimes used in communications gear, involves piezo-ceramic structures. Cost is the main deterrent to consumer applications.

Another form of mechanical filter proposed is a small resonant beam of gold ingeniously fabricated as an electrode in a field-effect transistor on a silicon chip. The major problems here appear to be that beam dimensions, tolerances, and production control are not easily matched to the necessary bandwidth and frequency requirements of a superheterodyne receiver. Temperature and voltage sensitivity as well as long-term stability data have not become generally available for an assessment of this filter method.

Breakthroughs in any of the foregoing areas could trigger exciting technical innovations in radio design. Many tools are at hand and in various stages of development. Whatever techniques are used, however, the integrated circuit is sure to play a most important role.
PART 3. PERFORMANCE OF PRACTICAL CIRCUITS

Designing Silicon-Transistor Hi-Fi Amplifiers

General considerations for conservative design using readily available silicon power transistors. Practical circuits of 10-, 25-, and 70-watt amplifiers and their performance are given.

By R.D. GOLD and J.C. SONDERMEYER
RCA Electronic Components & Devices

In addition to the consideration that must be given to the achievement of performance objectives and the selection of the optimum circuit configuration (discussed in the previous two parts of this series), the circuit designer must also take steps to insure reliable operation of the audio amplifier under varying conditions of signal level, frequency, ambient temperature, load impedance, line voltage, and other factors which may subject the transistors to either transient or steady-state high stress levels. Some of these steps are relatively straightforward. For example, it is necessary to insure that the power dissipation ratings are not exceeded at high line voltage and under worst-case signal conditions. For class-A amplifiers, the maximum power dissipation occurs at zero signal. For an ideal class-B push-pull stage, maximum power dissipation occurs when the drive signal is 64 percent of that required for maximum output power. The corresponding output power for this condition occurs at 42 percent of the maximum output power, and the dissipation in each transistor is 20 percent of the maximum power output. Also, for class-AB transformer-coupled amplifiers, the appropriate transistor breakdown-voltage rating must be greater than twice the d.c. collector voltage that is employed.

Thermal Stability Requirements

One serious problem facing the design engineer, not only in the quasi-complementary circuit but in all the circuits thus far discussed, is the ability to design a circuit which is thermally stable at all temperatures to which the amplifier might be exposed. Ideally, the quiescent current of an output stage should remain constant at all temperatures of interest. At low current levels however, the base-to-emitter voltage ($V_{BE}$) of a transistor decreases with increase in the junction temperature. This characteristic is the result of the increase in the small base resistance that is produced by the rise in temperature. The increase in base resistance with temperature has two beneficial effects: First, it helps to stabilize the transistor against thermal runaway because higher temperatures now require an increase in $V_{BE}$ to cause an increase in $I_c$. Second, the increased resistance causes a portion of the transfer characteristic to be linear. A lower distortion is therefore possible at high temperatures.

Thermal stability can be further improved by the addition of devices such as thermistors or bias diodes, the characteristics of which are such that they will tend to reduce the base drive voltage of the output transistor as temperatures rise. When these types of devices are used, it is possible to reduce or even eliminate emitter networks completely and thereby to reduce substantially the circuit losses at high power levels. It is interesting to note that a simple emitter diode itself will provide some improvement in circuit stability. The static resistance of a diode is fairly high at low currents (about 30 ohms at 20 milliampere for a 1N1612). A disadvantage of this technique is that the forward voltage drop of this diode decreases with increasing temperature and, therefore, reduces the stabilizing effects of the high dynamic resistance.

It should be noted that at high current levels, the base-to-emitter voltage of silicon transistors increases with a rise in the junction temperature. This characteristic is the result of the increase in the small base resistance that is produced by the rise in temperature. The increase in base resistance with temperature has two beneficial effects: First, it helps to stabilize the transistor against thermal runaway because higher temperatures now require an increase in $V_{BE}$ to cause an increase in $I_c$. Second, the increased resistance causes a portion of the transfer characteristic to be linear. A lower distortion is therefore possible at high temperatures.

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The quasi-complementary amplifier shown in Fig. 1 incorporates the stabilization techniques just described. A

Fig. 1. Quasi-complementary amplifier with compensating diodes.
resistor-diode network is used in the emitter of transistor Q3, and another such network is used in the collector of transistor Q5.

Previous discussion regarding the p-n-p driver and n-p-n output combination (Q3 and Q5) revealed that the collector of the output device becomes the "effective" emitter of the high-gain, high-power p-n-p equivalent, and vice versa. Therefore, in order to provide maximum operating-point stability, the diode-resistor network should be in the "effective" emitter of the p-n-p equivalent. Most quasi-complementary circuits employ the stabilization resistor in the emitter of the lower output transistor and thus do not improve the operating-point stability of the over-all circuit. The resistor, however, does provide some protection against thermal runaway of the lower output transistor. Such protection may be necessary unless it is provided by other means.

The circuit shown in Fig. 1 is biased for class-AB operation by the voltage obtained from the forward drop of two diodes, D1 and D2, plus the voltage drop across potentiometer R, which affords a slight adjustment in the value of the quiescent current. The current necessary to provide this voltage reference is the collector current of driver transistor Q1. The diodes may be thermally connected to the heat sink of the output transistors so that thermal feedback will be provided to further improve thermal stability. Because the forward voltage of the reference diodes decreases with increasing temperature, these diodes effectively compensate for the decreasing $V_{BE}$ of the output transistors by reducing the external bias applied. In this way, the quiescent current of the output stage can be held relatively constant over a wide range of operating temperatures.

The value of the transistor operating parameters that affect thermal stability can be calculated to insure freedom from thermal runaway. In these calculations it should be realized that the temperature-dependent collector leakage current limit specified by the transistor manufacturer actually consists of two components. One is related directly to the collector junction saturation current and is a strong function of temperature. In silicon transistors, this component is approximately doubled with each 7°C rise in junction temperature. At room temperature, however, it is on the order of only a few nanoamperes, so that a rise in case temperature of 140°C will cause the saturation current to rise only a few milliamperes.

The other component of collector leakage current is a surface leakage which is relatively independent of temperature. In fact, this leakage component may decrease as the temperature increases. The value of total leakage current ($I_{LE}$) specified by the transistor manufacturer is the sum of these two components. If the specified value is on the order of a few milliamperes, it will remain substantially constant with temperature. For example, in the published data for the RCA-40363, $I_{LE}$ is given as 0.5 milliamperes (maximum) at $T_c = 150^°$ C. The transistor is, therefore, quite stable thermally with respect to any changes that might occur in the amount of leakage current.

Effects of Large Phase Shifts

The frequency-response characteristic is an important factor with respect to the ability of the amplifier to withstand unusually severe electrical stress conditions. For example, under certain conditions of input signal amplitude and frequency, the amplifier may break into high-frequency oscillations which can lead to destruction of the output transistors, the drivers, or both. This condition is particularly a problem in transformer-coupled amplifiers because the characteristics of transformers depart from the ideal at both low and high frequencies. The departure occurs at low frequencies because the transformer inductive reactance decreases and, at high frequencies because the effects of leakage inductance and of transformer wind-
ing capacitance become appreciable. At both frequency extremes, the effect is to introduce a phase shift between input and output voltage.

Negative feedback is used almost universally in audio amplifiers, and the voltage coupled back to the input by the feedback loop may cause the amplifier to be potentially unstable at some frequencies, if the additional phase shift is sufficient to make the feedback positive. Similar effects can occur in transformerless amplifiers because reactive elements, such as coupling and bypass capacitors, transistor junction capacitance, stray wiring capacitance, and inductance of the loudspeaker voice coil, are always present. The values of some of the reactive elements (e.g., transistor junction capacitance and transformer inductance as the core nears saturation) are functions of the signal level, and coupling through wiring capacitance and unavoidable ground loops may also vary with the signal level. As a result, an amplifier which is stable under normal listening levels may break into oscillations when subjected to high-level signal transients.

A large phase shift is not only a potential source of amplifier instability, but also results in additional transistor power dissipation and increases the susceptibility of the transistor to forward-bias second-breakdown failures. The effects of large signal phase shifts at low frequencies are illustrated in Fig. 2, which compares the load-line characteristics of a transistor in a class-AB push-pull circuit, similar to that shown in Fig. 1, for signal frequencies of 1000 Hz and of 5 Hz. The phase shift is caused primarily by the output capacitor. In both cases the amplifier is driven very hard into saturation by a 5-volt input signal. The increased dissipation at 5 Hz compared to that obtained at 1000 Hz results from simultaneous high-current and high-voltage operation. The transistor is required to handle safely a current of 0.75 ampere at a collector voltage of 40 volts for an equivalent pulse duration of about 10 milliseconds; it must be free from second breakdown under these conditions of operation.

### Excessive Drive Levels

Simultaneous high-current and high-voltage operation may also occur in class-B amplifiers at high frequencies when the amplifier is overdriven to the point where the output signals are clipped. For example, assume that the input signal applied to the series-output push-pull circuit shown in Fig. 3A is large enough to drive the transistors into both saturation and cut-off. During a portion of the input...
cycle, therefore, transistor A will be driven into saturation, and transistor B will be cut off. Fig. 3B shows the collector-current waveform for transistor A under these conditions.

During the interval from r2 to r3, transistor A operates in the saturation region, and the output voltage is clipped. The effective negative feedback is then reduced because the output voltage does not follow the sinusoidal input signal. Transistor A, therefore, will be driven even further into saturation by the unattenuated input signal. When transistor B starts to conduct, transistor A cannot be turned off immediately because the excessive drive has resulted in a large storage time. As a result, transistor B is required to support essentially the full supply voltage (less only the saturation voltage of transistor A and the voltage drop across the emitter resistors, if used), as its current is increased by the drive signal. For this condition, a large input signal is required when the frequency is high enough so that the storage time is greater than one-quarter cycle.

Fig. 3C shows the type of load line obtained under such conditions. The duration of the high-current, high-voltage condition is usually short enough so that forward-bias second breakdown does not occur. For example, the load line shown is for a 2N3878 transistor operated at a frequency of 100 kHz; no second breakdown failure occurred.

Transistor A in Fig. 3A is also subject to forward-bias second breakdown if the d.c. supply voltage and a large input signal are applied simultaneously, because of the charging current through the output coupling capacitor.

If the load of a transformer-coupled amplifier is disconnected during operation, the transistor then sees an inductive load (the transformer primary inductance). When the transistor is turned off, reverse-bias second breakdown may occur. Direct- or capacitive-coupled circuits, on the other hand, are quite stable with the load removed.

If the amplifier high-frequency response is limited by the high-frequency capability of the output transistors, then the driver transistors may be unduly stressed under high-frequency, high-drive conditions. This stress is produced because the reduction in output voltage, as amplifier gain decreases, results in a smaller negative feedback voltage. The effective over-all amplifier gain is therefore increased, thereby causing the current in the driver transistors to increase. At sufficiently high frequencies, failure may then result because the drivers become overloaded.

This potential cause of failure can be avoided by the deliberate introduction of a frequency roll-off at the input, or by the use of high-frequency output transistors. The 2N3878, which has a typical gain-bandwidth product of 100 MHz, is well suited as an output for very wide band amplifiers. This transistor has been used in a low-distortion amplifier to obtain a frequency response which is down only 1 dB at 15 Hz and at 200 kHz at 20 watts output.

Short-Circuit Protection

Another important consideration in the design of high-power audio amplifiers is the ability of the circuit to withstand short-circuit conditions. When the output terminals of an amplifier are shorted, the feedback becomes ineffective, and the open-loop gain is such that overdrive conditions result in disastrously high currents and excessive dissipation in both driver and output stages. Generally, before the output fuse can blow, the transistors are destroyed. Obviously, some form of short-circuit protection is necessary.

One such technique is shown in Fig. 4. A current-sampling resistor R is placed in the ground leg of the load. If any condition (including a short) exists such that higher-than-normal load current flows, diodes D1 and D2 conduct on alternate half cycles and, thereby, provide a high negative feedback which effectively reduces the drive of the amplifier; however, this feedback should not exceed the stability margin of the amplifier. Notice that this technique does not in any way effect the normal operation.

10-Watt, Class-AB Audio Amplifier

The advantages of using silicon power transistors in the driver and output stages of high-power audio amplifiers are shown by the typical performance of three practical circuits designed to operate at widely different power-output levels (10 watts, 25 watts, and 70 watts). The performance data shows that silicon transistors can be used to develop high levels of audio output power in circuits that exhibit the wide frequency response, high sensitivity, and low distortion levels required in high-quality audio systems. Moreover, because of the high-temperature (Continued on page 80)
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November, 1966
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CIRCLE NO. 111 ON READER SERVICE CARD

CL-261

November, 1966
Diode Meter Protectors

By A. A. MANGIERI

How much protection is afforded by meter-shunting diodes and fuses? What is the effect on meter reading, accuracy?

Diode meter protectors are an inexpensive means of guarding costly meters against damage. In particular, volt-ohm-milliammeters are most susceptible to damage if the range switch is inadvertently left on a current range when circuit voltages are being checked.

Can we merely connect the diode protector to the meter and then assume it is completely protected? Does the protection afforded depend on the v.o.m. circuit, the range-switch setting, and the meter characteristics? With the diode connected, is meter accuracy dependent on the d.c. voltage and current waveforms? These factors should be considered when using shunt diode protectors.

Diode Characteristics

Diode meter protectors, as shown in Fig. 1, are shunted directly across the meter terminals. Each device contains two silicon diodes connected in parallel and back-to-back, affording protection against overloads of either polarity. The meter is protected by the forward V-I characteristic of one diode, while the other diode, being reverse-biased, is inactive.

Fig. 2 shows the measured forward V-I characteristic of an Ohmite OMC7111 "Metersaver." As shown in the diagram, the diode can be approximated as a voltage limiter which operates at 900 millivolts at rated current.

Meter-protecting diodes have very low forward currents in the zero- to 300-millivolt region and very low reverse current leakage. Below 300 millivolts, the d.c. resistance is above 600,000 ohms. Because meter resistances are much lower, shunting the diode across the meter terminals introduces errors of only about .5% or less, depending upon the meter resistance. The OMC7111 has an absolute maximum and continuous forward-current rating of 300 milliamperes. The Lectrotech "Metergard" is rated at 1 A continuous and is surge-rated at 6 A for one cycle.

Meter Characteristics & Overload

Quality d.c. meters can withstand at least a 10x overload (ten times full-scale value) for one-half second and a 1.5x overload continuously. Many can tolerate double or even triple these overloads with no serious damage. Because meter construction varies, there is much uncertainty as to meter overload capability beyond the 10x momentary and 1.5x continuous overloads.

Table 1 lists the electrical characteristics of a number of panel meters up to one milliampere full scale. Full-scale millivolts is obtained by multiplying full-scale current rating times the meter resistance. The method of calculating meter overload current multiplication factors is covered a little further on. These factors represent the overloads in the meter with diode protection and not the overload capabilities of the meter alone.

The first two instruments given in the table are representative of the high and moderate millivolt sensitivities found in the movements employed in most v.o.m.'s. The costlier low-resistance suspension type listed is found in meters of very low d.c. voltage drop that are used in transistor work.

The meter overload factor is found by dividing the diode-limiting voltage by the full-scale millivolt sensitivity of the meter. As an example, using 900 millivolts from Fig. 2, the calculation for the 50-microampere Simpson meter listed is 900 mV/250 mV or 3.6x. The maximum actual meter cur-
A. D.C. Range

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<tr>
<th>D.C. Range (Microamperes)</th>
<th>Simpson 1212</th>
<th>Knight 3½&quot; , 4½&quot;</th>
<th>Triplett 320R (Band-Suspension Type)</th>
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*Calculations based on 900-millivolt diode-limiting voltage (see text).

Table 1. Characteristics and overload factors for various types of basic panel meters discussed by author.

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Meter and Diode Fusing

Fig. 3A shows a voltage source V having an internal impedance R, delivering load current I, to load R. D1 and D2 are the shunt diodes of the meter protector. If R is shorted, the short-circuit current is \( \frac{V - .9}{R} \) for diodes limiting at 900 millivolts. Currents can easily rise to several amperes or more and destroy both diodes and meter unless the current is limited by a resistor or interrupted by a fuse.

Many v.o.m.'s, on current ranges, use the circuit of Fig. 3B. Note that the diodes are directly across the plus and minus test leads of the instrument and are therefore exposed to the full voltage that may be inadvertently placed across the meter. Such circuits require fusing.

Other v.o.m.’s, such as the Simpson 260, use the circuit of Fig. 3C. Note that the diode is not across the test leads because of the presence of the 3000-ohm resistor. This resistor acts as a current limiter tending to protect the diode, although this is not its primary circuit function. Fusing is optional, though preferable.

For maximum protection and because many of the overload factors in Table 1 are near or above 10X, it is necessary to interrupt the overload current within one-half to one second. This avoids overheating delicate meter hairsprings and is done by fast-action fusing.

Fuse ratings are based on the diode current ratings, allowing the use of low-cost, low-resistance fuses. Table 2 lists fast-blow instrument-fuse characteristics in the 1/4- to 1-ampere range. Use a 1/4-ampere fuse for the Ohmite OMC7111, as it will clear within one second at 220 milliamperes. Use a 1/4-ampere fuse for the Lectrotech "Metergard." Surge-rated diodes permit use of larger fuses if this is necessary to reduce fuse resistance. Either the .01- or 1-second clearing times in Table 2 may be employed, depending upon how the diode is surge-rated.

In multi-range v.o.m.’s, when the highest current range is less than the selected fuse rating, (Continued on page 76)
AN, am I tuckered!" Barney said, smothering a yawn. "What kept you up late, hamming or dating?" Mac, his boss, asked. "Nothing so fun-type," Barney replied. "A cousin of mine, fresh out of the Army and just home from Vietnam, and I were trying to figure out what help he could expect in continuing his interrupted education under the new Veterans' Readjustment Benefits Act of 1966. Believe me," Barney said, tapping a pamphlet on the bench in front of him, "wading through Public Law 98-358 here is worse than trying to trace one of those postage-stamp-size circuits pasted in the back of a Japanese transistor radio."

"Okay," Mac said, lighting his pipe and leaning back against the bench, "tell me about it. You know you're busting to."

"Thought you'd never ask," Barney said with a grin. "Anyway, the purpose of the bill is to make service in the Armed Forces more attractive, to help young people get an education they could not otherwise afford, and to compensate in part for educational and career sacrifices made by young men serving their country."

"Who's eligible for this help?"

"You make a wonderful straight man; you ask precisely the right questions—the ones I can answer," Barney marveled. "Any veteran is eligible for benefits who served on active duty for more than 180 days, any part of which occurred after January 31, 1955, and who was released under conditions 'other than dishonorable.' If he was released from active duty after January 31, 1955 for a service-connected disability, the 180-days-plus requirement is waived. And if he has served on active duty for at least two years and continues to serve on active duty, he is eligible for benefits while still in the service."

"But he doesn't get active-duty credit for training. He can't count a period when assigned by his service full-time to a civilian institution for a course substantially the same as one offered civilians, or periods of service as a cadet or midshipman in a service academy, or active training in the National Guard or Reserves."

"Where can he go to school? What kind of courses can he take?"

"He can attend any institution approved for training, including public or private secondary, vocational, correspondence, or business school; junior or teachers' college, normal school, college or university, professional, scientific, or technical institution, or any other institution which furnishes education at the secondary level or above."

"I notice you say 'approved' institution. I don't suppose the benefit would be granted for a course in surfboard riding."

"You suppose right. The Veterans' Administrator will not approve any course which is avocational or recreational in character unless the veteran can prove the course will be of practical use in his present or contemplated business or occupation. The Administrator ordinarily will not approve flight training, apprentice or other on-the-job training or institutional on-farm training. Neither will benefits be granted for open-circuit TV courses unless they are part of an in-residence program leading to a college degree."

"Let's get to the grubby, but interesting, details: how much money will the veteran receive?"

"That depends on several factors. If he engages in full-time institutional training, consisting of a minimum of 14 semester hours or the equivalent, he will be eligible for $100 per month. Having one dependent raises this to $125. Two dependents or more brings it to $150. On the other hand, if he takes only three-quarter time training, consisting of 10 to 13 semester hours or equivalent, the monthly payments are reduced to roughly three-fourths those figures. If he takes half-time training, consisting of 7 to 9 hours, payments are reduced to approximately one-half the full-time figures. Payments for a person taking less than half-time training or for one taking training while on active duty are computed at the rate of the established charges for tuition and fees required of non-veterans taking the course or at $100 per month for a full-time course, whichever is the lesser. Payments for veterans taking cooperative training is $80 a month for no dependents, $100 for one dependent, and $120 for two or more dependents."

"Thought you'd never ask," Barney said with a grin. "Anyway, the purpose of the bill is to make service in the Armed Forces more attractive, to help young people get an education they could not otherwise afford, and to compensate in part for educational and career sacrifices made by young men serving their country."
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November, 1966

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rolled. However, the Administrator can renew the allowance if the cause of the unsatisfactory conduct or progress is removed and the program the veteran is engaged in does not change. The Administrator may approve one additional change (or an initial change otherwise not permitted because of the student's failure) if it seems the veteran has a better likelihood of success by undertaking a new program.

"You spoke of a veteran's obtaining this educational assistance while in service. Does that mean he could be paid for training in a foreign school?"

"In some approved institutions of higher learning, yes. Keep in mind that any institution in which the veteran is engaged in a program of education at his own expense when payments started on June 1, 1966. Can he obtain educational assistance to help him continue this program? Can he obtain retrospective payments back to the time he started the course?"

"By obtaining approval of his course, he could receive payments to help him continue that course, but he could not obtain any retrospective payments going back beyond June 1, 1966. Benefits are paid starting with June, 1966 but only to veterans beginning a course in that month or those enrolled in a course which will continue beyond that month.

"Mac reached over and picked up the pamphlet to which Barney had been referring and leafed through it. "Did you winnow all this information out of the fine print in this booklet?" he demanded.

"I had other help," Barney admitted. "The Veterans' Administration, Washington, D.C. 20420, put out a summary of the Act entitled 'VA Pamphlet 23-66-1' that helps explain the legal wording. And the National Home Study Council, 1601 18th Street, N.W., Washington, D.C. 20009, has issued a series of clarifying bulletins, #14 and #20, that are most helpful in understanding the law, especially as it pertains to correspondence schools. My cousin had these with him."

"Just what does your cousin, or any other eligible person, have to do to obtain this educational assistance under the new G.I. Bill?"

"First, he obtains an application form at any VA office, active-duty station, or American Embassy. He fills this out and submits it to the nearest VA Regional Office if he is in the United States. If he is living outside the country, he submits his application and all subsequent communications to the nearest American Embassy for transmittal to the VA Benefits Office, 2033 M Street, N.W., Washington, D.C. 20421. If he is a veteran, he encloses a copy of his separation document, DD Form 214, with the application. Active-duty personnel must submit a Statement of Service from their Commanding Officer or designate. To receive additional allowance for a dependent (wife, child, or dependent parent), a certified copy of the public record of the marriage, birth, etc., should also accompany the application."

"I hope every veteran now eligible, and every one who later becomes eligible, will apply for this educational assistance," Mac said. "It's a wonderful opportunity, honestly earned, for these fellows to equip themselves to take their rightful place in the world they have helped preserve. And I'll bet a lot of them will take the training in our field—not necessarily in service work, but in some of the many other branches of electronics offering an attractive future, such as computers, space electronics, medical electronics, communications, color-TV broadcasting, and industrial electronics."

"After all, most of those men have had to postpone their own plans for college or advanced training and it is fair for Uncle Sam to give them a hand when they've finished the job. Such financial help is a very small return for what they've done for us."

"I'm with you, and the thing I like about the Act is its broad base. It offers something to practically every veteran. If he already has the necessary credits, he can use his benefits to become an electrical engineer or an electronics engineer. If he lacks the credits to get into a university or if he wants to work while he is training, he can take part-time vocational training to secure his education at his own pace through correspondence. Follows who learn more easily by doing rather than studying can take advantage of the cooperative schools. Finally, through the active-service allowance, a person in the Armed Forces can, if he wishes, start his training while he is still on active duty."

"Yep," Mac concluded the conversation, "the opportunity is there for the taking, and if I were eligible I'd certainly take advantage of it at the very first chance."
Now instant movies in sound start at $695.

The new Sony Videocorder deck (model CV-2000D) is both compact and versatile. It's also quite reasonably priced, $695.

It's just like current Sony Videocorder models, but without the built-in TV monitor. Using a separate monitor or TV set, you can tape selected TV programs off-the-air. Add the optional Sony TV camera and you can tape "live" action in sight and sound. Play back your tape, and you'll see instant movies in sound.

This new deck is small enough to fit on a bookshelf, as a part of your hi-fi component system. Light enough (only 44 lbs.) to take wherever you want it to perform. Adaptable enough to use with any TV monitor, small or large screen (the new Sony 8"-inch and 22"-inch receiver/monitors are perfect mates). It can be adapted to work with most home TV sets. Handsome too, in walnut-finish cabinet.

Looking for a Videocorder with its own built-in monitor? Then meet the rest of the Sony Videocorder family. TCV-2010 complete in its own carrying case, $995. The TCV-2020, handsome oil-finish walnut cabinet and with built-in timer to automatically tape TV programs while you're away, $1150. For taping "live" action, there is the Video Camera Ensemble VCK-2000 (camera, elevator tripod, microphone) at $350. For an unforgettable demonstration visit your Sony Videocorder dealer today. For free 16-page booklet write:

SONY® Corp. of America, 47-37 Van Dam St., Long Island City, N.Y. 11101 Dept. H

*Diagonal measurement. The Videocorder is not to be used to record copyrighted material. Sony and Videocorder are registered trademarks of the Sony Corp. All prices suggested list.
THE DEVELOPMENT OF INTEGRATED CIRCUITRY is the dawn of a new age of electronic miracles. It means that many of today's job skills soon will be no longer needed. At the same time it opens the door to thousands of exciting new job opportunities for technicians solidly grounded in electronics fundamentals. Read on the facing page what you need to know to cash in on the gigantic coming boom, and how you can learn it right at home.
Tiny Electronic "Chips" each no bigger than the head of a pin, are bringing about a fantastic new Industrial Revolution. The time is near at hand when "chips" may save your life, balance your checkbook, and land a man on the moon.

Chips may put you out of a job ...or into a better one.

"One thing is certain," said The New York Times recently. Chips "will utterly change our lives and the lives of our children probably far beyond recognition."

A single chip or miniature integrated circuit can perform the function of 20 transistors, 18 resistors, and 2 capacitors. Yet it is so small that a thimbleful can hold enough circuitry for a dozen computers or a thousand radios.

**Miniature Miracles of Today and Tomorrow**

Already, as a result, a two-way radio can now be fitted inside a signet ring. A complete hearing aid can be worn entirely inside the ear. There is a new desk-top computer, no bigger than a typewriter, able to perform 166,000 operations per second. And it is almost possible to put the entire circuitry of a color television set inside a man's wristwatch case.

And this is only the beginning!

Soon kitchen computers may keep the housewife's refrigerator stocked, her menus planned, and her calories counted. Her vacuum cleaner may creep out at night and vacuum the floor all by itself.

Money may become obsolete. Instead you will simply carry an electronic charge account card. Your employer will credit your account after each charge account card. Your employer is always looking for.

But at the same time the booming sales of articles and equipment using integrated circuitry has created a tremendous demand for trained electronics personnel to help design, manufacture, test, operate, and service all these marvels.

There simply aren't enough college-trained engineers to go around. So men with a high school education who have mastered the fundamentals of electronics are being begged to accept really interesting, high-pay jobs as engineering aides, junior engineers, and field engineers.

### How To Get The Training You Need

You can get the up-to-date training in electronics fundamentals that you need through a carefully chosen home study course. In fact, some authorities feel that a home study course is the best way. "By its very nature," stated one electronics publication recently, "home study develops your ability to analyze and extract information as well as to strengthen your sense of responsibility and initiative." These are qualities every employer is always looking for.

If you do decide to advance your career through spare-time study at home, it makes sense to pick an electronics school that specializes in the home study method. Electronics is complicated enough without trying to learn it from texts and lessons that were designed for the classroom instead of correspondence training.

The Cleveland Institute of Electronics has everything you're looking for. We teach only Electronics—no other subjects. And our courses are designed especially for home study. We have spent over 30 years perfecting techniques that make learning Electronics at home easy, even for those who previously had trouble studying.

Your instructor gives your assignments his undivided personal attention—it's like being the only student in his "class." He not only grades your work, he analyzes it. And he mails back his corrections and comments the same day he gets your lessons, so you read his notations while everything is still fresh in your mind.

### New Opportunities for Trained Men

What does all this mean to someone working in electronics who never went beyond high school? It means the opportunity of a lifetime—if you take advantage of it.

It's true that the "chip" may make a lot of manual skills no longer necessary. But at the same time the booming sales of articles and equipment using integrated circuitry has created a tremendous demand for trained electronics personnel to help design, manufacture, test, operate, and service all these marvels.

There simply aren't enough college-trained engineers to go around. So men with a high school education who have mastered the fundamentals of electronics theory are being begged to accept really interesting, high-pay jobs as engineering aides, junior engineers, and field engineers.

### Get FCC License or Money Back

No matter what kind of job you want in Electronics, you ought to have your FCC Commercial License. It's accepted everywhere as proof of your education in Electronics. And no wonder—the Government licensing exam is tough. So tough, in fact, that without CIE training, two out of every three men who take the exam fail.

But better than 9 out of every 10 CIE-trained men who take the exam pass...on their very first try! This has made it possible to back our FCC License courses with this famous Warranty: you must pass your FCC exam upon completion of the course or your tuition is refunded in full.

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Want to know more? The postpaid reply card bound in here will bring you free copies of our school catalog describing today's opportunities in electronics, our teaching methods, and our courses, together with our special booklet on how to get a commercial FCC License. If card has been removed, just send us your name and address.

### VETERANS

If you had active duty in any branch of the Armed Forces after January 31, 1955, you may be entitled to Government-paid tuition for any CIE course.

---

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EUROPEAN color TV has reached an impasse. At a recent meeting in Oslo, Study Group XI (TV) could not agree on which color system to use in Europe, so each country is now free to choose, at its discretion, the color-TV system that seems most suitable to it.

The majority of Western European countries—Denmark, Eire, Finland, Great Britain, Iceland, Italy, Liechtenstein, Netherlands, Norway, Sweden, Switzerland, and the Federal Republic of Germany—have chosen the PAL system. Next year Great Britain, Netherlands, Italy, and the Federal Republic of Germany will start PAL color broadcasting.

France, Greece, and Monaco have decided on SECAM III, as have the Eastern Bloc countries of Albania, Byelorussia, Bulgaria, Czechoslovakia, Hungary, Poland, Rumania, the Ukraine, the U.S.S.R., and Yugoslavia. The British territories of Australia, New Zealand, South Africa, and Nigeria advocated PAL, while Iran and Israel acknowledged the technical advantages of this system.

Twenty-two countries outside Europe, including 16 African nations, nine of which have no TV at all, voted for SECAM.

The political controversy at Oslo grew to such an extent that a new system, spawned by a French and Russian alliance, was put up as a compromise. This system, called SECAM IV, is a variant of the French SECAM system further worked over by the NIIR (Nauktschno Issledovatelski Institut Radio), the U.S.S.R.'s scientific radio research institute. Both the French and Russians admitted that their composite system was not finished, and its features are still unknown. From these purely technical aspects, there seem to be no prospects for the compromise proposal.

The situation now looks like this. At present, there are eleven monochrome standards in Europe. This means that there would have been 11 color standards if one color system had been adopted for all countries. With each faction in Europe now ready to produce color TV with one of three (incompatible) systems, the color-TV picture grows infinitely more complex, and an exchange of programs within Europe or across the Atlantic will be impossible without the use of a number of scan converters in the transmission path.

Laser Earthquake Detector

One of the major problems with earthquakes is that they happen at almost unpredictable times. Now, however, three scientists at The Boeing Co. have disclosed that they have been measuring movements along earth faults within the shaft of an abandoned mine tunnel in California for the past two years, using a laser beam in a specially designed interferometer.

The laser interferometer measures small earth strains in two independent directions along an earth fault that intersects the mine tunnel. Buildup of these infinitesimal strains is thought to precede a major earth shift at the fault lines.

In essence, the interferometer measures the difference in phase between a light wave crossing the earth fault and a beam that does not cross the fault. Variations in phase between the two beams can indicate earth movements of less than a millionth of a centimeter.

New Phono Styli

The major difference between the two types of phono styli presently available, the diamond and the sapphire, is that the diamond far outlasts the sapphire in use. This is due to the fact that a diamond crystal is very abrasion-resistant along certain of its crystal axes. Because of its great hardness and resultant high cost of fabrication, the diamond is expensive.

Sapphire, on the other hand, can be easily worked to the correct tip shape, but this relative softness reduces its operating life.

Now, scientists at Toshiba have developed a new stylus from special crystal-oriented corundum (aluminum oxide, the hardest mineral except for the diamond). These new styls are expected to be as low in cost as a sapphire yet have the life of a diamond.
Safari II 5-Watt 5-Channel Transceiver Kit

Versatile, easy and fun to build, features compact solid-state design with factory assembled and aligned transmitter section, yet is priced remarkably low. Full 5 watts input power, 5 crystal-controlled channels. Just 2 1/8 x 6 7/8 x 8 1/2" overall. Connects to 12-volt battery in car, truck or boat in minutes...use as portable with optional battery pack, or as base station with optional AC supply. Simple 3-control operation—illuminated channel selector, squelch control, on/off volume control. Series gate noise limiter circuit overcomes interference. Unique push-to-talk microphone/speaker.

With Mike/Speaker, Channel 9 Crystals
$59.95

Safari III 5-Watt 23-Channel Transceiver Kit

Designed for those who want the best in CB at a low price. All the deluxe features of the Safari II above...PLUS provision for 23 crystal-controlled channels; easy-to-read front-panel "S" meter and fine tuning control to tune in stations that are off frequency; and transmit indicator light.

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November, 1966
In operation, the amplifier detects the manually reset latching-type relay. The contacts of the relay, located in the v.o.m. input circuit, latch open and remain open until the user depresses the manual reset button. If the overloads are smaller and not sufficient to "fire" the amplifier, no damage can be caused to the instrument.

Auxiliary contacts on the latching relay automatically disconnect the meter's battery immediately after the relay is energized by the transistorized amplifier, preventing continuous battery drain. This feature allows the Model 630-APLK to be left in the relay-energized state for indefinite periods with no battery drainage. In the normal operating condition, with the reset button "in," the overload protection amplifier draws negligible standby current. This current is less than one microampere, the approximate shelf-life drain on the 30-volt battery furnished with each instrument. A fuse in the input circuit provides added protection for the relay contacts.

Protection against overload damage is provided on all ranges. The one- and ten-ampere ranges are protected by 3- and 15-ampere fuses respectively. The inherent high resistance of the 100,000-ohm, 1000- and 5000-volt a.c. and d.c. range circuits limits current to a level which will not damage the meter. All other ranges are protected by the transistorized overload safeguard.

Additional protection to the meter is provided through the use of a dual silicon-diode network. It prevents damage to the meter pointer by bypassing instantaneous transient voltages that might bend the meter pointer before the latching-relay contacts open.

The new v.o.m. has a sensitivity of 20,000 ohms per volt d.c. and 5000 ohms per volt a.c. It has an accuracy of ±1½% of full scale for all d.c. ranges with the exception of the 5000-volt range (±3½%) as well as an accuracy of ±3% for the a.c. ranges. All accuracies are based on meter placement in the horizontal position. All resistance ranges have an accuracy of ±1½% of scale length. A mirror-backed, 4½-inch-long scale insures reading accuracy by eliminating parallax.

The meter itself is a rugged suspension type having a sensitivity of 30 microamperes full scale. Conventional pivots, bearings, and hairsprings are completely eliminated; therefore, increased repeatability is provided. Friction between pivots and bearings is no longer a problem. Also, greater ruggedness and durability is achieved since there are no moving parts in contact, and the elimination of the hairspring prevents snagging and tangling. Temperature variations cannot cause sticky operation of the pointer.

The suspension system consists of a moving coil which floats in a magnet by virtue of the suspension bands held in tension by a spring. These bands, fabricated of precious-metal alloy, provide torque and carry the current to the moving coil. The moving-coil assembly is held by a rigid, one-piece, die-cast frame in a large self-shielded "bar-ring" magnet.

The Model 630-APLK volt-ohm-milliammeter is priced at $95.

Eico Model 888 Engine Analyzer
For copy of manufacturer's brochure, circle No. 30 on Reader Service Card.

For the electronics man who likes to work on his own car, here is a piece of equipment that will do just about all his measurements for him. For example, the output of the voltage regulator can be checked on the 16-volt scale of the instrument; voltage drops in the car's wiring can be checked on the 3.2-volt scale; the setting of the contact relay in the car's battery-charging circuit can be measured on the 90-ampere scale.

In addition to these useful voltage and current scales, the new Eico 888 incorporates a transistorized Schmitt...
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Includes ALL parts (except tubes) . . . All labor on ALL makes. Fast 24-hour service with 1-year warranty

Sarkes Tarzian, Inc., largest manufacturer of TV and FM tuners, offers unmatched tuner overhaul and factory-supervised repair service.

Tanzian-made tuners received one day will be repaired and shipped out the next. More time may be required on other makes. Every channel checked and realigned per original specs. And, you get a full 12-month guarantee against defective workmanship and parts failure due to normal usage. Cost, including labor and parts (except tubes) is only $9.50 and $15 for UV combinations. Replacements at low cost are available.

The analyzer can be applied to marine engines as well as auto engines. It is completely self-powered, using four easily replaced flashlight cells. The meter employed for all indications is completely self-powered, using four D-cell batteries. The instrument also serves as a dwell meter, measuring the number of degrees of rotation that the breaker points remain closed. To do this, the analyzer is used as an averaging ohmmeter that is connected across the breaker points. In a 6-cylinder engine, the maximum dwell time is 1/6 of 360°, or 60°. This would occur with the points closed all the time. Normally, the points would be closed for just over half this time, so that the dwell would measure 30° to 35°, or whatever value is specified by the car manufacturer.

A most useful portion of the instructions manual for the 888 is a seven-page section covering proper idling speeds and dwell angles for just about all American and foreign cars, going back as far as 1950 for some models.

In addition to the features mentioned above, the instrument can also be used as a conventional ohmmeter, a diode tester (for the rectifiers employed with the car's alternator), and a spark-plug and ignition-coil tester. A built-in 0.22-µF capacitor can also be switched across the test leads to take the place of the one used across the breaker points in the car.

The analyzer can be applied to marine engines as well as auto engines. It is completely self-powered, using four easily replaced flashlight cells. The meter employed for all indications is six inches wide so that it can be readily seen from a considerable distance. The
A WELL-regulated power supply that will deliver up to 30 volts d.c. at 300 mA has a number of important applications. It can be used to power most solid-state circuits in the laboratory, on the production line, or on the service bench. It can also be used in the classroom for industrial training programs or high school and college electronics courses. The Acopian Model K55 is just such a unit. It is small in size (only 3 3/4" x 5 1/2" x 5 3/4" high) and light in weight (3 lbs).

The unit has a continuously variable output voltage from 1.25 to 30 volts with a full-load output current of 300 mA over the entire range (see diagram). The load regulation is ±0.5% or 50 mV, whichever is greater, while the line regulation from 105 to 125 volts is 10 mV. The supply has low output ripple, being only 1 mV r.m.s. at full load. The output binding posts are insulated from ground and floating.

The supply uses a full-wave silicon-diode bridge along with a four-silicon-transistor voltage-regulator circuit. Short-circuit protection is provided by the regulator circuit so that the supply can be used safely by students or inexperienced personnel. A built-in meter is included for monitoring voltage or current.

The compact power supply is available for $98.

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New RCA "AUTOTEXT" programmed instruction will help you learn faster and easier!

If you're considering a future in electronics, now is the time to start! A great new teaching aid—"AUTOTEXT"—programmed instruction developed by RCA and introduced by RCA Institutes will help you master the fundamentals of electronics almost automatically. Even people who have had trouble with conventional home training methods are finding it easier and more fun to start their training in Electronics Fundamentals the RCA way. Prove it to yourself as others throughout the country are now doing. An interest or inclination in electronics is what you need. RCA "Autotext" helps you to do the rest. You'll be ready to go on to advanced training sooner than you ever thought possible! The future is unlimited; the jobs are available. The important thing is to get started now.

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The Most Trusted Name in Electronics
Diode Meter Protectors (Continued from page 57)

fusing at B in Fig. 3B sidesteps fuse resistance problems and also protects the meter shunts. If the highest selectable current range is above the fuse rating, place the fuse at A as shown. Fusing at A requires that the fuse resistance be no larger than 1% of the meter resistance to avoid excessive decalibration.

For a v.o.m. using a 1-milliampere, 50-ohm meter, use a ½- or even 1-ampere fuse at A, along with a diode having at least a six-ampere surge rating. Fuse resistance is no problem in Fig. 3C due to high meter resistance.

Diode Clipping

D.c. currents in pulse and multivibrator circuits, unfiltered battery chargers, and unfiltered d.c. SCR power supplies often have very high peak-to-average values. Typical d.c. meters respond to average values. By voltage-limiting action, the diode protector will clip the peaks, resulting in very large meter errors, particularly near full scale.

Fig. 4 shows the voltage waveforms observed across the load current meter of an unfiltered half-wave battery charger in operation. Peak voltage (Vp) to average (Vavg) is 9 to 1 in this case. Upon connecting the diode, it clipped at voltage V1 and introduced a meter error of nearly 50%. (Compare Vavg in Fig. 4B with Vavg in Fig. 4A.)

To detect clipping, switch the v.o.m. to a higher current range and compare readings. A large difference indicates diode clipping, which can be reduced or eliminated by using a higher current range and restricting readings to the lower portions of the scale.

An effective remedy is to connect a capacitor across the meter terminals which will act like a filter for the a.c. components. Sizes may vary from 0.01 μF disc types to 50-μF transistor electrolytics, depending upon repetition frequencies and meter and circuit resistances. To be certain of obtaining the desired results, compare meter indications with the diode removed, diode attached, and with diode and capacitor connected. A capacitor permanently connected across the meter terminals has little or no effect on the v.o.m. a.c. ranges but this should be checked for the particular instrument being used.

Two diodes in series will double the meter's immunity to diode clipping. It will also reduce diode insertion error by more than one-half. However, it will double the overload factor by doubling the limiting voltage. But this is an acceptable compromise for meters having a low factor around 3X with one diode.

Diode Selection

The lower current rated diodes are preferred for use with the more sensitive high-resistance meters. This reduces diode insertion errors to a minimum. The higher rated diodes are preferred for the lower resistance meters because they have high current-handling ability.

Ordinary top-hat and epoxy diodes are often suitable for use as protectors but may introduce larger diode insertion errors than the commercial protectors. Select the most suitable by noting the meter error at full scale on the lowest current range. Use two diodes back-to-back for v.o.m.’s, as in Fig. 3A.

When the meter current range is not very small compared with the diode rating, the diode is less able to carry the major part of the short-circuit current. Higher rated diodes such as stud types can be used to effect an improvement. One exception is the circuit of Fig. 3C in which the diode always sees a fairly large resistance regardless of the range-switch setting. Higher current meters are adequately protected with fast-action fusing alone.

To conclude, v.o.m.’s should be safeguarded by a properly matched diode-fuse combination for maximum protection of the costly meter.

Linear IC’s: What’s Available (Continued from page 42)

zero d.c. offset: the leakage when the gate is in another position is typically 1 nanoampere. The switch can safely pass 100 mA of current. Turn-on and turn-off times are 0.5 and 2 microseconds respectively.

Two other companies presently offer analog gates. These are General Microelectronics and General Instrument Corp. The latter provides an entire line of switches in its MEM5000 series, ranging from six-position single-throw through double-pole, double-throw. Prices are now in the $40 to $90 range, but the devices will inevitably become low-cost IC’s once volume usage sets in and development costs have been returned.
ELECTRONIC CROSSWORDS
By JAMES R. KIMSEY
(Answer on page 104)

ACROSS
1. In a.c. theory, a polar  17. Optical counterparts.
In which voltages, currents, or  18. An oscillator circuit employing
impedances fan out from the  a.c. theory employing
center at their proper phase  an oscillator circuit employing
angles.
3. The unit of magnetic intensity  a cmos circuit employing
whose frequency is greater  an oscillator circuit employing
than 1600 kHz (abbr.).
plastic placed around delicate  27. Chemical abbreviation.
components.
5. A practical unit of current  28. Contact at the end of a plug.
(abbr.).
6. The common system of radio  29. Sixty (Rom. num.).
broadcasting (abbr.).
7. Unit of length equal to one-  30. Connected, alive,
millionth of a meter.
8. Third note in the musical scale.  31. Pertaining to or utilizing sound
9. Optical maser.  32. Connected, alive,
10. The current, voltage, or power  33. Type of current (abbr.).
that is fed into a circuit.
11. Elevator direction.
12. The higher audio frequencies.
13. Designation for the band from  35. Waves higher than 1600 kHz (abbr.).
3000 to 30,000 MHz (abbr.).
ator.
15. Two of a kind (abbr.).
characteristics.
20. Malt beverage.
22. Type of calibrated meter  38. Small rug.
(abbr.).
23. A connecting wire, etc.
heard (abbr.).
25. Elevator direction.
26. Type of switch.
27. Chemical abbreviation.
28. Type of switch.
29. Connected, alive, energized.
30. A metal partition or shield.
31. Pertaining to or utilizing sound  40. Sound network (abbr.).
waves.
32. Connected, alive, energized.
33. Type of current (abbr.).
34. Variations of a chemical ele-  41. Greek letter used as a symbol
ment, each having the same  for amplification factor.
atomic number but different  42. One-thousandth of an ampere
atomic weights.
35. Waves whose frequency is  43. Protective coating of cured
higher than 1600 kHz (abbr.).
36. Type of antenna.
37. Posses.
38. Small rug.
40. Sound network (abbr.).
41. Greek letter used as a symbol
for amplification factor.
42. One-thousandth of an ampere
(abbr.).
43. Protective coating of cured
plastic placed around delicate
components.

DOWN
1. British Commonwealth term  14. Licensed amateur radio oper-
for tubes.
ator.
2. In series.
3. The unit of magnetic intensity  15. Two of a kind (abbr.).
in the cgs electron-magnetic
system.
4. Any shifting of a station's sig-  16. Possessing non-directional
nal from the original dial setting.
5. A practical unit of current  17. Optical counterparts.
(abbr.).
6. The common system of radio  18. An oscillator circuit employing
broadcasting (abbr.).
7. Unit of length equal to one-
millionth of a meter.
8. Third note in the musical scale.
10. The current, voltage, or power  11. Elevator direction.
that is fed into a circuit.
11. Elevator direction.
12. The higher audio frequencies.
13. Designation for the band from  35. Waves higher than 1600 kHz (abbr.).
3000 to 30,000 MHz (abbr.).
ator.
15. Two of a kind (abbr.).
characteristics.
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ment, each having the same  for amplification factor.
atomic number but different  42. One-thousandth of an ampere
atomic weights.
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for amplification factor.
42. One-thousandth of an ampere
(abbr.).
43. Protective coating of cured
plastic placed around delicate
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Power Inductors (Continued from page 35)

hermetically sealed types offer the greatest amount of protection and best appearance, while having the poorest heat dissipation and higher cost. Many types of construction between these two extremes are available which combine the desired qualities of each. For example, many fully enclosed types of inductors are available which are not hermetically sealed but which have more protection and better appearance than the open-frame types.

The hermetically sealed inductor is completely enclosed in a metal case which has been filled with a suitable compound and sealed by soldering all the seams and openings. Filling material may be wax, pitch, epoxy, or polyester, depending upon the temperature requirements of the item. This type offers maximum protection against mechanical and environmental stresses but is generally larger and heavier than equivalent units of other construction. Molded and encapsulated types offer reasonable protection and are increasing in usage where size and weight are significant in equipment design. Epoxies are prominent as encapsulants, and silicon rubber is often used for high-temperature applications.

Encapsulated or molded inductors offer good moisture resistance, mechanical strength, and heat dissipation but are not as impervious to thermal conditions as hermetically sealed types.

Open-frame, varnish-impregnated units are quite common in commercial applications where environmental conditions are not severe. Varnish impregnation offers moderate protection against moisture and climate. Variations of this open construction offer several levels of protection by use of end covers, partial enclosures, etc.

Commercial & Military Specs

MIL-T-27B, "Transformers and Inductors (Audio, Power and High Power Pulse), General Specification for," sets forth minimum standards for inductors used in military equipment. Areas covered by this specification include: materials, design, inspection requirements, case sizes, marking, environmental requirements and testing, and packaging levels. Transformers and inductors supplied to this specification are normally hermetically sealed (grades 1 or 4) or encapsulated or molded (grades 2 or 5). Open-frame types may be purchased to this specification (grades 3 and 6) but are normally used only where further protection will be provided in the equipment, such as encapsulation of sub-assemblies.

Transformers and inductors supplied to MIL-T-27B are marked with a MIL type number, such as TF4RX01EA. This number indicates the grade, temperature class, life expectancy, family, and case size of the unit. An additional three digits following this type number indicate that the unit is designed to a particular government MS drawing.

Compliance with this specification is mandatory for items supplied for most military equipment, and complete qualification testing must be performed for many contracts.

Commercial standards, although not as strictly followed by individual contractors as the military equivalents, set specifications which are generally adhered to by the electronics industry. For power inductors, RS-197 (revised of TR-110-B) covers filter inductors and RS-181 (revision of TR-127) covers iron-core charging inductors. These particular standards are available through the engineering department of the Electronic Industries Association (EIA).

Specifying Power Inductors

The following ten points should be considered when selecting or specifying inductors for electronic power circuits. Some of these points will be dictated by the electrical requirements of the circuit in which the inductor is to be used, while others will depend largely upon the construction of the equipment and its intended usage.

1. Application and circuit used. For charging inductors, a schematic of the circuit should be made available, while for filter inductors, specifying the type of rectifier circuit (i.e., full-wave bridge, etc.) should be adequate.

2. Inductance and tolerance. Due to the complexity of design and number of variables on inductors carrying direct current, at least 10% tolerance should be allowed. Standard tolerance on off-the-shelf inductors of this type is ±20% to ±50%.

3. A.C. operating voltage and frequency.

4. Direct current or range of direct-current values that are present in the coil.

5. D.C. resistance and tolerance when necessary to circuit operation.

6. Dielectric strength and/or maximum working voltage.

7. Case type (open frame, encapsulated, etc.).

8. Terminals (wire leads, turret type, lugs, etc.).

9. Environmental requirements, including maximum temperature rise and operating temperature, moisture resistance, thermal shock, vibration and shock, life expectancy, and other applicable factors.

10. Applicable military or commercial specifications.
Linear Integrated Circuits
(Continued from page 26)

avoid the use of large resistors by substitution of transistors. A typical example is the simulation of a constant-current source by use of a transistor in place of a large-value resistor.

(g) When possible, replace a capacitor with a transistor. Fig. 10 shows an example in which coupling between two stages is accomplished by a capacitor in one case and by a transistor in the other. In integrated form, the two-stage amplifier using only transistors is markedly lower in cost than the one that uses a capacitor.

4. Prepare a breadboard design, using parasitic (not circuit-interconnected) IC components for all active devices (transistors and diodes). The parasitic capacitance is simulated by connecting the substrate of the device to the most negative voltage point. The parasitic components that are used must match, in area, those which will appear in the final monolithic design. Because the impurity concentration and distribution employed in the fabrication of the monolithic circuit can have a marked effect upon the characteristics, it is also important that all parts of the process for the parasitic components and the process to be used for the fabrication of the circuit be identical.

After these steps are completed, a circuit can be released for layout, mask preparation, and fabrication. After fabrication, the circuit is subjected to a complete d.c. analysis. The limits used for this analysis are determined in advance by the circuit-design engineer. After successful completion of the static tests, the circuits are then subjected to a complete dynamic performance analysis.

Fig. 10. Circuit (A1) employs a transistor in place of the capacitor shown in (B).

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Designing Hi-Fi Amplifiers

(Continued from page 50)

Fig. 6A shows the schematic of a 25-watt a.c./d.c. transformer-coupled audio amplifier intended primarily for public-address systems and other applications for which a high degree of flexibility with respect to load impedance is important considerations. The high breakdown voltage of the silicon power transistors used in the output and driver stages permit the amplifier to be operated directly from a 120-volt a.c. or d.c. line. The negative-voltage terminals of the amplifier (i.e., circuit ground) is isolated from chassis ground by a 0.22-megohm resistor to reduce the risks of electrical shock. The signal input should be transformer-coupled to the power amplifier to avoid shock hazard from the signal-source ground. A 0.1-μF capacitor provides a low impedance connection between circuit ground and chassis ground at r.f. frequencies to prevent high-frequency oscillations. Each driver transistor is connected to the associated output transistor in a Darlington arrangement; the output is transformer-coupled to the speaker.

Drive-signal phase inversion is provided by a transistor inverter-splitter circuit. The small amount of forward bias required for class-AB operation is provided by the 180,000 and 510-ohm resistors and the 1N3754 diode. The diode also provides the temperature compensation required so that the quiescent current will remain relatively constant for wide variations in temperature. With the 10 dB of over-all

The Future

The most important single development in linear integrated circuits over the next few years should be the design of standard types and the acceptance of these types by equipment manufacturers. Large volume requirements with extreme emphasis on low cost will encourage the development of special circuits with multi-function uses, particularly in consumer and some limited industrial applications. Technological developments will extend the frequency range through u.h.f., and large improvements will be forthcoming in low-noise applications at both high and low frequencies. Extension into greater power-handling capability will, to a large extent, be determined by economic considerations. Combinations of MOS and bipolar transistors offer some unique technical advantages and will become a part of the standard types offered by more manufacturers.

The most significant contribution that integrated circuits will make to equipment of the future is that more complex instruments will be generated because one or more orders of magnitude of electronic functions will be purchased for the same cost. In addition, the improvement in reliability will permit such designs. As a result, equipment manufacturers will be stimulated to design products which today are neither practical nor economically feasible.

Production Testing

Because an integrated unit performs a circuit or multiple-circuit function, testing can be a substantial portion of the cost. However, a large part of the testing cost can be avoided by use of a.c. or dynamic specifications which permit performance deviations within the normal process variables. Under such conditions, an integrated circuit can generally be evaluated completely by means of static or d.c. testing. These static tests are fast (typical automatic-equipment static test rates are on the order of 30 to 60 tests per second) and provide a high probability that the circuit will perform properly under dynamic conditions because the components of the integrated circuit are frequently more sensitive to d.c. than a.c. evaluation.

There are obvious exceptions for which d.c. tests cannot assure compliance with an a.c. specification, particularly when capacitive coupling is used. In such cases the pellet is d.c.-probed before diencing at internal points and then may be a.c.-tested after the mounting and bonding have been completed.

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feedback from the output to the emitter of the first stage, the amplifier has an input impedance of 2500 ohms. Performance curves for the 25-watt unit are shown in Figs. 6B, 6C, and 6D.

70-Watt, Class-AB Audio Amplifier

Fig. 7A shows the schematic of a high-quality 70-watt direct-coupled series-output audio amplifier in which unique techniques are used to obtain stable and reliable performance. The three 1N3754 diodes in the driver stage are thermally connected to the output transistor heatsinks so that the thermal feedback required to maintain a preset 20 milliamperes of quiescent output current is obtained at all case temperatures up to 100°C. Small-value emitter resistors are employed in the output stage because additional stability is not necessary and output losses must be held to a minimum. A 1N1612R diode is placed in the emitter of one output transistor to cancel the offset voltage of the input transistor and thereby maintain the quiescent output voltage near zero. Short-circuit protection is provided by the 0.27- and 0.33-ohm emitter resistors and the zener diode. If any condition exists which will cause higher-than-normal current (5 amperes) to flow through these resistors, the voltage potential across the zener diode will be such that the diode conducts in the forward direction during the negative output half cycle and exceeds the diode breakdown voltage during the positive half cycle. In this way, the driver is clamped below the 5-ampere level, and no increase in output current above this value is allowed. The drivers and output transistors, therefore, are protected from high currents and excessive power dissipation that may result from a reduced load resistance or, in the worst case, a short-circuit. In addition, a 100°C thermal cut-off is attached to the output transistor heatsink which will turn off the amplifier when these abnormal conditions cause sustained higher-than-normal output dissipation.

The frequency response of the amplifier is flat within 1 dB from 5 to 25,000 Hz. The input sensitivity of the amplifier is 0.8 volt r.m.s. for full rated output. The input resistance is 700,000 ohms. The performance curves for the 70-watt amplifier are shown in Figs. 7B, 7D.

(Editor’s Note: The three amplifier circuits shown in this article are not intended as construction projects. We have no information on sources for any of the special parts required. Rather the circuits were included to illustrate the various design principles discussed in this three-part series of articles.)

November, 1966
Square-Wave Generator

(Continued from page 43)

the base of this transistor to the emitter momentarily and note that the collector voltage should rise as the other side becomes conducting. Do this several times, and if results are consistent, the flip-flop is operating. If pulses had been observed at point A, the trouble would have been in the trigger network consisting of C3, D1, D2, and R3. Diode polarities and bad capacitors are the usual causes of trigger trouble.

Once square waves are being produced, audio equipment can be tested by any of the well-known methods. If the scope used with the generator does not have d.c.-coupling or a low-end response to below 5 Hz, it will affect the waveshape, and this should be taken into account before some possibly innocent amplifier is accused of having poor low-end response.

At the other extreme of the spectrum, rise time and overshoot measurements will allow equipment to be judged to beyond 100 kHz.

For great accuracy, either a frequency counter or an accurate audio signal generator used in the well-known Lissajous pattern system can be employed to calibrate R2. In lieu of these, a procedure having intermediate accuracy can be performed as follows:

1. Adjust the scope sweep so that a single low-range 60-Hz sine wave (line frequency) applied to the vertical input occupies the bulk of the calibrated scope graticule. Adjust the scope controls so that the sine wave is stationary and its zero points cross noted graticule marks.

2. Remove the 60-Hz signal from the scope and substitute the square-wave generator output. Adjust R2 so that one complete square wave now occupies exactly the same space as the 60-Hz sine wave. This is the 60-Hz setting of R2 and this point should be so marked.

3. Reset the scope sweep speed so that three cycles of 60-Hz square wave now occupy the same space as the single one did previously. Adjust R2 so that one square wave now occupies this space. This is the 20-Hz setting of R2. If R2 will not reach 20 Hz, reduce the value of R3 by 100,000-ohm steps until it does.

To calibrate the higher frequencies, "walk up" the audio spectrum as follows:

1. Fill the graticule space with a 20-Hz square wave. Adjust R2 for two square waves in this space. This is the 40-Hz setting.

2. Change the scope sweep speed for one 40-Hz square wave on the graticule. Adjust R2 for two square waves. This represents the 80-Hz setting.

3. Continue the above procedure to produce settings at 20, 40, 80, 160, 320, 640, 1280, 2560, and 5120 Hz, and at 10.240 and 20.480 kHz at the end of the R2 rotation. Unfortunately, in spite of the use of logarithmic potentiometer for R2, the frequencies will tend to bunch up at the maximum resistance end of the pot.

---

SPEAKER EFFICIENCY AND AMPLIFIER POWER

By R.S. Oakley, Jr.

In the table below, the second column refers to the percent of amplifier power converted to acoustic power by the loudspeaker. Direct radiators in small cabinets will normally be about 0.5% to 2.0% efficient; direct radiators in large cabinets will be about 2.0% to 10% efficient. Horn-loaded systems will be about 10% to 50% efficient.

The columns marked "Amplifier Power" refer to continuous power ratings (per channel) of amplifiers. It is assumed that 0.25 acoustic watt per channel will result in natural sound levels. For instance, an amplifier rated at 25 clean continuous watts per channel would normally be sufficient to drive speakers of 1.0% efficiency. In a room that is much larger than normal or in a room with very "dead" acoustics, 100 watts might be needed.

The column marked "Music" takes into account the fact that peak power in music signals will be from ten to one hundred times greater than the normal average power. In a larger-than-normal "dead" listening room, a speaker of 10% efficiency might have to handle as much as 10 watts on very loud orchestral peaks. But assuming a peak-to-average ratio of only 10 dB, the average power of a music signal fed to the speaker would not normally exceed about .25 watt.

(Note: This material was derived from information supplied by Acoustical Research, Inc.)

<table>
<thead>
<tr>
<th>SPEAKER EFFICIENCY</th>
<th>AMPLIFIER POWER</th>
<th>MUSIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low 0.5%</td>
<td>50</td>
<td>5.0</td>
</tr>
<tr>
<td>Low 1.0%</td>
<td>25</td>
<td>2.5</td>
</tr>
<tr>
<td>Medium low 2.0%</td>
<td>15</td>
<td>1.25</td>
</tr>
<tr>
<td>Medium 5.0%</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>Medium high 10%</td>
<td>5.0*</td>
<td>0.25</td>
</tr>
<tr>
<td>High 20%</td>
<td>2.5*</td>
<td>1.25</td>
</tr>
<tr>
<td>Very high 50%</td>
<td>0.5*</td>
<td>0.05</td>
</tr>
</tbody>
</table>

*Commercially available amplifiers rated at less than 10 watts per channel may have excessive distortion for wide-range music applications. On the other hand, some amplifiers rated at more than 10 watts per channel may have too much hum or noise for high-efficiency speakers.
JAPANESE IC'S

JAPANESE semiconductor manufacturers are now deeply involved in the development of integrated circuits. Afraid that overseas patents may restrict Japanese manufacturers, the Japanese Government is presently allocating $80,000 per year to six semiconductor manufacturers: Fujitsu Ltd., Nippon Electric Co. Ltd., Mitsubishi Electric Corp., Tokyo Shibaura Electric Ltd. (Toshiba), Oki Electric Ltd., and Hitachi Ltd. for integrated circuit research and development.

These government fears stem from the Japanese patent applications of Fairchild Co., Texas Instruments, and General Electric. In the opinion of some Japanese manufacturers, the American IC's now constitute a very serious menace to the Japanese electronics industry.

The present standing of the bulk of Japanese IC manufacture is as follows:

- **Fujitsu Ltd.** Computer manufacturer. Mostly thin-film hybrid digital. Latest IC contains 15 transistors and 13 resistors.
- **Hitachi Ltd.** Computer manufacturer. Mostly digital types. Latest IC contains 15 transistors and 13 resistors.
- **Kyodo Electronic Labs. Inc.** This organization was established a few years ago by cooperation of the five largest component manufacturers in Japan: Toko Inc. (coils, ceramic capacitors, resistors, mechanical filters, memory matrices); Nippon Chemical Condenser Co. Ltd. (capacitors, recording tapes); Koden Electronics Ltd. (radio direction finders, loran systems); Alps Electric Co. Ltd. (switches, TV tuners); and Pioneer Electronic Corp. (speakers, hi-fi systems). The lab is devoted to the development of IC's and has produced a high-speed hybrid flip-flop and several other digital types. They are looking into IC's for use by the member firms. Incidentally, the chief engineer is an American.
- **Matsushita Electronics Corp.** Has a close connection with Dutch Philips and is developing a linear IC for low-level hearing-aid use.
- **Mitsubishi Electric Corp.** Has developed a hybrid linear IC for audio use, called the "Molectron". They also make digital thin-film hybrid types.
- **Nippon Columbia in conjunction with Toa Capacitor** have produced an IC using four transistors, ten capacitors, and twelve resistors.
- **Nippon Electric Co. Ltd.** One of the first Japanese IC manufacturers. Their latest is a digital device having four capacitors, four resistors, and two transistors.
- **Oki Ltd.** Computer manufacturer. Developing strictly digital types.
- **Sony Corp.** Developing linear IC's. Their latest is a two-stage direct-coupled wide-band amplifier.

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BOOK REVIEWS


This book grew out of a classroom assignment at Harvard Business School. As the authors worked on their assignment it became obvious to them that there was a need for a non-technical, in-depth report on optical scanning, written for men at the decision-making level.

The material has been divided into five sections covering an introduction to optical scanning (outline of the report, brief history, and major conclusions); machine technology (document control, scanning techniques, logic, and machine classifications); scanners in data processing systems (turnaround source document systems, fan source document systems, type-scan versus keypunch, other system considerations, and implementation); industrial and governmental applications; and future trends (implications of standard font, alternative inputs, and handwriting readers).

The text is quite lavishly illustrated and it is presented in easy to assimilate form.


This volume has been produced by NARM in cooperation with 32 of the major relay manufacturers. It provides engineers, management personnel, and technicians with a comprehensive source of information on operating principles, properties, performance characteristics, application requirements, specifications, and testing.

While technology is covered to some extent, the major emphasis in this book is on the practical. One particularly valuable chapter deals with the various ways in which a relay for a particular service can be specified to obtain desired performance.

The appendix contains extensive information valuable to engineers when designing relays into circuits or systems.

It also includes a comprehensive bibliography which will be invaluable for user, designer, or manufacturer.


Although this handbook is written around General Radio's line of stroboscopes, much of the material and many of the techniques described can be applied to stroboscopes in general.

The text describes modern electronic stroboscopes, their accessories, and their application in speed measurement, motion observation, and high-speed photography.

Chapter 6, a 42-page section, covers the many applications for strobes—indexed to one or more of the 37 uses discussed in the chapter. The entire book is filled with photos, line drawings, pictorials, graphs, charts, and schematics, amplifying the various points under discussion.


This is a revised, expanded, and updated version of the author's "Cathode Ray Oscilloscope" which received a warm reception a number of years ago.

The text material is divided into four parts and 33 chapters. The first part deals with the instrument itself and covers the construction of the CRO and CRT, the power-supply unit, time-base unit, deflection amplifiers, while Part II covers the general measuring technique—including setup and preliminary adjustments, amplitude measurements, null-indication in a.c. bridge circuits, the electronic switch, the uses of intensity modulation, phase measurements, frequency measurements, and rise-time measurements.

Part III is devoted to a practical discussion of various examples of scope applications, while Part IV deals with the problems of photographic recording and large-picture projections of oscillograms.

Although the text is oriented toward British equipment, it remains an excellent reference handbook for all those who work with cathode-ray oscilloscopes and their accessories.


This book is an outgrowth of the various audio courses the author has given at RCA Institutes and is designed as a textbook for electronics students, technicians, or engineers who need more information on all types of audio systems. Users of this book will need algebra, trigonometry, and a little calculus since the treatment is mathematical.

The text is divided into eight chapters and an introduction and covers signals, noise, and distortion; decibels and volume units; attenuators; mixing and bridging systems; amplifier systems; recording systems; equalizers; and audio transducers. As is usual in textbooks, there are problems appended to each chapter with answers given for the odd-numbered problems. The text is amplified by a generous use of schematics, graphs, oscillograms, line drawings, and photographs. It is also suitable for use as a self-instruction text.


The tremendous growth in automated processing and the widespread adoption of the ubiquitous computer has created demand for switching specialists. As the authors point out, not only is there a scarcity of skilled workers but there is a paucity of available information to eliminate this shortage. This volume is an attempt to fill the gap.

Although the book is primarily concerned with the basic elements of relay circuitry, much of the information is also applicable to electronic switching techniques. In many cases the theoretical information is illustrated by means of practical examples. Self-checking questions at the end of each chapter permit the user to test his grasp of the material discussed.

For those lacking the requisite background, the authors have provided a chapter on the elements of switching algebra—the understanding of which is valuable for those involved with electronic switching techniques.

As a reference work as well as a textbook, this volume should prove a worthwhile addition to any technical library.
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November, 1966
This instrument is used when fast, accurate frequency response measurements are needed in the laboratory, on the production line, and at the service bench. Sweep methods and parameters used by most manufacturers are covered.

Selecting

A Sweep Frequency Generator

By SAMUEL C. ALLEN / Supervisor, Quality Assurance Engineering Jerrold Electronics Corp.

When the need arises for a fast, accurate method of making frequency-response measurements, whether in the laboratory, on the production line, or at the service bench, a sweep frequency generator is usually chosen to fill the assignment. But a look through several manufacturers' catalogues will indicate that many types of sweep generators are available, each having its own distinct advantages and disadvantages.

The ability to select the correct instrument for a particular application requires a knowledge of the theory, operation, and descriptive terms concerning sweep generators. This article will explain in general the sweep methods and parameters used by most instrument manufacturers who offer sweep equipment.

A sweep frequency generator is a device employing an oscillator whose output frequency is varied through a particular band. The rate at which the frequency excursion of the sweeping oscillator occurs is determined by a time-base generator.

Fig. 1 is a block diagram of a simple sweep generator illustrating the function of the time-base generator and sweep oscillator as well as the leveling amplifier whose job it is to maintain the oscillator output constant under varying loads and at different sweep bandwidths.

By connecting a sweep generator to a mechanical recorder or to an oscilloscope, measurement of frequency response can be made quickly and accurately. The numerous benefits of sweep techniques over methods requiring point-to-point voltage vs frequency plots make sweep techniques desirable for qualitative and quantitative measurements.

Motor-Driven Sweep Generator

The motor-driven device shown in Fig. 2 is a sweep generator in the simplest form. By studying its operation, we are able to apply these fundamentals to more complex equipment.

The motor-driven sweep uses an electric motor to turn the tuning capacitor of a variable frequency oscillator throughout the oscillator's range. This causes the oscillator output frequency to vary from minimum to maximum frequency and then back to its lowest frequency again as the motor turns the tuning capacitor through its range. Whether the variable frequency oscillator operates in the audio, r.f., or microwave range, sweeping action will take place.

The rate at which the sweeping oscillator repeats its cycle from the lowest frequency to the highest and back again is dependent upon the motor speed. Thus, a slower motor speed results in a slower sweep repetition rate.

To observe the output frequency response of the motor-driven sweep, a scope is connected so that the horizontal scope speed is synchronized with that of the motor, and the vertical scope amplifier is connected to the generator output. The scope presentation will be a frequency vs time response of the generator output as the generator is driven through its frequency range. Note that observation of generators whose frequencies are above the range of the scope vertical amplifier must be accomplished by detecting (demodulating) the signal before applying it to the scope.

Synchronization of the horizontal scope speed with the motor speed is established through a phase-shifting network which allows the forward and return sweep traces to be superimposed on the scope screen, thereby giving a linear frequency vs time display.

Mechanical-Type Sweep Generator

At this point, it should be noted that sweeping action may be accomplished by either electromechanical or by all-electronic methods.

The most frequently used mechanical sweep technique employs a vibrating inductor or capacitor, sometimes called a wobbulator.

Figs. 3 and 4 show a refinement of the motor-driven sweep in which the motor has been replaced by a small speaker-like device which has its diaphragm specially constructed to support a set of capacitor plates. These plates mesh with rigid plates, forming a variable capacitor.
In order to better understand this type of sweep generator, a voice-coil-driven capacitor is substituted for a fixed capacitor in the tank circuit of the 100-MHz oscillator in Fig. 5. When the capacitor plates of the wobbulator are fully meshed (causing maximum capacitance across the tank coil), the oscillator frequency is driven below 100 MHz. The oscillator frequency will be tuned above 100 MHz when the wobbulator plates are unmeshed. Neglecting stray circuit capacitance, the range of frequencies the oscillator will sweep over is determined by the circuit inductance and the maximum and minimum values of capacitance presented by the wobbulator capacitor.

By applying a 60-Hz current to the wobbulator, sweeping action takes place as the capacitor plates are vibrated at a 60-Hz rate. Increasing the amplitude of this 60-Hz current increases the mechanical excursion of the wobbulator diaphragm; thus, the minimum and maximum values of capacitance are extended, resulting in wider sweep bandwidth. Hence, frequency bandwidth is a function of the amplitude of the modulating signal.

A variable d.c. current is also applied to the wobbulator voice coil. This current allows the operator to vary the mechanical resting place of the diaphragm. Hence it serves to provide a fine control of the center frequency around which the oscillator sweeps.

A separate coarse center-frequency control is provided by an adjustable tuning slug placed in the main tank coil.

Inductive tuning may be accomplished with a wobbulator device by substituting a brass or iron tuning slug in place of the capacitor plates on the wobbulator diaphragm. This assembly is then positioned so that the tuning slug may travel through the center of the oscillator tank coil and thus control the oscillator frequency in a manner similar to that of the capacitor previously described.

**Electronic Sweep Generator**

The all-electronic sweep generator may take the form of a modulated microwave tube, a variable-permeability device, or a voltage-controlled capacitor. While modulated microwave tubes find application at microwave frequencies, some manufacturers have used these tubes in conjunction with a fixed oscillator to provide a heterodyned output in the v.h.f. or u.h.f. bands. Variable-permeability devices employing a saturable reactor generally provide coverage of the 1- to 250-MHz band. Voltage-controlled capacitors are used in all bands, audio through microwave, and permit excursions greater than other electronic sweep methods.

**Microwave Sweep.** In the microwave region, where great frequency coverage and wide bandwidths are desirable, most manufacturers offer rather large equipment employing a grid-modulated backward-wave oscillator tube. By modulating this tube with a sweep-drive voltage, bandwidths of 200 to 400 MHz are easily achieved.

Some microwave sweeps have also been made by modulating the repeller of a klystron or modulating a tuned magnetron with the sweep-drive voltage.

**Saturable-Reactor Sweep.** Variable-permeability or saturable-reactor type sweep generators find wide use particularly because of the frequency bands covered and relative simplicity resulting in lower price. Saturable reactors, while chiefly used in the less expensive service-shop instruments, are also employed in more elaborate laboratory equipment because they are easily operated at the slow speeds that are necessary in order to drive mechanical recording instruments.

Fig. 6 shows a simple circuit diagram of a saturable-reactor sweep, and Fig. 7 pictures the actual construction and placement of such a device in a sweep generator.

Referring to both figures, it can be seen that the reactor is made up of the oscillator tank coil enclosed in a ferrite iron cup-shaped housing or core. This cup core is physically placed between the poles of a stack of U-shaped laminations. These laminations appear much the same as those used in transformer construction. Around one leg of the laminations is another coil which forms the plate load for the power-amplifier tube (V2).

To understand the operation of this circuit, let us suppose the oscillator circuit (V1) operates at 50 MHz when...
no external modulation is applied and that some nominal amount of plate current is flowing through the plate load coil (L1). Now, if the d.c. bias on the power-amplifier grid is decreased, allowing the grid to become less negative, more plate current will flow through the plate coil (L1), thereby raising the magnetic flux induced in the laminations and hence across the cup core. The core, being made of a ferrite material, will be driven closer to its saturation point and the inductance of the oscillator tank coil will be reduced. Therefore, as the flux field increases, output frequency increases to a maximum determined by circuit capacitance and inductance. On the other hand, when grid bias is increased, plate current is reduced below the nominal value, thus reducing the flux field which in turn drives the output frequency below 50 MHz.

By applying a modulating a.c. signal to the power amplifier, the r.f. oscillator will sweep through a frequency band determined by the amplitude of the modulating signal—high-amplitude sweep drive results in a maximum sweep excursion or maximum bandwidth. Saturable-reactor sweep generators are capable of approximately two octaves of bandwidth with relatively good frequency linearity.

Center-frequency control is accomplished by varying the d.c. bias on the power-amplifier grid, which will change the nominal plate current around which the modulating current will swing. Coarse frequency control may be obtained by shunting the oscillator plate coil with fixed or variable capacitors.

Although saturable-reactor sweep equipment suffers from the effects of drift and residual FM, wide sweep bandwidth, relatively good frequency linearity, and the ability to be driven at slow speeds make this type of equipment popular in many service-shop and laboratory applications.

**Varactor Sweep.** The voltage-controlled capacitor or varactor-type sweep generator relies on a reverse-biased semiconductor diode which exhibits a capacitance change in accordance with applied voltage. Varactor sweep generators can be used in any frequency band, audio through microwave, resulting in a distinct advantage over other sweep methods.

Sweep action is established by placing the varactor across the tank circuit of an oscillator as in Fig. 8. A change in the varactor bias voltage will result in a capacitance change and thus a frequency shift. Modulating the varactor with a 60-Hz a.c. signal results in sweep action with the sweep bandwidth controlled by varying the amplitude of the 60-Hz voltage within the limits of the varactor. Center-frequency control is achieved by varying the tank-circuit inductance or capacitance.

This type of sweep equipment offers several advantages over other electronic or mechanical sweep methods since the effects of drift, hysterisis, and limited frequency range are non-existent. These advantages make varactor
sweep equipment well suited for narrow-band, high sweep rate, and all-band operation.

**Sweep Drivers**

Next in importance when considering sweep-generator operation is the sweep driver. The sweep driver is that section of the generator which provides the sweeping oscillator control voltage, whether it be 60 Hz, variable speed, or manually controlled.

Most often used is the 60-Hz speed found as a standard feature in inexpensive service-shop instruments. Sixty-hertz sweep speed is popular because it is easily obtained from the power line and because this speed allows accurate measurements for all but a few applications dealing with sharp amplitude excursions where a 60-Hz sweep speed will not allow the scope and detector to follow the fast response changes.

Measurements of high-Q trap circuits and crystal filters frequently require sweep speeds well below 60 Hz as do measurements of audio-frequency devices. Sweep generators offering a variable sweep speed often allow the sweep rate to be reduced to one sweep every two minutes, permitting the measurement of steep amplitude excursions and the use of mechanical recording equipment.

Manual control of the sweep is useful in the laboratory where investigation of a discrete part of the sweep trace is desired. When used with a frequency meter, the manual control may be employed to spot or mark desired frequencies of interest along the response curve, such as the 3-dB down points.

Less expensive service-shop equipment generally provides only sine-wave sweep drive, resulting in equal trace and retrace times. However, laboratory equipment is available which allows selection of pyramid or saw-tooth modes, thus providing choice of various trace-to-retrace ratios for use with a mechanical recorder.

**Important Parameters**

After considering the sweep oscillator and drive modes available, thought should next be given to the following parameters: output power, sweep flatness, output impedance, and attenuation facility.

**Output Power.** The output power requirements of a sweep generator are determined by the intended application. Generators to be used for checking varactor frequency multipliers, such as those employed in microwave service, must be operated at specified power levels if proper results are to be expected. Generators used to measure extremely lossy circuits must provide sufficient output power to cover all intended uses. Consideration should also be given to wideband amplification and attenuation devices available for v.h.f. applications.

**Flatness.** Accurate measurements and ease of operation require the sweep output to be as flat as possible over the entire sweep bandwidth. Flatness is usually controlled by an a.g.c. circuit as shown in Fig. 9. A sample of the output sweep voltage is detected and the resultant d.c. voltage amplified by a direct-coupled amplifier having a cathode-follower output. The amplifier output controls the sweeping oscillator plate voltage and thus its output level. In this way, drop in output voltage is automatically compensated for by increased oscillator output.

Depending upon the gain of the a.g.c. amplifier and the flatness of the sweep oscillator, extremely flat outputs may be obtained. Variation of ±1 dB over narrow bandwidths may be expected using less expensive equipment, while ±0.75 dB flatness over 200 to 400 MHz is available on more costly industrial and laboratory equipment.

When comparing flatness specifications, it is important to note over what band and at what power level the sweep flatness is being specified. For instance, the output level of some equipment is adjusted by varying the sweep oscillator plate voltage and/or by a variable attenuator, either of which may cause the flatness to deteriorate when the output level is changed. It is also important to note that flatness is contingent on the generator output impedance being matched to that of the test circuit.

**Output Impedance.** Test-equipment manufacturers generally offer as standard a 600-ohm output impedance at audio frequencies and 50 ohms at r.f. While these impedances cover most applications, some segments of the industry have standardized on other impedances; for example, 75- and 300-ohm impedances are used by TV manufacturers. Thus, many instrument manufacturers serving this market offer equipment with an optional 75-ohm output which can easily be converted to 300 ohms. However, if a power loss can be tolerated, the standard 50-ohm impedance may be matched to test circuits of different impedance by a properly designed resistive L pad or a tapered line.

**Attenuation.** Attenuation facilities built into some sweep equipment offer several advantages. First, this arrangement allows the convenience of adjusting the output level in calibrated steps, thereby offering a means of measuring the gain or loss of the item under test. Secondly, built-in attenuators allow control of sweep output power without...
the expense of additional equipment and offer isolation between the sweep output and test circuit. Isolation is desirable, particularly at high r.f. frequencies, since external circuit impedance mismatch may cause deterioration of sweep flatness.

**Blanking.** Most sweep equipment allows the operator to blank either the forward or return sweep excursion. This is accomplished by reducing the generator output to zero during sweep trace or return, thus allowing a zero output reference trace to be established on the oscilloscope screen. Amplitude measurements are thereby made far more meaningful as well as more convenient.

**Marker Injection**

Several methods are commonly used to provide a frequency reference or marker on the sweep-generator output response. Frequency markers may be obtained by passing the sweep signal through a high-Q crystal filter, by inserting the output from a variable frequency generator into the sweep output or the detector, or by mixing a portion of the sweep-generator output with that from a variable frequency source. Absorption-type markers are generally used at microwave frequencies. These markers are produced by a calibrated, tunable trap or wavemeter, which produces a suck-out in the sweep response at the desired frequency.

Relatively simple marker injection, useful for most applications, is shown in Fig. 10. Note that the marker signal is not passed through the test circuit but rather is post-inserted at the detector. Since strong marker signals may overload or otherwise distort the operation of the test unit, post-injection is desirable in all but a few situations.

Better control of marker amplitude and shape is achieved by extracting a sample of the sweep output, heterodyning this with a signal from a variable or crystal-controlled oscillator, and feeding the resultant beat signal to the oscilloscope. Control of marker gain and shape is particularly useful when the sweep is changed from wide to extremely narrow bandwidths. Wide sweep widths require greater marker width and height, while reduced marker size and width are necessary at narrow sweep bandwidths.

Pulse-shaped markers formed by sweeping a crystal filter or tuned circuit can be used to modulate the sweep output or can be injected at the vertical input of the oscilloscope. Pulse markers offer the same control of amplitude and shape obtainable with the previous system.

**Applications**

Over the years, sweep techniques have been best known for use in the alignment of television receiver i.f. circuits and FM discriminators. However, recent expansion in the area of microwaves, crystal filters, and wide-band TV distribution has demanded more sophisticated and versatile equipment. Features such as slide-rule tuning, amplitude modulation for recovery of weak signals, built-in automatic r.f. switches, and manual sweep triggering are but a few of the conveniences serving to broaden the usefulness of modern sweep systems.

A typical radio-frequency sweep measurement setup is shown in Fig. 11. Aside from the advantages of sweep techniques over point-to-point methods, this setup provides both simultaneous and accurate measurements of gain, loss, and tilt by employing commercially available coaxial attenuators and automatic r.f. switches.

Fig. 12 demonstrates a relatively simple way of making wide-band impedance-match measurements. In this application, the sweep generator is used to establish a ripple pattern on the oscilloscope screen. This ripple pattern results when a wide-band sweep generator is coupled to a section of coaxial cable or open-wire line which is electrically open (unterminated). The ripple, which looks like simple audio sine waves, is the result of the reflections of energy back and forth along the line. All the r.f. has been removed by the detector, so the pattern represents the standing waves on the line. The ratio of ripple amplitude produced when the line is open to the ripple amplitude when the line is connected to the item under test establishes a direct indication of impedance match. This ratio may easily be related in terms of v.s.w.r. If the load were perfectly matched (v.s.w.r. = 1), then the ripple amplitude would drop to zero and the pattern would be a straight line.

The same time-saving sweep techniques so useful for broadband response measurements also serve the needs of the designer who is investigating oscillator circuitry. In this function, a sample signal from the oscillator being tested is applied to the marker input of the sweep system. Proper setting of the sweep-generator bandwidth and center frequency provides a visual display of the fundamental, harmonic, and any spurious output frequencies. With such a sweep setup the designer can easily juggle components to achieve the desired conditions in regard to frequency stability, harmonic output, relative amplitude, and spurious emission.

Manufacturers of sweep generators are constantly demonstrating new techniques, and through the development of sweep accessories such as r.f. switches, r.f. impedance bridges, and marker systems, many previously laborious and time-consuming measurements can now be made with speed and accuracy. Indications are that continued research will further expand the versatility, speed, and accuracy of sweep frequency systems.

When used in conjunction with an oscilloscope, sweep frequency generators greatly simplify the making of frequency response measurements, particularly on broadband equipment.

Ancillary equipment for creating frequency markers on the oscilloscope trace greatly aid the sweep generator by providing a reference point from which the pertinent frequency response points can be determined.

Some service-type sweep generators have this provision built in, while others use an external source of accurately known frequencies as a reference.
EW Lab Tested
(Continued from page 16)

The Model 7T has eight inputs, selectable by a front-panel rotary switch, plus recording and playback connections for a tape recorder, controlled by a separate "Tape Function" lever switch. A unique feature is the pair of front-panel jacks for recording and playback connections to a second external tape recorder. The preamp has low-level equalized inputs for a tape head and two magnetic cartridges, plus an unequalized microphone input. There are four high-level inputs.

On the rear of the chassis, in addition to the various input jacks, there are two pairs of parallel-connected output jacks for driving the power amplifiers and a pair of parallel-connected center-channel (A + B) output jacks with their own level control. The main outputs will drive loads as low as 600 ohms without distortion. There are five switched a.c. outlets and one unswitched outlet. A pair of screwdriver-adjusted controls permits the NAB tape-playback equalization to be trimmed to compensate for head wear in the recorder. As a final touch, there is a pair of "Scope Test" output jacks for checking phase shift or stereo separation with an oscilloscope.

The four tone controls (separate bass and treble controls for each channel) use step switches instead of the usual continuously variable potentiometers. The treble controls have five positions of cut and five of boost while the bass controls have four positions of cut and six of boost.

In the center flat position of each tone control, all tone-control circuitry is bypassed. Each step on the treble controls provides a 2.5-dB boost or cut from 20 to 20,000 Hz. The RIAA phono equalization was within 0.5 dB of the ideal characteristic from 30 to 15,000 Hz and the NAB tape equalization was accurate to within 0.7 dB. The filters had near-ideal shapes, with no effect on mid-range response. Their cut-off frequencies were almost exactly as specified. (See figure.)

At 10 volts output (far more than could be used to drive any power amplifier), the harmonic distortion was under 0.15% between 20 and 20,000 Hz. At lower signal levels, it was too low to measure. The IM distortion was less than the residual distortion of our instruments up to 10 volts output. (Both the harmonic and IM distortion measuring equipment used in our tests have residual distortions of about 0.02%.)

At maximum gain, a signal of 60 millivolts at a high-level input, or 0.6 mV at the phono input, was sufficient to drive the Model 7T to a 1-volt output, which is enough to drive almost any power amplifier to full output. There was no measurable (or audible) crosstalk between inputs. The noise level (a smooth hiss audible only at or near maximum gain) was 84 dB below 1-volt output on high-level inputs.
and 72 dB below 1 volt on phono. No hum was detectable.

In use, there were absolutely no clicks or other switching transients when operating the controls. All controls had a silky smoothness and positive “feel” which must be experienced to be appreciated. The tone-control curves were excellent for loudness compensation and even at their extremes did not produce an unnatural effect. The filters were highly effective in removing noise with minimum effect on the program material.

Used with a good power amplifier, the preamp provides almost limitless flexibility—more than of most of us could use—combined with almost ideal frequency response and linearity characteristics. It could well be a lifetime investment and the manufacturer offers a three-year warranty. The Marantz Model 7T sells for $325.00. An oiled walnut cabinet is available for $24.00. ▲

Tape Cartridges
(Continued from page 32)

board lighter. Some are also battery powered.

Philips, G-E, Mercury Records, Sony, Panasonic, Magnavox, Concord, and Revere-Wollensak are some of the manufacturers of these units. Mercury has recently announced the release of 49 stereo cassettes at $5.95 each, including 26 albums from their own catalogue, 8 from Philips, and the rest from smaller pop-field companies. Philips has an extensive library of European recordings in cassettes.

(Editor's Note: According to the manufacturer, more than a million units of the cassette instrument have been sold throughout the world since its introduction in 1964. They predict that by the end of this year more than 500,000 auto, home, and portable units will be on the market at $15 per set to $40 or more for home speakers.)

Recording & Sound Quality

For those who want to make their own recordings, several record/playback units are available including 4- or 8-track single-reel cartridges or in two-reel cassettes. Some have been built in combination with disc players or conventional reel-to-reel tape players, and all of them record directly into the cartridge. All have inputs for microphones or for other playback equipment which the owner may have. Prices range from around $90 for table models to $400 for consoles.

Still missing from the single-reel cartridge picture is the fast-forward and reverse feature. You cannot spot a particular selection on a given band of music unless it occurs at the beginning of the tape. However, since each band contains only about 15 to 20 minutes of music, the wait cannot be too long. Meanwhile, if the listener knows the content of his cartridge well enough, he can switch channels to spot the music he wants. (In the case of the cassette system, fast-forward and fast-reverse speeds are provided as well as special recording cassettes for spotting a particular selection on the tape.—Editor.)

When considering the quality of sound in cartridge equipment it is important to remember that most of it was first designed for the car where its stereo effect surpasses anything coming from the car radio. Also, the cartridge was originally designed for the mass consumer market and not the sophisticated audiophile. Over the past year, cartridge technology has improved to the point where many cartridge players have a frequency response from 50 to 14,000 Hz. Recording standards have not yet reached this potential with any consistency and most recordings average about 7500 Hz top. However, improved magnetic heads are rapidly changing this picture; and tape manufacturers are working on finer oxide coatings which should make it possible for cartridge recordings to match the quality of 7½ ips reel-to-reel recordings. Meanwhile, a few record companies are turning out a consistent quality of about 11,000 Hz top.

In summary, there are many advantages of cartridge over disc or reel-to-reel tape. These include less storage space and a self-contained package with no threading or rewinding. And safety—you can trust a child to play a cartridge without damage to your player or recording.

The choice of a system is up to the consumer's taste and pocketbook: lower-priced 4-track units with a larger existing pop following; more expensive 8-track players with a smaller current selection from the major record companies; a compatible unit which will allow the user to play either. Or, there is the Philips cassette system, a mighty midget for which a large European library and some American labels are already available. And if these choices are not enough, there is still the RCA reel-to-cassette system, which has been on the market for several years. And now there is a newly announced continuous loop cassette system from MGM, using 1¼ tape. All in all, the magnetic tape cartridge is here to stay, in one form or another.
Looking for Hi-Fi equipment, but in the dark about which to buy? Well you can always...

1. Ask your Uncle Fred. He used to fix your toaster....
2. Inquire from store to store to store to store....
3. Choose the one that looks nicest. And cross your fingers....

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- hi-fi systems
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PLUS—special directories for home TV tape recorders and tape cartridge machines for cars and boats!

Every technical specification, measurement, special feature, optional accessory, price and model number of all the latest products is at your fingertips. Including detailed photos. To help you compare similar items—feature for feature, dollar for dollar—and decide which is best for you. Before you buy!

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November, 1966
Line-Operated TV Sets
(Continued from page 27)

with the model. In the 19-inch portable, a single-ended output stage is used. This transistor, a 71N1, is a low-current, high-voltage type with a collector load impedance of approximately 3000 ohms. This is quite similar to a typical audio output tube.

One of the novel features of this receiver is the light-dependent resistor (LDR) circuit that provides automatic brightness adjustment for varying room lighting conditions. The light-dependent resistor, R1 in Fig. 2, is mounted near the front of the TV set but is electrically connected across the emitter resistor of video output amplifier Q1. This transistor receives the video signal on its base and receives a fixed forward bias through R2 and R3. Emitter resistor R4 is shunted by the LDR. Note that the collector of Q1 is d.c.-connected to the cathode of the picture tube as well as to the brightness control, which is a d.c. adjustment. When room lighting increases, LDR resistance becomes smaller, which means that there is less total emitter resistance in Q1. With less emitter resistance, Q1 has more gain and thereby produces a larger amplitude video signal. At the same time, the average d.c. collector voltage is reduced because a larger current is being drawn through R5. Because of the d.c. connection of the Q1 collector, this increased voltage drop lowers the positive voltage on the cathode of the picture tube, increasing brightness as well as contrast.

If ambient room lighting decreases, LDR resistance increases. This reduces the gain in Q1 as well as the current drawn by R5 and thereby provides less contrast and less brightness on the picture-tube screen. A 33-ohm resistor is connected in series with the LDR to limit the variation of its resistance to avoid over-correction. As shown in Fig. 2, the screen grid of the picture tube controls the beam current for a given level of ambient light, contrast, and brightness. In combination with the front-panel contrast and brightness adjustments, the secondary control (LDR adjustment R6) is used to set the operating range of the automatic brightness circuit.

The sync separator and the vertical oscillator output circuits are very much like those found in other transistor receivers. The vertical deflection coils are connected in parallel across an iron-core choke. This TV receiver is the first model to use a conventional blocking oscillator transformer and circuit to generate horizontal sweep voltage. This circuit, shown in Fig. 3, uses a single transistor and two diodes to provide the a.f.c. as well as the saw-tooth generation function. The output of the sync separator is applied to a set of dual diodes for phase comparison with a feedback signal from the horizontal output transformer, just as in all TV receivers. The d.c. correction

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Produces distinctive 2800 or 4500 cps tone, draws only 3 to 14 milliamps.

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High reliability — solid-state oscillator drives piezoelectric sound transducer.

High output — 60 to 80 db sound level.

Standard models available for operation on 6 to 28 volts DC, 6 to 28 volts AC, 110 volts AC. Can be supplied with pulsed output, 3 to 5 pulses per second. For data, typical circuitry for over-voltage, undervoltage, overheat, security, and many other signalling applications, write Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., P.O. Box 1558, Indianapolis, Indiana 46206.
voltage developed there, however, is then applied directly across diode D1, which acts as a capacitor that is variable by the d.c. applied across it. Transistor Q1 oscillates easily because of coupling between the collector and base through the two respective windings of T1 and forward-biasing resistor R1. The frequency of oscillation is controlled by a resonant network consisting of L1, C1, and diode D1. The horizontal hold control sets the positive voltage which is placed on the cathode of D1 and thereby controls the action of the d.c. correction voltage from the phase comparator. The resonant frequency of L1, C1, and D1 is varied by changing the d.c. voltage across D1, either through a change in correction voltage from the phase comparator, or through a change in the positive voltage from the horizontal hold control. Across the collector winding of the blocking oscillator transformer, diode D2 and a series resistor limit the high positive voltage spike which occurs when the transistor is cut off.

The third winding on transformer T1 provides output pulses to Q2 (the horizontal driver stage). Resistor R2 is a temperature-sensitive resistor which is mounted near Q1 and which compensates for temperature variation. As the temperature of Q1 increases, R2 will decrease in resistance, producing a heavy load across T1 and causing a change in the inductance reflected back into Q1. With proper polarity connections, the inductance change is such as to correct for any frequency drift of the oscillator, and this stabilizes the collector current as well.

The horizontal output circuit of the Magnavox unit is very similar, at least in its principle of operation, to that described for previous transistor receivers. The output transistor drives the two horizontal deflection coils in parallel, as well as the primary of the flyback transformer. An autotransformer secondary is used to step up the voltage for the vacuum-tube rectifier which produces +18 kV. The damper diode is connected directly across the output transistor, and a separate diode is used to rectify the boost voltage to provide +500 volts, which is then used for the focus element and the screen grid of the picture tube.

NEW WWV STARTING DATE

THE National Bureau of Standards (U.S. Department of Commerce), recently announced that effective 0000 UT, December 1, 1966, all of the services presently provided on 2.5, 5, 10, 15, 20, and 25 MHz by the Bureau’s broadcast station WWV located at Greenbelt, Maryland, will be continued by WWV now installed in its new location at Fort Collins, Colorado.

Did you ever...

...lift a wire-lead component from a printed wiring board for testing?
...test or replace a capacitor or resistor on a crowded tube socket?

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November, 1966
NEW PRODUCTS & LITERATURE

COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • HAM • COMMUNICATIONS

INFRARED PYROMETERS
Infrared radiation pyrometers which are capable of measuring the temperature of objects up to 25 feet away with an accuracy of ±2 percent are now available. The new instruments are of the quantum detector type. They use semi-conductors in a remote-mounted detector head to measure radiation. Electrical signals are produced and transmitted to an amplifier system where they are changed to usable form and displayed on a pyrometer.

If control action is desired, the Series 700 temperature controller may be integrally installed in the amplifier housing. "On-off", time-proportioning, or SCR proportioning control action is then available. The initial model in the series, Model 860, uses a lead sulfide photon detector and reads temperatures in the 200° to 1050°F range at wavelengths from 2 to 2.6 microns with a response speed of 0.1 second for 95 percent in full scale. API

Circle No. 126 on Reader Service Card

600-WATT FULL-RANGE DIMMER
A new economically priced full-range, 600-watt dimmer control is now being marketed as the No. 6681. Listed by UL, the new device provides push-on, push-off control and is designed for easy installation.

The dimmer features Specification Grade construction, including printed circuits; a radio-TV interference filter; definite "on-off" positions; and components selected to resist vibration, shock, and temperature change. The No. 6681 is rated at 600 watts, 120 volts a.c., incandescent only. A three-way version is also available. Leviton

Circle No. 1 on Reader Service Card

SELECTIVE NULL DETECTOR
A tunable null detector with a sensitivity of 1 microvolt for full-scale meter deflection, a frequency range of 15 to 100,000 Hz, and ±10% bandwidth is now available as the CA3005. The instrument operates from two 6-volt dry cells. ITT

Circle No. 127 on Reader Service Card

ELECTRONIC CONTROL KITS
Three "experimenter kits" which make possible the construction of 14 different electronic control circuits using silicon controlled rectifiers, thyristers, and photocells are now on the market. Among the circuits which can be built are: speed controls for food mixers, power tools, and electrical appliances; time and time-delay switches for photography; warning flashers; battery chargers for 6- and 12-volt batteries; light dimmers; light- and heat-activated controls for automatic lighting and heating; and overload and synchronous switches.

The basic kit, KD2105, includes one SCR, five silicon rectifiers, and two transistors. Two "add-on" kits, KD2110 and KD2106, can be used with the basic kit to permit construction of more exotic control devices. An 80-page manual, KM-70, gives step-by-step instructions for the construction of each control circuit. RCA Electronic Components and Devices

Circle No. 2 on Reader Service Card

MICRORESISTORS
Two new cermet element microresistors have been introduced as the Models 4205 and 4201. The Model 4205 measures just 0.3 x 0.05 x 0.03 and has gold-plated nickel leads emerging from an epoxy-coated alumina substrate. The Model 4201 is a resistor chip without leads measuring just 0.1 x 0.05 x 0.03. Its sides are grooved and tinned with solder, allowing maximum connection versatility. It is especially suited to dense hybrid circuit packaging applications since it can be inserted between other microcomponents.

Standard resistance tolerances of ±1%, ±2%, ±5%, and ±10% are available. The resistance range is from 10 to 200,000 ohms for the Model 4201 and 200,000 ohms to 1 megohm for the Model 4205. Power rating is 0.07 watt at 100°C. Bourns TN

Circle No. 129 on Reader Service Card

LINEAR IC's FOR FM SETS
Two "economy-line" linear IC's for use in FM radio receivers and other commercial and industrial equipment applications have been introduced as the Types CA3005 and CA3014. The CA3005 is a r.f. amplifier and is designed to be used in the first stage to handle I.F., mixer, oscillator, and i.f. driver functions while the wideband amplifier/discriminator type CA3014 performs the functions of i.f. amplifier, AM and noise limiter, FM detector, and audio pre-amplifier.

Each of the CA3014 chips is no larger than the letter "o" on a typewriter and can replace 39 discrete circuit components. The IC offers excellent performance between 100 kHz and 20 MHz. The IC's are packaged in the TO-5 transistor-type case no larger than an aspirin tablet. Additional technical information on the CA3005 and CA3014 is available on request. RCA Electronic Components and Devices

Circle No. 129 on Reader Service Card

INSTRUMENT MOTOR LINE
A new line of sub-fractional horsepower, synchronous and induction motors has been introduced as the 1020 series. The entire stator is insulated with an epoxy coating which is applied in powdered form and is cured by heat to form a continuous film. By eliminating the conventional slot-cell and end-lamination insulators, the dielectric strength has been increased, reliability improved, and manufacturing costs reduced. The thin, epoxy film also allows additional copper windings in the stator slots for increased efficiency. Heat dissipation and resistance to moisture are also improved.

The 1020 motors offer a smooth output speed at a high-rated running torque. The motors are as short as 11/2" yet offer torques from 0.3 to 150 oz./in and speeds from 1 to 1800 rpm. Complete information on this new line is available on request. Amphenol Controls

Circle No. 130 on Reader Service Card

GARAGE-DOOR OPERATOR
A new electronic garage-door opener whose transmitter is completely portable and requires no installation has been introduced as the "Electro-Lift". The new unit is especially designed for single-car garages but may also be used on two-car garages with one-piece solid doors.

The openers will open, close, and securely lock the garage door automatically as well as control the garage light to provide safe and convenient "doorman" service from 100 feet away.

Of all-transistor design, the new units meet FCC rules and are certified for operation without a license. A catalog sheet, LCG-680, describing the "Electro-Lift" in detail will be forwarded on request. Perm-Power

Circle No. 3 on Reader Service Card

INFINITE RESOLUTION TRIMMER
The new Series IRW trimmer measures 1.262" long x 0.323" high x 0.288" thick, offers infinite resolution, 0.01% stability, and 0.0005% setability.

Its different design concept consists primarily of a contact which slides along the entire length of the spiral winding instead of from turn to turn. This eliminates any danger of the contactor shorting turns together, as well as eliminating vibrations that shorting the adjacent turns by the contactor as environmental conditions vary. For easy setability, elements are up to three feet long.

Applications are in fields where resistors must be preset to pinpoint accuracy and maintain a constant ratio with no change over longer periods.
of time. These include such fields as navigational equipment, test equipment, machine tools, and production equipment. CTS

Circle No. 131 on Reader Service Card

NEW POWER RECTIFIERS

High-current rectifier types, numbering 238 items in all, have been added to a power rectifier line which consists of a broad selection in the 100, 150, and 160 ampere range and over a hundred types in the 240, 250, and 275 ampere series. Power conversion equipment using these components supplies thousands of kilowatts of d.c. power for motor drives, arc furnaces, electrochemical extraction and refining processes, and general-purpose power in mills and mines.

Detailed engineering specifications on this new line are available on request. IRC, Inc.

Circle No. 132 on Reader Service Card

TV REPLACEMENT RELAYS

A standard stock line of TV replacement relays is now available. Designed for specific television chassis, the line combines new and tested materials; nylon cans and glass-finished nylon bobbin and cover; acetal copolymer material is used in the integral molded platform bearing and armature hinge, greatly reducing friction and extending operating life.

The relays are available in either open, snap-on dust cover, or hermetically sealed construction. No changes are required in mounting, terminals, or ratings. Cornell-Dubilicr

Circle No. 4 on Reader Service Card

REGULATED 500-WATT SUPPLIES

The development of a series of solid-state continuously variable regulated power supplies delivering 500 watts d.c. has been announced.

Three models with output ranges of 2 to 32 V, 2 to 55 V, and 2 to 125 V are designed for continuous heavy-duty production testing; design; electronic and electromechanical circuit development in industry; laboratories and schools; as well as for aircraft, military, and commercial uses where a regulated d.c. output is required.

Ripple is less than 1% at maximum rated current and load regulation is less than 1/2% for both line and load changes. All have solid-state circuitry with silicon rectifiers and SCR regulation. Fused input, circuit-breaker output protection is provided. Full details are included in Spec. Sheet PS-3 which will be forwarded on request. Electric Products

Circle No. 133 on Reader Service Card

MICROCIRCUIT SOLDERING IRON

An answer to the problem of hand soldering microcircuits is being offered in the "Princess" soldering iron. The new unit combines ultraminimization with great thermal efficiency and work capacity.

For high-density circuits, flat or stacked packs, and discrete components, the iron has a special series of subminiature copper or iron-clad soldering nibs, some drawn as fine as 0.005". In heat ranges, the user has a choice of 6-, 10-, 15-, or 18-watt heat capsules with temperatures from 450°F to 1000°F. Ungar

Circle No. 5 on Reader Service Card

GERMANIUM RECTIFIER

The new 1N91-93 germanium rectifier features an extremely low forward voltage drop (0.45 V—f or low power low) plus high rectification efficiency (75% at 100 kHz).

According to the company, both performance characteristics of the 1-ampere device series are about 50% better than comparable low-current silicon rectifiers and are improvements over the ratings of a previously available, limited-source, JEDEC-registered 1-ampere germanium type.

Applications for the new units can be found in low-power circuits where voltage losses must be minimized, such as low-current battery charging and amplifier voltage biasing circuits. The new series is packed in the DO-13 flangeless case. Motorola

Circle No. 134 on Reader Service Card

NEW LASER

A "Q"-switched yttrium aluminum garnet (YAG) laser system, the Model LCW3, capable of pulse rates up to 5000 pulses per second has been put on the market. The laser is pumped continuously by two 1000-watt tungsten lamps in a double elliptical cavity. Output is at 1.06 microns and beam divergence is 4 milliradians. Rated lamp life is 500 hours. The LCW3 is water-cooled from ordinary tap water sources.

The compactly packaged laser is 8" × 5" × 21". It can be supplied with a stabilized d.c. power supply if extreme stability is required. An adjustable a.c. supply is ordinarily furnished, along with a small power supply for the "Q" switch. Raytheon

Circle No. 135 on Reader Service Card

FET FOR V.H.F. AMPS/MIXERS

The new 2N3823 "n"-channel FET offers extremely low cross-modulation and intermodulation distortion along with a guaranteed 100 MHz noise figure of 2.5 dB maximum. The drain and source are interchangeable, making it possible for the designer to choose the pin configuration best suited to his printed board layout.

Because of its low transfer capacitance of 2 pF maximum and low input capacitance of 6 pF maximum, the new device can also be used...
as a low-noise u.h.f. amplifier at frequencies up to 500 MHz.
The 2N3823 is housed in a standard TO-72 package. Motorola

Circle No. 136 on Reader Service Card

SOLID-STATE POWER SUPPLY
A low-cost solid-state power supply designed for a wide variety of applications is now available as the Model PS-200.

The unit employs zener-referenced voltage regulation and delivers 9 volts d.c. to loads up to 200 mA with complete dead short protection. A locking screwdriver-adjusted programming potentiometer permits the output voltage to be adjusted over a 1-volt range.

Specifications include: input voltage 105-125 volts a.c., 60 Hz, 5 watts; output voltage 9 volts d.c.; maximum load current 200 mA. It is housed in an enameled steel case measuring 9" x 2 1/4" x 3 1/2". Weight is 44 ounces. Round Hill

Circle No. 137 on Reader Service Card

HIGH-ACCURACY A.F. BRIDGE
A new high-accuracy (0.01%) a.f. bridge which features electronic nulling and five-figure read-out for the resistive and reactive terms of any component or impedance/admittance is now on the market as the Model B331. A discrimination of 10 parts per million is achieved on the B331 by combining three decades of push-button switches with continuous metering, giving an over-all measurement range of from 0.001 pF to 1 F; 100 ohms to 1000 kohms; and 0.01 µH to 100 mH.

Lamps indicate the correct switching sequence for rapid backing-off until the settings for maximum accuracy have been established. No search procedures are necessary and outputs are provided for recorders. Wayne Kerr

Circle No. 138 on Reader Service Card

COMPACT DEPTH SOUNDER
A compact "Fathometer" depth sounder, which measures 4 1/2 x 4 1/2 x 4 1/2 inches, has been developed especially for use in outboard and small inboard motors.

An easy-to-read dial on the Model DE-728 shows depth of water under the boat in one-foot steps up to 50 feet. A "vary-go-round" feature permits the outgoing ultrasonic signal to frequently yield second or third resolution readings over hard bottoms, allowing readings in water two or three times as deep as the rated 50-foot scale.

The depth sounder employs a compact transducer especially matched to the system. The transducer can be permanently installed through the hull of a boat, or it can be attached to a boat's transom for greater safety in boats that are trailered or beached. The transom mounting bracket is included.

The DE-728 draws only 1/40th amperes from a 12-volt line or a separate battery. Raytheon

Circle No. 6 on Reader Service Card

H.F. VARIABLE AIR CAPACITOR
The new 5200 Series variable air capacitors provide improved rotational life, noiseless contact while adjusting, greater stability under shock and vibration, broader operating temperature range, and greater soldering ease, according to the manufacturers. These capacitors are the result of a new one-piece rotor construction.

The new line features: capacity 0.8 to 10 pf; working voltage 250 V d.c.; temperature coefficient, 0 ± 30 ppm; "Q" at 100 MHz of over 3000; sinusoidal vibration greater than 60 g's; random vibration greater than 2 g's; and shock greater than 275 g (6 milliseconds). The unit is constructed with 570 solders. Johnson

Circle No. 139 on Reader Service Card

HI-FI—AUDIO PRODUCTS
SOLID-STATE AM-FM-STEREO TUNER
The new Model LT-325T solid-state AM-FM stereo tuner features HIF FM sensitivity of 2 µV, plus LF rejection of better than —35 db. The front panel includes an easy-to-read slide rule dial and illuminated d'Arsonval meter for pinpoint tuning accuracy.

The circuit uses 18 transistors and 17 diodes. Frequency range is 20-15,000 Hz ±2 db; capture ratio is 5 dB; S/N is 60 db at 98 MHz (100% modulation); and stereo separation is 35 db at 400 Hz.

The tuner measures 13" x 3 1/4" x 9 1/4" and comes complete with a walnut-finish metal case. Lafayette

Circle No. 7 on Reader Service Card

SOLID-STATE GUITAR AMPLIFIER
The new "Ampli-Vox Baronet 890" is a portable, powerful solid-state guitar amplifier which operates from flashlight batteries and provides separate channels for microphone and instruments.

One set of ten "D" cells will provide a full year's service. An a.c. adapter is available for indoor use. Designed for portability, the 30-watt transistor amplifier and 9" oval speaker are housed in an attached-type case which weighs only 16 pounds. Perma-Power

Circle No. 8 on Reader Service Card

B-TRACK CARTRIDGE MACHINE
The new "Duo-Vox" 8-track stereo tape player is designed to be used on the 12-volt battery systems of cars, boats, buses, trucks, and planes but with an accessory converter, it can be used on the power lines as well.

Standard 8-track cartridge players will provide two hours playing time and then repeat automatically if desired. Tracks are changed by pressing a knob. A remote or foot control for track changing is also available.

The 13-transistor unit provides a frequency response of 60 to 10,000 Hz. It may be used with either two or four speakers. A variety of speakers for use with this system is available from the company. Duosonic

Circle No. 9 on Reader Service Card

BASS GUITAR SPEAKER SYSTEMS
Two new portable systems, engineered to obtain maximum performance from bass guitar amplifiers, are being marketed as the PMC-1 and PMC-2.

Both systems are about the size of a 2-suiter suitcase. The PMC-1 has a 12" woofer and handles 60 watts while the PMC-2 has two 12" woofers and handles 120 watts. Utah

Circle No. 10 on Reader Service Card

RADIO/CASSETTE RECORDER
The Model 1962 compact cassette recorder permits recording up to 1 1/2 hours live from a microphone or direct from the AM-FM-shortwave portion of the radio. The radio will also play prerecorded tapes now available on the Phillips and Mercury labels.

The cassette system plays at 1 1/4 ips while the radio is an AM-FM-shortwave-aircraft model. It has a full-range tone control, automatic frequency control and extended coverage on shortwave. A unique feature of this radio is separate volume controls for radio listening and tape recording. This feature allows a recording to be made direct from the radio either while listening or while the volume control of the radio is turned down.

The radio works on six flashlight batteries, measures 13 1/4 x 3 1/2 x 9", weighs 10 1/2 pounds with batteries, and comes complete with cassette, carrying case, and dynamic microphone. It is also a.c. adaptable. Norelco

Circle No. 11 on Reader Service Card

SOLID-STATE STEREO AMP/PREAMP
The TA-1120 is a solid-state stereo amplifier/preamp whose power amplifier section has an FCC-registered power rating of 200 watts per channel at 4 ohms. Dis-
any of the three standard sizes of cartridges which are being used in car stereo players. The player will not handle the Philips cassettes or Orrtronic cartridges.

The tape cartridge unit is activated the moment a selector knob is set and the cartridge inserted. An exclusive electronic sensing device then automatically determines the type of cartridge and number of tracks. It also switches tracks automatically, shuts off both motor and amplifier at the end of the tape, and releases the cartridge. These 120-volt a.c. units are being incorporated in the firm's consoles and consoles. Arvin

Circle No. 13 on Reader Service Card

PRECISION TURNTABLE

A moderately priced automatic turntable, which incorporates many of the features previously found only in professional units, is now on the market as the "McDonald 500". The 500 has a low-mass pickup which is so perfectly counterbalanced, both vertically and horizontally, that the entire turntable can be turned on the bias while playing without interrupting the record, according to its maker. Stylus pressure is controlled by a micrometer-like pressure setting which permits precise ½ gram adjustment from 0 to 6 grams. The pickup arm is supported on horizontal ball-bearing pivots which minimize vertical friction. The arm is also protected against accidental overloading with a uniquely designed mechanism which assures continued function of the arm even if it has accidentally locked down during the change cycle. The turntable accepts either mono or stereo cartridges and has an automatic lock which secures the arm to its rest whenever the machine turns off. BSF (USA) Ltd.

Circle No. 14 on Reader Service Card

CB-HAM-COMMUNICATIONS

COMMUNICATIONS RECEIVER

The new HA-700 communications receiver is a 6-tube superhet with two i.f. mechanical filters, a sensitive r.f. stage with front-panel antenna trimming, and continuous filament voltage on the oscillator/mixer stages to maintain frequency stability. The silicon diode automatic noise limiter and a.v.c. circuitry provide efficient noise suppression. The built-in i.f.o.s and product detection stages permit clear reception of c.w. and SSB signals. Electrical bandwidth calibrated at 10 kHz per division on 80 meters, 5 kHz per division on 40 meters, and 50 kHz per division on 10, 15, and 20 meters makes the receiver easy to tune. The receiver, which draws 45 watts at 110-117 V a.c., 50/60 Hz, measures 7½" x 15" x 10". Lafayette

Circle No. 15 on Reader Service Card

PORTABLE TRANSCEIVER

Boasting a receiver sensitivity of 0.75 μV for 10 dB signal-to-noise ratio, the 15-200 portable transceiver measures 6" x 6" x 1¼". Features include two crystal-controlled channels with 2-watt output from 13 transistors; simple push-button operation throughout with "on-off" switch, preset volume control, squelch control, and channel selectors. It uses a combination speaker-microphone with push-to-talk switch. For portable operation, the unit uses 8 "AA" batteries or cadmium equivalents. It comes complete with 4 crystals (2 transmit and 2 receive) and dynamic microphone-speaker. Claricon

Circle No. 16 on Reader Service Card

SOLID-STATE COMMUNICATIONS RECEIVER

The new DR-30 communications receiver is a compact, high-performance, dual-conversion, solid-state superhet unit for amateur and other applications. The use of FET's in the r.f. stages of the DR-30 is said to provide greater sensitiv

ity, better image rejection, and exceptional freedom from cross-modulation or overloadings on strong signals. All of the circuitry is contained on nine plug-in, glass-epoxy modules for easy access and a rugged ¾" thick aluminum extrusion used for the chassis provides rock-like stability. The receiver offers complete ham-band coverage, 80 through 10 meters plus a portion of 6-meter band; 9.5—10.5 MHz for WWV and 31-meter SWL band plus provision for two optional crystals for additional frequency coverage. The receiver measures 4" x 7¼" x 6". Daveo

Circle No. 17 on Reader Service Card

MOBILE-TYPE MICROPHONE

To supplement the firm's transistorized "M+2", the first microphone with a volume control, the "M+2-2", a mobile-type unit, has been put on the market. The "M+2-2" is designed especially for mobile applications where more output may be needed or where variable output level is desirable.

The microphone features fingertip volume control, self-contained two-transistor preamp, and a 300-3500-Hz voice response range. An electronic switching model is also available at extra cost. The unit comes complete with battery, dash bracket, and 5-foot coiled cord. Turner

Circle No. 18 on Reader Service Card

CB TRANSCEIVER

A compact, transistorized CB transceiver with new crystal socket accessibility and solid-state switching has been introduced as the "Slimline 675". The new unit is a 10-channel, 5-watt transceiver which allows the addition of transmitter and receiver crystals merely by removing three knobs and two shaft nuts from its front-panel controls. The panel can then be lifted away, exposing the bank of crystal sockets and the channel indicator dial. The 675 measures only 2½" high by 6½" wide by 9" deep and has a built-in p.a. system. Amphenol

Circle No. 19 on Reader Service Card

MANUFACTURERS' LITERATURE

POWER SUPPLIES

A new 82-page catalogue and application manual on regulated d.c. power supplies is now available to systems engineers, circuit designers, and electronic packaging engineers. Containing complete details of the company's line of high-, medium-, and low-voltage rack and bench supplies, the booklet also includes a 32-page illustrated section that covers power-supply circuit principles and options, special application problems, and definitions and measurements. Hewlett-Packard/ Harrison Div.

Circle No. 140 on Reader Service Card

COAX INSTALLATION

A new 16-page illustrated booklet describing installation procedures for all coaxial cable types manufactured by the company has been made. Covering Styroflex, foamax, and helical membrane cables, the publication (Bulletin IP-2) discusses cable-cutting tools, reel handling, cable-cutting and lashing techniques, testing, leak detection, and three types of installation (aerial, tower, and underground).

The new booklet is a complete revision and updating of a similar manual on coaxial cable (Bulletin IP-1) that was published some years ago. Phelps Dodge

Circle No. 20 on Reader Service Card

INSTRUMENT MOTORS

A line of reluctance synchronous, hysteresis synchronous, induction, and servo control motors is described and illustrated in a new 8-page catalogue. Listed in the booklet is a wide range of output speeds and torques available for record and control applications. Amphenol

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AIR CAPACITORS

A new line of microminiatuure, high-"Q" variable capacitors (Series 4700) is fully described in a new catalogue sheet. Featuring coin silver and gold-plated brass construction, glassed-alumina insulation, and silicone rubber seals, the capacitors are available in printed-circuit, lug terminal, and turrent terminal configurations. Johnson

Circle No. 142 on Reader Service Card

SOLDERING COPPER WIRE

Complete information on the technology of soldering the fine copper wire used to manufacture microcircuit devices is contained in a new 4-page bulletin (TR-1018). Discussed in the booklet are types of alloys and fluxes, magnet-wire stripping, various copper-wire manufacturing methods, and design considerations. Alpha Metals

Circle No. 143 on Reader Service Card

FRACTIONAL H.P. MOTORS

A wide range of fractional horsepower motors for industrial applications is featured in a new 16-page illustrated catalogue. Special- and general-purpose devices, laundry equipment units, direct-drive blower types, and motors specially designed for room air conditioners, refrigerators, oil burners, and jet pumps are covered in the booklet. Emerson

Circle No. 144 on Reader Service Card

FUSE HOLDERS

A new 4-page condensed catalogue which describes a variety of military-approved indicating and non-indicating fuse holders along with several non-military indicating types has been released.

The illustrated booklet also lists a number of blown-fuse indicators. Fuse Indicator

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LAMINATED WIRE

Information on a complete line of fused, high-temperature, Teflon-laminated wire and cable is

November, 1966

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CAPACITOR RELIABILITY

Tantalum-foil capacitor reliability is the subject of a new 26-page illustrated report (No. GET -2998). The publication defines reliability, discusses methods of measuring failure rates, and lists various product features and capabilities that contribute to reliability. Featured in the brochure is a 4-page statement on the company's quality-control policy. General Electric

COUNTER PLUG-IN

Information on the Type DP-140 event counter and slave plug-in is offered in a new illustrated catalogue sheet. Fully transistorized and providing three-digit all-electronic display, the unit is designed for use with the company's DMS-3200 digital measuring system to permit exten-
sion of the system's frequency-measurement and event-counting capability. Hickok

INTEGRATED CIRCUITS

Design data and applications for seventeen DTL circuits are contained in a new 26-page booklet on SE100J-Series IC's. A 9-page section is devoted to characteristic curves, including design limit curves, for all elements of the series. In addition, the brochure contains block dia-

TEST INSTRUMENTS

A line of panel and portable electrical and
electronic test instruments is described and illus-
trated in a new 12-page catalogue (No. 49-T). Covered in the booklet are circuits, resistance, vol-

RUBLISH BOOKLET

A new pocket-sized 26-page booklet entitled "Helping Hand for Electrical Wiring" is now available. The brochure discusses electricity, types of circuits, resistance, splices, and a variety of terminals. Typical installations are illustrated, and a handy 7-page glossary of terms is pro-

AUDIO PRODUCTS

A line of audio accessories, including audio mixers, speaker controls, couplers, adapters, selector switches, molded cable assemblies, and a wide range of connectors, is described and illus-

MILITARY SWITCHES

Comprehensive selection charts covering one-
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72 ........................ Acopian
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93 ........................ Marantz Co., Inc.
WHEN observing a waveform on a d.c.-coupled oscilloscope, an error due to the d.c. shift of the trace may occur which may cause the observed waveform to be misinterpreted.

Such a d.c. shift could occur when a d.c. potential, or a step function, is applied to the scope's vertical amplifier input. The trace may be deflected beyond the applied voltage level and may require as much as several seconds to drift back to the applied voltage level and stabilize in that position. Such a d.c. shift is shown in Fig. 1. This problem is often overlooked when calibrating or using a d.c. scope.

To detect any d.c. shift requires only a v.o.m. and several seconds. First, set the sweep controls for a reasonable sweep speed and to extend the trace the full length of the screen. Then, set the vertical amplifier gain to permit sufficient vertical deflection of the trace in response to the v.o.m. output voltage.

Position the scope trace on the bottom line of the CRT graticule, then select a resistance range on the v.o.m. and several seconds. First, set the sweep controls for a reasonable sweep speed and to extend the trace the full length of the screen. Then, set the vertical amplifier gain to permit sufficient vertical deflection of the trace in response to the v.o.m. output voltage.

Connect the v.o.m. common lead to the scope ground terminal and the positive lead to the scope vertical input. The trace may be deflected beyond the applied voltage level and may require as much as several seconds to drift back to the applied voltage level and stabilize in that position. Such a d.c. shift is shown in Fig. 1. This problem is often overlooked when calibrating or using a d.c. scope.

As the leads are attached to the scope terminals, watch the movement of the trace.

If it rises to the applied voltage level and remains there, no d.c. shift is present. If the trace rises above the applied voltage level, there is some time to drift back and stabilize at the applied voltage level, no d.c. shift is present.

In some cases, a small amount of d.c. shift may be expected due to oscilloscope manufacturing tolerances, and the scope manufacturer's manual should be consulted if the error appears large.

Such d.c. shift may be due to improper scope alignment or a faulty component (usually a tube) in the oscilloscope vertical amplifier.

Fig. 1. When a step function is applied to the input of a d.c. coupled amplifier, the d.c. shift shown usually occurs when the circuit (usually tubes) is faulty.

---

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FOR SALE


GOVERNMENT Surplus Receivers, Transmitters, Scopes, Teletype, Shortwave, Amateur, Citizens Radio, Rush $1.00 (Refunded). ETCO, Dept. Z, Box 741, Montreal, Canada.

CANADIANS -Giant 7TH AVE., MIAMI, FLA. 33168.

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DETECTIVES! Free brochures! Electronic Surveillance devices. SILMAR ELECTRONICS, 3476 GERRY AVENUE, Hollis, N.Y. 11423.

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